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FOREST MANAGEMENT WORKING PLAN

Paper – 2 | Section – A

EDITION : 2024 – 25

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Gole ka mandir, Morar, Gwalior (MP) 474005

SYLLABUS

Indian Forest Service (IFoS) [Paper 1 | Section A] **Jharkhand PSC (ACF) Main 2024**	***Forest Management and Management Systems*** : ◈ ***Objective***, ***Principles***, and techniques; ◈ Concept of ***Sustained Yield*** (its principle, scope, and limitation); ◈ ***Rotation***, its types, and steps for reducing rotation age; ◈ ***Normal Forest***; ◈ ***Growing Stock***; ◈ ***Stand Structure*** and dynamics; ◈ ***Management of forest plantations***, commercial forests, and forest cover monitoring. Approaches viz., (i) site-specific planning, (ii) strategic planning, (iii) Approval, sanction, and expenditure. (iv) Monitoring (v) Reporting and governance; Regulation of yield. [***Covered in Module 3*** : Details of steps involved such as formation of Village Forest Committees, Joint Forest Participatory Management] ***Forest Working Plan*** : ◈ ***Forest Planning***, ***Evaluation***, and monitoring tools and approaches for integrated planning; ◈ Multipurpose development of forest resources and forest industries development; ◈ ***Working Plans*** and ***Working Schemes***, their role in nature conservation, bio-diversity, and other dimensions; ◈ ***Preparation*** and control. Divisional Working Plans, Annual Plan of operations.
Jharkhand PSC State Forest Service (RFO) Main Exam 2024 [Paper II]	***Forest Management*** : ◈ Definition, scope, objective and principles of forest management, ◈ Organization of state forests, ◈ sustained yield – definition, principles and limitations. ◈ Sustainable Forest Management – criteria and indicators, ◈ Increasing and progressive yields ◈ Rotation – definitions, various types of rotations, length of rotations, choice of type and kind of rotation. ◈ Normal Forest – definitions basic factors of normality. ◈ Factors governing the yield and growth of forest stands. ***Working Plan Preparations*** : ◈ objectives and uses – forest maps and their uses. ◈ Joint Forest management – concept and principles ◈ Modern tools in forest management. ◈ Introduction to the concept of forestry as a common property resource, ◈ Definition, Scope and necessity of community forestry – Forests and man-Forestry in support to agriculture, animal husbandry and horticulture ◈ development of cottage industry in rural environment ◈ NFP 1988 and the importance of people in forest conservation, ◈ Community forest management, Community forest development, social economic and environmental aspects, Community forest development through NGOs, civil societies, citizen groups – Gender dimensions in Community forest management. ◈ Social Forestry – definition, NCA report of 1976, need and purpose, Social Forestry for – fodder production – fuel wood – leaf manure – timber production. ◈ Integrated rural development approach – with proper marketing facility – Employment generation in raising, tending and harvesting of tree crops. ◈ Place of social forestry in the national forest policy of India, ◈ Role of forest department.

Module - 4

CONTENTS

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20 Out Of 29 Selections In RFO

INDIAN FOREST SERVICE (IFoS) PYQs [2010 to 2024]

[Part – I] PRINCIPLES & CONCEPTS

2024	• Differentiate between ***Sustained Yield Management*** (SYM) and Sustainable Forest Management (SFM) [P2/1(a) | 8 M]. • What is ***Normal Growing Stock*** (NGS)? Explain briefly the method of determination of NGS in clear felling system with formulae [P2/3(a) | 15 M].
2023	• What are the objectives and principles of forest management? [P2/1(e) | 8 M]. • Describe the methods for assessment of ***Growing Stock*** [P2/2(a) | 15 M]. • What is village forest committee? Explain its role in forest management [*Linked* Q |P2/2(c) | 10 M]. • Describe the role of **MAI** (Mean Annual Increment) and **CAI** (Current Annual Increment) to decide rotation of a forest stand [P2/3(b) | 15 M]. • Describe the importance of forest management. How will it be operated in forest plantations? [P2/4(a) | 15 M].
2022	• What is the ***Purpose of Classifying Forests***? How are the forests classified for silvicultural management? [*Linked* Q |P2/1(a) | 8 M]. • Define Forest Management and write its ***Objectives***. Discuss in brief the major activities related to forest management [P2/2(a) | 15 M].
2021	• "Forestry enterprise is ***Peculiar*** compared to other enterprises" Justify [**P1**/1(b) | 8 M]. • Define ***Working Circle***. Mention different ***Types of Working Circles*** generally constituted in India. Explain ***Biodiversity Working Circle*** [P2/3(c) | 10 M]. • Define ***Rotation of Maximum Volume Production***. Explain the methods for fixing up of rotation of maximum volume production with the help of a neat diagram [P2/4(a) | 15 M]. • Differentiate Stand density and Canopy density. Mention Canopy density classification as per Forest Survey of India [P2/1(d) | 8 M].
2020	• What are the recommended practices *for* ***Strategic Harvest Planning?*** [P2/1(d) | 8 M]. • What are the factors that affect a ***Stand Structure***? Describe in brief the DBH distribution in even, uneven, and multi-aged normal forest stands [P2/2(a) | 15 M]. • What are the Socio-ecological implications of ***Modifying Rotation Lengths*** in forestry? [P2/3(c) | 10 M].
2019	• Explain the role of Normal Series of ***Age Gradation*** and ***Age Class*** in forest management [P2/1(a) | 8 M]. • Describe the method for calculation of ***Normal Growing Stock*** with the help of yield table [P2/2(a) | 15 M]. • What is ***Progressive Yield*** ? How is annual yield obtained in a forest worked with periodic block method? [*Linked* Q : *Yield regulation* | P2/4(a) | 15 M].

	• What is Compartment*?* why is its study and description required when making a working plan? (15 m) [*Linked* Q : *Working Plan* | P2/2(b) | 15 M].
2018	• What is **Sustained Yield** ? Mention the positive and negative aspects related to sustained yield [P2/1(b) | 8 M]. • What is **Growing Stock**? How is normal growing stock calculated in **Clear Felling System** based on final MAI? [P2/2(b) | 15 M]. • Define **Rotation**. Explain different types of rotation with special reference to ecological, industrial, and economical benefits [P2/2(c) | 10 M]. • What is **Increment** ? Discuss different types of increments. Discuss the graphical relationship between current annual increment and mean annual increment [P2/3(b) | 15 M]. • Define forest management. Give its objectives. How does the attitude of the owner put impact on the management of forests? [P2/4(a) | 15 M]. • What is sustained yield? Explain how it is achieved in practice [**P1**/1(c) | 8 M]. • How is the rotation of any particular species at any particular locality practically decided? [**P1**/2(c) | 10 M].
2017	• Why site-specific planning is essential for forest management? Explain different components of site-specific management [*Linked* Q : *Silviculture* | P2/1(a) | 8 M]. • How the **Forest Cover** was measured prior to and post 1980's in India? Define the various categories of forest cover [P2/1(b) | 8 M]. • Describe the different formulae used in forest trees for determining **Increment Percent** in diameter and volume [*Linked* Q : *Mensuration* | P2/3(a) | 15 M]. • Write about the concept of **Normal Forest** and the kind of abnormalities which affect the normal growing stock [P2/4(a) | 15 M].
2016	• How are the forests classified in India? Discuss its significance in forest management [*Linked* Q : *Silviculture* | P2/1(a) | 10 M]. • What is **Normal Growing Stock**? Explain the determination of NGS in clear felling system with graphical illustration and numerical examples [P2/1(b) | 10 M]. • How do you visualize the concept of **Normal Forest** in Indian context? describe the effect of silvicultural system on normality [P2/2(b) | 10 M]. • What is the **Increment Percent** ? Discuss the relationship between CAI and MAI of a forest stand [P2/2(c) | 10 M]. • Explain the concept of rotation and its application in regular and irregular forests [P2/4(b) | 10 M].
2015	• **Progressive Yield** concept differs from **Sustainable Yield**. Under the present situation, which would you suggest and why? [P2/2(a) | 15 M]. • Discuss how the **Rotation of Minimum Volume Production** differs from the **Silvicultural Rotation** [P2/2(c) | 10 M]. • Enumerate the importance of **Forest Survey of India** (FSI) in the forest management system [P2/7(c) | 10 M]. • Show by your interpretation, either graphically or theoretically, how the forest yield depends upon the **Growing Stock** [*Linked* Q : *Working Plan* | P2/2(b) | 15 M].

2014	• Define rotation and describe the various **types of Rotation** prescribed [P2/1(e) | 8 M]. • With the help of a diagram, discuss the **relationship between MAI and CAI**. What is their role in forest measurements? [P2/2(c) | 10 M]. • What are the **Peculiarities** you have observed in **Forest Management** practices? Suggest ways to overcome them [P2/4(b) | 10 M]. • Define **Growing Stock**. Explain the estimation of growing stock and density [P2/7(a) | 10 M]. • How enumeration of the **Growing Stock** is done? describe in brief the various methods of enumeration for preparing a working plan (15 m) [*Linked* Q : Working plan | P2/2(a) | 15 M].
2013	• Describe the **scope and objectives of Forest Management**. What is the impact of restrictions laid down by the Hon'ble Supreme Court on green felling in forests? [**P1**/8(a) | 10 M]. • Define the **rotation** and describe **its various types** used in Indian forestry [P2/2(a) | 20 M]. • Describe the compound interest and Schneider's formulae for calculation of **increment percentage** [*Linked* Q : Forest mensuration | P2/2(b) | 10 M].
2012	• Differentiate between – **CAI and MAI** [**P1**/3(a) iv | 4 M]. • Describe compound interest formula for calculation of diameter increment percent [P2/1(e) | 8 M]. • Explain **dynamics of forest vegetation** giving an example of the evolution of Sal Forest in Uttaranchal [P2/8(c) | 10 M].
2011	• Write short notes on – interrelationship between **CAI** and **MAI** [**P1**/3(b) i | 5 M]. • Explain the situations under which a **Forest** becomes **Abnormal** [P2/1(a) | 10 M]. • Define **Rotation** & discuss different **Types** of **Rotations** giving suitable examples [P2/3(a) | 20 M].
2010	• Discuss the significance of normality in **sustainable management of forest** [P2/1(a) | 8 M]. • How is **De-Liocourt's principle** utilized to ensure normality concept in selection forest? [P2/1(c) | 8 M]. • How do variation in density and quality of a forest influence annual yield estimation? [*Linked* Q : Yield Estimation | P2/1(d) | 8 M]. • How are yield table data used for the assessment of **normal growing stock**? [P2/1(e) | 8 M]. • What is **working circle**? How is it decided in working plan exercise? [*Linked* Q : *Working plan* | P2/1(a) | 8 M]. • Briefly discuss the relative importance of **physical and silvicultural rotations** in respect of existing forest resources of India [P2/2(d) | 8 M]. • Explain the components of **compartment description** [*Linked* Q : *Working plan* | P2/3(d) | 10 M]. • How is the **soil expectation value** helpful for deciding financial rotation ? [P2/4(a) | 10 M]. • What is **intermediate yield** ? How does it differ from final yield ? [P2/4(d) | 10 M].

[Part – II] YIELD REGULATION

2024	• What is yield regulation? What are the bases of yield regulation? Enlist different methods applicable to regular and irregular forests [P2/4(a) | 15 M]. • What are allometric growth models? Mention different types and explain their application in growth and yield management of forest stands [P2/4(b) | 15 M].
2021	• Explain the **French Method (1883)** of yield regulation in irregular forests. What are its advantages and disadvantages? [P2/3(a) | 15 M].
2020	• What are the classical methods for determining the allowable cut? [P2/2(b) | 15 M]. • What are the *key decision parameters* in an *uneven-aged forest management* [P2/1(a) | 8 M].
2019	• What is **progressive yield** ? How is annual yield obtained in a forest worked with periodic block method ? [*Linked* Q : Principles & Concepts | P2/4(a) | 15 M].
2018	• 50 *equi-productive* coups are to be worked out from 2000 hectares of forest under clear felling system with the following densities [P2/1(c) | 8 M]. *Area (ha)* – *Densities* 600 – Normal density 400 – 0·75 density 800 – 0·50 density 200 – 0·25 density Find out the number of coupes in different densities. *8*
2017	• How a selection forest is managed under the **Felling Series**? Describe with suitable examples/diagrams [*Linked* Q : *Silviculture System* | P2/2(a) | 15 M].
2014	• How yield is regulated? Describe the **Von-Mantel's formula** for yield regulation in forests [P2/2(b) | 15 M]. • Describe the general principle of **yield regulation in Uneven-aged Forest** crop [P2/7(b) | 10 M]. • Give a short account on - the management of uneven-aged forests [**P1**/1(e) | 8 M].
2013	• What is the yield regulation in forest management? How can the yield regulation by **Judeich method** be used? [P2/1(e) | 8 M].
2011	• How is yield regulated in a forest which is worked under clear felling system? [P2/1(d) | 10 M]. • Discuss **Smythies Safeguarding formula** for annual harvest of timber from a selection forest (20 m) [P2/2(a) | 20 M].
2010	• Describe the procedure for allotting different **types of periodic blocks** in a forest [P2/3(b) | 10 M].

[Part - III] WORKING PLAN

2024	• What is unit of working plan in India? How does it differ with other temperate countries? Briefly explain the Annual Plan of Operations (APOs) [P2/1(e) | 8 M]. • What is the National Working Plan Code 2023? What are its salient features? Discuss its importance in sustainable forest management and biodiversity Conservation [P2/2(a) | 15 M].
2023	• Differentiate between forest working plan and forest management plan [P2/1(a) | 8 M]. • What are Maps? How are they helpful in the management of forests? [P2/1(c) | 8 M]. • Describe the role of working plan in forest conservation [P2/3(c) | 8 M]. • Describe regeneration survey in natural forest and explain the significance of regeneration stock map [P2/4(b) | 15 M].
2022	• How is the regeneration Map of Moist deciduous forest prepared [**P1**/1(c) | 8 M]. • *Maps* play a significant role in working plan preparation. Explain [P2/2(c) | 10 M]. • Describe the outline and the components of the *preliminary working plan report* [P2/3(a) | 15 M]. • "Working plan is a document of enforce systematic, obligatory and mandatory regulations for continuous management of a given forest". Discuss [P2/3(c) | 8 M].
2021	• "Working plan is a basic prerequisite for the management of forest division" Discuss [P2/1(c) | 8 M]. • What is **forest regeneration survey map**? How is it useful in the management of natural forests? [P2/3(c) | 10 M]. • Briefly explain the steps involved in **preparation of working plan** according to national working plan code, 2014 [P2/4(b) | 15 M]. • What are the recommended practices for strategic harvest planning? [P2/1(d) | 8 M].
2020	• A well-defined working plan is crucial for the **sustainable management of forests** and **biodiversity**. Write your answer in brief in the light of **National working plan code 2014** [P2/4(b) | 15 M].
2019	• Describe the **significance** of **working plan** and **working scheme** in conserving biodiversity [P2/1(b) | 8 M]. • What is Compartment? why is its study and description required when making a working plan? [*Linked* Q : *Principles & Concepts* | P2/2(b) | 15 M].
2018	• Define working plan. Discuss objectives and scope of a working plan. Describe salient features of a good working plan [P2/3(a) | 15 M]. • What are the **forest stock maps**? Discuss the details shown in stock maps for a working plan report [P2/1(e) | 8 M].
2017	• What are the objectives of working plan? How it is helpful for conservation of biodiversity and natural resource conservation of forests? [P2/1(c) | 8 M]. • Describe the Various **Kinds of Maps** prepared by the Working Plan Officer. What is their utility and purpose ? [P2/3(b) | 15 M].
2016	• Differentiate **Working Plan** and **Annual Plan** of operations. Suggest the changes needed

	in the working plan preparation for more effective application in forest management [P2/2(a) | 10 M].
2015	• Maps are an integral part of forest management. Give your perceptions about the kind of maps you consider important for managing a forest circle [P2/3(b) | 15 M].
2014	• Describe the following – (a) Regeneration Survey [**P1**/6(b) *iv* | 2.5 M].
2013	• What are the main contributions of Dr. D. Brandis in Indian forestry? Enumerate the various stages of working plan. What is the role of silvicultural system in the working plans? [P2/1(b) | 8 M]. • Describe a stock map. Discuss the scheme of recording crop composition (including colouring pattern used) and crop density [P2/4(a) | 8 M].
2011	• What is a **regeneration stock map**? How is it prepared? [**P1**/1(d) | 10 M]. • Explain various types of maps prepared by Working Plan Officer [P2/1(c) | 10 M].
2010	• What are the **different regeneration categories** that are observed and recorded during sal regeneration survey? [P2/1(b) | 8 M]. • What is working circle? How is it decided in working plan exercise? [*Linked* Q : Principles & Concepts | P2/2(b) | 8 M]. • Explain the components of **compartment description** [*Linked* Q : Principles & Concepts | P2/3(d) | 10 M].

Primary Reference Resources

- Forest Management by Ram Prakash, IBD Publication, Dehradun (2006 edition)
- Guidelines for the management of tropical forests, Ian Armitage, FAO, 1998.
- Forest Management by Steven P. Grossberg, Nova Science Publishers, inc. New York
- National working plan code 2014, MoEFCC, Govt. of India.
- Forest Ecology and Conservation : A handbook of techniques by Newton A. C., Oxford University press, US (1st Edition, 2007).
- Ecological and Silvicultural strategies for Sustainable Forest Management. Fujimori T, Elsevier (1st Edition, 2001).
- Forest dynamics and Disturbance Regimes : Studies for temperate evergreen-Deciduous forests. Frelich L.E. Cambridge University Press (1st Edition, 2002)
- Ecological Silviculture : Foundations and Applications, by Brian J. Palik, Anthony W. D'amato, Jerry F. Franklin, K. Norman Johnson by Waveland Press (2021).
- The practice of Silviculture : Applied forest ecology, Smith D.M., Larson, B.C., Kelty M.J., Ashton P.M.S., by Wiley Publication. (9th edition, 2014).
- Growing plantation forests, by P.W. West, Springer publication (2006 edition).
- Indian state of forest report 2021, Forest Survey of India, Dehradun.

CHAPTER 1

INTRODUCTION

Chapter outline

1.1 HISTORICAL BACKGROUND

Britishers look over our natural forest resource as a source of timber to feed the growing demand of the British royal navy and industries like railway sleepers, power-supply poles, domestic furniture demands, etc. Therefore, they start managing our forest resources just like agriculture practices over the vast natural area through –

(a) Establishing a monopoly over the production and harvesting of timber resources,

(b) Production should be sustainable in the sense of harvesting an equal amount of wood annually or periodically (and not in the modern sense of sustainability).

(c) Exploiting timber without giving much importance to its negative impact on the wildlife habitat, tribal economy, local watershed, and forest ecology.

To handle this, they compiled the contemporary European knowledge of various subjects of forestry, including silviculture systems and yield regulation, with some modified and original Indian versions in a linear structural format to systematize knowledge that make them easy to train next-generation foresters. That's why we often see this type of outdated content in our Indian academic textbooks.

However, this colonial legacy remained continued till the 1970s. as there were few major changes happening in Indian perspectives.

- Raise of many International and national organizations working on forest and wildlife sectors after the Stockholm conference (1972) on the human environment.
- Legislative changes : like shifting forest and wildlife subjects from the state list to the concurrent list (1976), passing the Wildlife protection act (1972), Water Act (1974), Forest conservation act (1980), Air act (1981), environment protection act (1986), Biodiversity conservation and many more.
- Achieved food security after the success of the green revolution. Therefore, the need to prioritize food production over forestry remains

CHAPTER 2

FOREST ORGANIZATION

Chapter outline

In 1806 the government of Madras appointed Captain Watson as the first conservator of forest, which laid the foundation of modern-day forests administration. It was further strengthened with the establishment of the Indian Forest Service in 1867. For a *better description*, *administration*, *management*, and *record-keeping*, forest areas are generally divided into 3 major categories. These categories are –

A. Territorial classification or system
B. Administrative (or Organizational) structure
C. Management (or Silvicultural) classification

2.1 TERRITORIAL CLASSIFICATION

At range level, a forest area is divided into Blocks, Compartments, and Sub-Compartments based on its executive and protective functions.

- Forest **Block** : In general, A forest range is divided into 15 to 30 blocks, which are the *main territorial divisions*. A block usually has a distinct *clear-cut boundary* all around marked by numbered pillars and *has its Local proper name*, *i.e.*, Haldwani block.
- **Compartment** : A forest block is divided into several compartments, which are the permanently defined forest territorial Units for the purposes of administration and record.
  - A compartment is a **permanent**, **recognized geographically** unit of forest land forming on the basis for planning, prescription, monitoring, and permanent record of all forest operations.
  - Use Arabic numbers 1, 2, 3, etc. for their naming
  - It is the **smallest permanent working plan unit** of management, Its Boundaries are chosen carefully on the ground and marked on the map. The boundaries are formed either by natural features such as ridges, valley bottoms, streams or artificial fire lines, etc.

CHAPTER 3

SUSTAINABLE YIELD
[EVEN FLOW]

Chapter outline

In Europe, forestry emerged as a profession and national forests were created based on the belief that unregulated markets would result in forest devastation. It was believed governments must own or regulate forests to perpetuate timber resources. This belief is still widely held and is the basis for extensive public forest ownership in Europe, India, and elsewhere. The profession of forestry began somewhere in Germany several centuries ago. Before the industrial revolution, forest management practised by professional foresters had spread from Germany to most other parts of Europe and the world.

A common forest management philosophy like the concept of sustained yield, yield regulation, and many other associated ideas emerged in this environment that continues to have a major and most unfortunate impact on forestry today.

3.1 SUSTAINABLE YIELD

[Concepts/Principle] It is the theoretical equilibrium concept, and according to it, a forest should be managed in such a way that the *annual or periodic* (when the period is short) *removal* of mature timber does not exceed the annual or periodic *stock growth* under the *existing environmental conditions*, and at a given *intensity of management*, without *harming its renewable process* and *productivity* of the forest area. In other words, Sustainable yield can be expressed as the allowable cut which may differ slightly from net increment (*i.e.*, gross increment minus natural losses due to fire, wind, epidemics, etc.) depending on the growing stock and distribution of age-classes.

[Definition] The *regular* and *fixed supply* of the desired forest produce with *its full capacity without harming the productivity* of forest crop or soil is called sustainable yield.

MAXIMUM SUSTAINABLE YIELD

The maximum sustainable yield (MSY) is defined as the *highest average yield* one can harvest from the forest over an indefinite period.

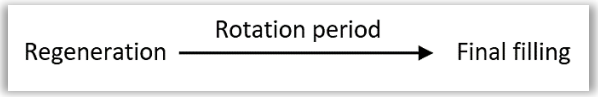
CHAPTER 4

ROTATION [PRODUCTION PERIOD]

Chapter outline

4.1 ROTATION

A rotation or production period is the *time period* which a *forest crop* takes between its *formation* and *final felling*. Put simply, it is the period of time a crop of trees is allowed to grow.



The number of years fixed by the *working plan* between its regeneration and the final felling of a crop **[Brasnett]**.

The rotation or Production period is the interval of time between the formation of a young crop by seeding, planting, or other means and its final harvesting **[Osmaston]**.

Rotation age is the age of trees or crops at which when they are felled, objects of management, for the time being, are best served **[Knuchel]**.

Rotation is the period which elapses between the formation of wood and the time when it is finally cut over **[Jerram]**.

Term **rotation** is correctly applied for **regular crop only** (*i.e.,* clear-felling system or plantation), where entire crops of a sizable area felled at a time or periodically (in the shelterwood system). For uneven or irregular forest, term "exploitable age" or "utilizable size/age" is used

ROTATION PERIOD	EXPLOITABLE AGE
The time period is taken by forest crop between its formation and final felling	Age at which tree attains the size required to fulfill the object of management
Applicable : Regular crop ✓	Regular crop ✗
Individual tree ✗	Individual tree ✓

CHAPTER 6

GROWING STOCK

Chapter Outline

Growing Stock is the sum (Number or volume) of a total of trees growing in a forest or a specific part of it, which has more than a certain diameter at breast height (DBH).

Figure : Growing stock also known as **Forest Capital**

The concept of growing stock is relative, and what one can include in it and what cannot depend upon one's views and objects of forest management. I mean, if our object of forest management is the production of timber, then we count trees of specific diameter only (above specific DBH). If our forest management objectives are carbon capturing and storage, we estimate all above-ground and underground biomass in growing stock; it includes all trees, climbers, stumps, leaf litter, underground roots, etc.

IMPORTANCE OF GROWING STOCK

Periodic estimation of the growing stock is essential for developing national policies and strategies for sustainable use of the forest resources.

(a) Provides information about (i) the volume of wood available inside forests, (ii) Current Forest carbon storage and carbon sinking potential, (iii) the tangible economic value of forests. This will help in forest certification, carbon trading, and fulfilling our INDC's obligations (2.5 to 3 billion tonnes of carbon sink storage.

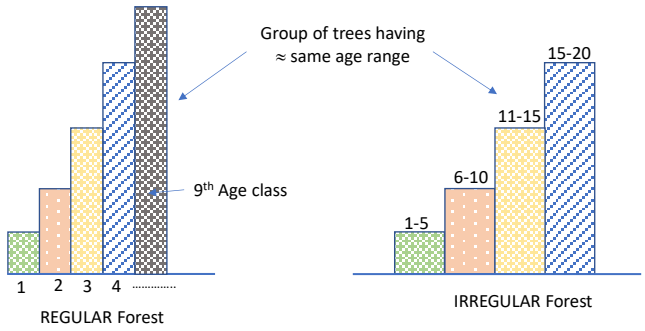
CHAPTER 7

AGE CLASS & AGE GRADATION

Chapter Outline

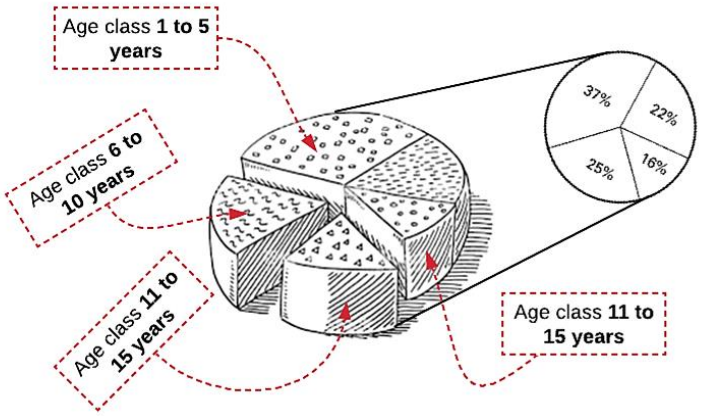
► **AGE CLASS** : one of the intervals into which the range of trees growing in a forest is divided for classification purposes or use.

Example



Age CLASS	No of trees per hectare	Volume per tree
1 – 5 year	130	-
6 - 10 year	110	-
11-15 years	85	-
16 - 20 years	70	-
21 - 25 years	60	-

► **AGE CLASS DISTRIBUTION** : Proportional representation of different age classes in a forest.



CHAPTER 9

STAND STRUCTURE & DYNAMICS

Chapter Outline

9.1 INTRODUCTION

The **stand** concept has long been central to the practice of Silviculture and has traditionally been defined as ***a group of trees that are relatively homogenous in composition, age-class distribution, and structure growing on a site of uniform quality***. Stands, as defined in this context, have served as the primary unit of forest management around the globe with the stand-by-stand application of silvicultural treatments for achieving a sustainable yield of produce.

The size and number of stands recognized depend upon the intensity of forest management, the value of stand, the diversity of site conditions, and the ease of mapping. Where intensive forestry is feasible, stands as small as a quarter hectare may be recognized. Under extensive forestry, the same forest might be divided into units no smaller than several hundred hectares.

Stand *v/s* Forest

A forest is a collection of stands. Remember that a stand is a unit of silvicultural interest. Foresters practice silvicultural operations on stands, but not on forests. It is not an ecological management unit.

- **Forest** : A plant association predominantly of trees or other woody vegetation.
- **Stand** : An aggregation of trees occupying a specific area and sufficiently uniform in species composition, structure, size, age class distribution, arrangement, Site quality, and condition as to be distinguished it from adjacent communities.

9.2 KINDS OF STANDS

Based on Composition, a stand may consist of a single species or several species. When single species form the stand, it is called a **pure stand**, and that consisting of several species is called a **mixed stand**. If a species constitutes 80 percent or more of the over-wood, it is usually

CHAPTER 11

FOREST MANAGEMENT PLANNING

Chapter Outline

11.1 BASIC ELEMENTS OF PLANNING

Planning is an active process requiring careful thought about what could or should happen in the future and involves the coordination of all relevant activities to achieve specified goals and objectives. Planning is an integral component of forest management. steps that should be taken to achieve those objectives.

- **Two levels of planning** : A working plan for 10 years and an annual plan of operations.
- A balance between production, Social & Environmental objectives.
- Participation of all stakeholders in planning, *i.e.*, Tribal economy, Wildlife, Forest department, local forest ecosystem, NGOs, watershed, Timber and NTFP market, Climate change, etc.

11.2 YIELD PREDICTION

A yield prediction model uses the quantitative relationships between measured growth variables to predict forest yields. It is a tool that helps to schedule and regulate harvests at sustainable levels.

METHODS

- **Diameter Class Growth Projection** : Oldest method, was first used in Myanmar in 1856 for simulating the growth of tropical forests. The basic steps involved in the construction of a Yield prediction model are the following -
  - **Data collection** : Compile the relevant tree population and size data collected from a whole management unit or part of it (felling series), for which a yield determination is proposed.
  - **Stand table preparation** : Prepare a tree/diameter class distribution. DBH classes are spaced at intervals of 5 or 10 cm.
  - **Growth and Mortality Rates** : Determine average diameter growth and average tree mortality rates from sample plots.

CHAPTER 13

YIELD REGULATION IN IRREGULAR FOREST

Chapter Outline

13.1 INTRODUCTION

Uneven-aged or irregular forests (a) are those forests containing more than two or three distinct age classes or age cohorts. (b) Forest stand consists of trees of all ages. The range of difference is usually more than 20 years and, in the case of long rotation crops, more than 25 % of rotation age.

Uneven-aged management is the process of making decisions to best achieve ownership objectives while maintaining an uneven-aged structure. These objectives might include maintaining constant forest cover, earning more frequent income from the stand, providing a specific type of wildlife habitat or a specific set of plant communities, or studying uneven-aged management techniques.

Advantages of Uneven Forest Management

- Uneven-aged stands have a diverse structure, with small, medium and large trees providing a multi-layered canopy. This forest structure provides habitat for many plant and wildlife species.
- Because the site is always occupied by trees = provides continuous cover on a site, reducing problems with erosion and excessive run-off after heavy rains.
- It provides more frequent cash flow, and, because it typically relies on natural regeneration, it has relatively low investment requirements.
- Many people are offended by the sight of a clearcut. With uneven-aged management, the stand is never clearcut = Socially more acceptable.

Disadvantages

- It does not work well when light demander species are desired. Example Teak, Sal, Chir-pine, etc.
- Uneven-aged management is complex and difficult to maintain.

CHAPTER 16

SURVEY & ASSESSMENT OF FOREST RESOURCES

Chapter Outline

► **EXAMINATION OF TERRITORIAL UNITS** : WPO will inspect and examine the forest area (including range, beat, sub beat), village, block, compartment and sub-compartment and ascertain that the extent of forest cover is properly maintained. Also check –

- Area of forests under different legal classes (RF, PF, UF and others), Site quality assessment,
- Forest area under different working circle/ management plan
- Land use, land use change and forestry
- Distribution of different forest types
- Marking compartment boundaries

► **FOREST RESOURCE ASSESSMENT** : On the basis of this assessment, past performance is evaluated and future management will be prescribed

- **Conservation and enhancement of Biodiversity** : Forest composition and distribution, plant species diversity, status of biodiversity conservation of forests, status of species prone to overexploitation, conservation of genetic resources, fauna and their habitats, threats and challenges to wildlife, protection and management of fauna.
- **Enhancement of Forest health and vitality** : Status of regeneration, area affected by forest fires, area damaged by natural calamities, area protected from grazing, lopping practices, area infested by invasive weed species in forests, Incidences of pests and diseases, forest degradation and its drivers.
- **Conservation and Maintenance of Soil and Water Resources**: Assessment of excess runoff from discharge zone and conservation measures for soil, groundwater, and soil moisture.
- **Maintenance and Enhancement of Forest Resource Productivity** : Growing stock of wood/bamboo, increment in

FOREST MENSURATION & REMOTE SENSING

Paper – 2 | Section – A

EDITION : 2024 – 25

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Gole ka mandir, Morar, Gwalior (MP) 474005

Module - 4

SYLLABUS

Indian Forest Service (IFoS) [Paper 1 | Section A] **Jharkhand PSC (ACF) 2024 – 25** [Paper 1 | Section A] **Jharkhand PSC (RFO) 2024 – 25** [Paper 2]	***Forest Mensuration*** : ◈ Methods of measuring – diameter, girth, height and volume of trees; ◈ Form-factor; ◈ volume estimation of stand, current annual increment; mean annual increment, ◈ Sampling methods, and sample plots. ◈ Yield calculation; yield and stand tables. ***Remote Sensing*** : ◈ Forest cover monitoring through remote sensing, ◈ Geographic Information Systems for management and modelling.

Module - 4

CONTENTS

INDIAN FOREST SERVICE (IFoS) PYQs [2010 to 2022]

FOREST MENSURATION

2024	• Explain (*i*) ***Crop Diameter***, (*ii*) ***Crop Height***, (*iii*) Spectral signature and (*iv*) General ***Volume Table*** [P2/1(b) | 8 M]. • What is ***Commercial Volume***? Explain different methods of volume estimation of felled logs and compare with quarter girth method [P2/2(b) | 15 M]. • Which criteria have to be considered while choosing statistically sound ***Sampling Design***? How do you estimate the sample size for forest inventories? Explain different kinds of sampling units [P2/3(b) | 15 M].
2023	• What is ***Point Sampling***? How is it used in forest enumeration? [P2/1(b) | 8 M]. • Explain briefly the reference point for measurement of diameter and girth of tree species [P2/1(d) | 8 M]. • How does the yield table differ from the ***Volume Table***? Describe the contents of yield table with justifications [P2/2(b) | 15 M].
2022	• Explain (i) Artificial Form Factor, (ii) Absolute ***Form Factor***, (iii) Normal Form Factor, and (iv) Form Quotient [P2/1(e) | 8 M]. • Describe the tangent method used to calculate height of trees on (i) Level ground, and (ii) Sloping ground [P2/4(b) | 15 M]. • Describe the graphical method of preparation of ***Volume Table*** [P2/1(b) | 8 M].
2019	• Explain ***Metzger's Theory*** of tree form and its significance in volume calculation [P2/1(c) | 8 M] • Describe the procedure for estimating the volume of standing and felled tree [P2/1(e) | 8 M]. • Explain the principles of the height measuring instruments giving suitable examples [P2/2(c) | 10 M]. • What is ***Point Sampling***? How is it helpful to find out the basal area of a forest? [P2/3(b) |15 M]
2018	• What are the precautions required for diameter measurements with ***Calipers***? Discuss the errors that occur due to non-observation of the precautions [P2/2(a) | 15 M]. • Define ***Volume Tables*** and give their classification [P2/3(c) | 10 M]. • Define forest ***Sampling***. Give advantages of sampling Discuss different types of non-random sampling methods used in forestry [P2/4(b) | 15 M].
2017	• How ***Volume Tables*** are classified on the basis of kind of out-tum? Describe briefly [P2/1(e) | 8 M]. • How the geometrical measurements for calculating volume yield are made in (i) Buttressed tree, (ii) Leaning tree on a slope, and (iii) a tree forked at the base? Give a thematic presentation [P2/2(b) | 15 M]. • Describe the different formulae used in forest trees for determining ***Increment Percent*** in diameter and volume [*Linked* Q | P2/3(a) | 15 M]. • Write a note on kinds of enumeration and explain in brief different random ***Sampling*** techniques used in forest inventories [P2/4(c) | 10 M].

2016	• Discuss the significance of ***Stump Analysis*** in forest mensuration. How does it help in understanding the past growth of trees? [P2/1(c) | 10 M]. • *Sampling* has a very important role in ***Forest Inventory***. Discuss with the help of kinds of sampling [P2/4(c) | 10 M].
2015	• Which of the instruments has ***Wheeler's Pentaprism*** replaced and why? [P2/1(c) | 8 M]. • How important are the ***Increment Borers*** in forest health and growth analysis? Does Pressler's borer have any adverse effects on the tree sampled? Elaborate on the issue [P2/1(d) | 15 M]. • How far do ***Taper Tables*** help in measuring the volume of a tree? Discuss their types and methods of preparation [P2/4(a) | 15 M]. • Why are ***Sample Plots*** laid out in different forest species? What is their utility and how are they enumerated? [P2/4(b) | 15 M].
2014	• What is a ***Stand Table***? Give a brief description for preparation of a stand table [P2/1(a) | 8 M]. • How is ***Stump Analysis*** carried out and what kind of information does it yield? [P2/1(c) | 8 M]. • What is a *tree* ***Stem Form***? How is tree stem form calculated and what are its uses in forestry? [P2/3(b) | 15 M]. • Differentiate between ***Sample Plots*** and preservation plots. Discuss their role in management [P2/3(c) | 15 M]. • "***Spiegel Relaskop*** is an instrument of great use in forestry" justify with reasons. How is the basal area per hectare determined by this instrument? Explain [P2/4(c) | 15 M]. • In brief, but in an explanatory way describe the preparation and utility of yield tables in forestry [P2/5(a) | 8 M]. • What is an ***Increment Borer***? Describe its role in forestry [P2/6(c) | 15 M].
2013	• Differentiate between the graphical method and the regression equation method for the preparation of general ***Volume Tables*** [P2/2(a) | 8 M]. • Differentiate between ***Hojer's Formula*** and ***Behre's Formula*** for *tree form* [P2/1(d) | 8 M]. • Describe the compound interest and Schneider's formulae for calculation of ***Increment Percentage*** [*Linked* Q | P2/2(b) | 10 M]. • Differentiate between ***Random Sampling*** and non-random sampling. Describe different methods of non-random sampling that are used in forest inventories [P2/2(c) | 10 M]. • In ***Stem Analysis***, diameters of 30th ring (as computed on BH section) at different height sections was found as follows [P2/4(c) | 10 M].

Ht. of Section (m)	01.37	04.24	07.24	10.24	13.24	14.74
Diameter (cm)	29.5	25.2	21.0	16.00	10.40	06.60

The diameter curve of 30th ring cuts the height axis at 18.24 m
(The average seedling takes 10 years to reach 1.37 m)
Calculate the MAI at 40 years of Age of the tree.

2012	• What are the items of information available in the ***Volume Table*** in addition to the volume of

	tree? Briefly describe them [P2/1(a) | 8 M]. • Describe the process of ***Tree Height*** measurement by the Abney level. What are its advantages and disadvantages? [P2/1(b) | 8 M]. • Describe various formulae for calculation of the ***Volume Of Logs*** [P2/1(c) | 8 M]. • Define ***Stem Analysis*** and discuss its purpose [P2/1(d) | 8 M]. • Describe ***Compound Interest Formula*** for calculation of diameter increment percent [*Linked* Q | P2/1(e) | 8 M]. • Describe the indirect methods for ***Volume Estimation*** of trees [P2/2(a) | 14 M]. • If the ***Angle Of Elevation*** to the tip of the tree is 30° and 45° respectively, measured from two sides of a ravine, and width of the ravine at the top is 15" m and height of the eye of observer from the ground is 1·5 m, find the height of the tree [P2/2(b) | 8 M]. • *Calculate values* of – [P2/3(a) | 10 M]. (i) Bark thickness; (ii) Log volume OB; (iii) Log volume UB; (iv) Volume of bark, and (v) Bark percentage, for a log with measurements DBH OB = 130 cm, DBH UB = 124 cm and Length = 4·8 m • Discuss the ***Metzer's Theory*** of Stem Form [P2/3(c) | 8 M]. • A tree with elliptical c/s when measured at BH by a ***Calipers*** gives two values as 71 cm and 65 cm. Girth of the tree at BH by tape is 1·82 m. Calculate the basal area by three different methods, listing the methods clearly, and discuss which method is the correct one [P2/3(d) | 12 M]. • Estimation of ***Crown Volume*** depends on which factors and what are the different geometrical shapes of crowns? Write down the various formulae for measurement of crown volume [P2/2(c) | 10 M]. • Briefly explain the ***Monteith Formula*** for biomass estimation of plants [P2/7(e) | 5 M].
2011	• Describe reference point of ***Diameter/Girth Measurement*** on a standing tree [**P1**/1(b) | 10 M]. • Explain principles of ***Height Measuring*** instruments [P2/2(b) | 10 M]. • What is ***Quarter Girth Formula***? Why is it preferred for calculation of log volume? [P2/2(c) | 10 M]. • What is ***Yield Table***? How contents of yield table is utilized in forestry? [P2/3(c) | 10 M].
2010	• Comment on the comparative significance of ***Calliper*** and ***Tape*** for D.B.H. Measurement [P2/2(a) | 8 M]. • Write down the methods for laying out ***Sample Plots*** for periodic recording of growth data [P2/2(c) | 8 M]. • Explain the principle and use of ***Abney's Level*** [P2/3(c) | 10 M]. • Write principle of ***Christen Hypsometer*** and its use [P2/4(c) | 10 M].

[Part-II] REMOTE SENSING & GIS

2024	• What is **GPS**? Briefly explain its segments and its applications in forest inventories and monitoring [P2/1(c) | 8 M].
2022	• "Application of ***Remote Sensing*** and **GIS** helps in continuous forest cover monitoring and efficient forest management activities". Explain with Examples [P2/4(a) | 15 M].
2021	• Define ***Gioinformatics***. What are its elements? Explain its role in management and monitoring of forest resources [P2/2(a) | 15 M].
2020	• Why should **GIS** be considered as a 'Pure Science'? [P2/1(b) | 8 M]. • What are the application of ***Remote Sensing*** in forestry? [P2/3(a) | 15 M].
2019	• Describe the role of ***Remote Sensing*** and **GIS** in monitoring forest resources [P2/4(b) | 15 M].
2018	• Define ***Remote Sensing***. Discuss its *application in forest management* along with GIS applications [P2/4(c) | 10 M].
2017	• What are the applications of ***Remote Sensing*** and **GIS** in the field of forestry and wildlife? [P2/1(d) | 8 M].
2016	• Define ***Photogrammetry***. Discuss in detail its application in forest management [P2/1(d) | 10 M] • Thermal ***Remote Sensing*** has specific application in forest management, Describe [P2/3(b)|10 M] • The recent developments in **GIS** ***and Digital Image*** *Processing* make forest cover assessment and mapping more easier and accurate. Explain your views [P2/4(d) | 10 M].
2015	• Discuss how the microwave ***Remote Sensing*** has been found to be more useful in forestry than other satellite imageries [P2/4(c) | 10 M].
2014	• Differentiate between ***Geostationary*** and ***Sun Synchronous Satellite***; and satellite imagery and remote sensing [P2/1(b) | 8 M].
2012	• What are the advantages and disadvantages of **LANDSAT** images? [P2/2(d) | 8 M].
2011	• How is ***Remote Sensing*** advantageous as compared to ground surveys? [P2/1(e) | 10 M].
2010	• What are the ***Pictorial Elements*** used of interpretation of aerial photo graphs [P2/3(a) | 10 M]. • How does the ***Flying Height*** influence the scale of aerial photo graphs in hilly areas [P2/4(b) | 10 M].

Primary Reference Resources

- Forest mensuration by Chaturvedi AN & Khanna LS, IBD publication Dehradun.
- Forest mensuration by Anthonie VL and Alparslan A, Springer publication.
- Forest mensuration by Kershaw JA et. al, Wiley Blackwell publication (5th edition).
- Forest inventory, Methodology and application by Annika k & Mattis M, Springer publication.
- FAO web portal.
- Remote sensing and GIS by Basudeb Bhatta, Oxford University press (3rd Edition, 2020)
- Websites for Previous year Papers – UPSC, OPSC, HPPSC, UKPSC, UPPSC and crowd sourcing.

CHAPTER 2

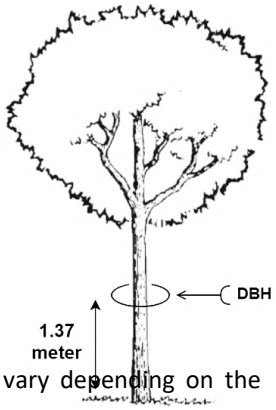
DIAMETER & GIRTH MEASUREMENT

2.1 OBJECTIVES BEHIND DIAMETER/GIRTH MEASUREMENT

- To estimate the quantity of timber, firewood, and other forest produce, *i.e.*, Cubic feet wood in a teak tree.
- Measure the rate of tapering, its form, and the shape of logs that will help in determining timber quality (Volume of logs).
- To know the basal area of trees/crop
- It helps in making an inventory of growing stock as well as correlating height – Volume – Age –increment of a tree or crop.

2.2 CONCEPT OF DBH AND GBH

► **BREAST HEIGHT (BH)** is a universally accepted standard height above ground level for measurement of Girth, Diameter, and basal area of standing trees. If we take the diameter at that height, we call it *diameter at breast height* (DBH), and if we take the girth, it calls *girth at breast height* (GBH).



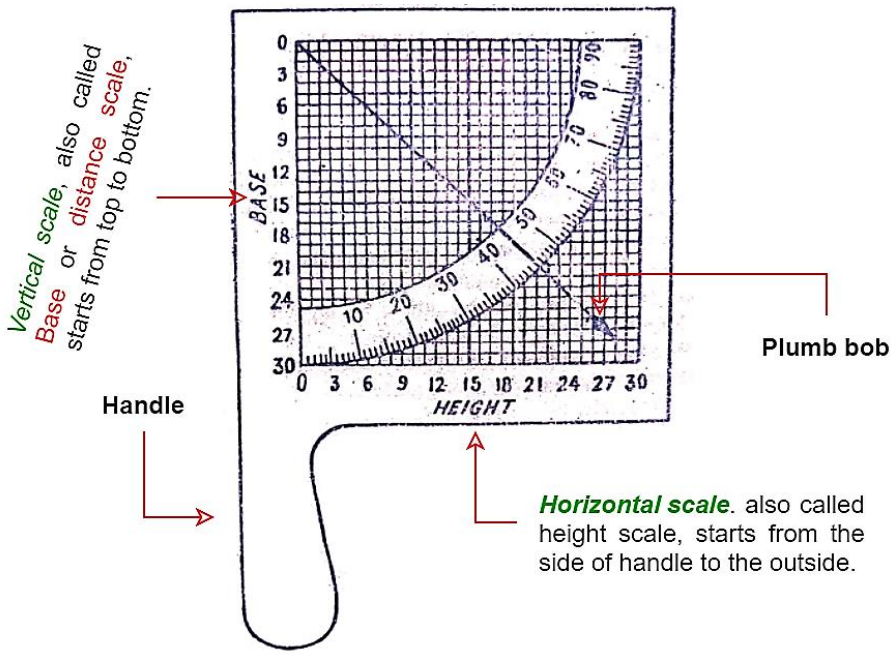
In India***, Burma, S. Africa, USA & other British colonies	In UK, Europe & FAO***
BH = 1.37 m (4 feet 6 Inches)***	BH = 1.30 m (4 feet 3 Inch)***

It is important to note that the place of measurement of diameter/girth may vary depending on the conditions –

► **THE BREAST HEIGHT HAS BEEN ACCEPTED AS THE STANDARD FOR DIAMETER & GIRTH MEASUREMENT BECAUSE OF THE FOLLOWING REASONS**

- The bases of the trees are generally covered with grasses, shrubs, and thorns sometimes, so the measurement of Diameter or Girth at the base is usually challenging and requires extra effort to clear these before the measurement.
- Many trees develop root swellings, Buttressing, and fluted stems near the base and may extend to several meters above ground, especially in tropical rainforests. These create difficulties in getting the actual diameter.
- It gives a uniform point of measurement and therefore standardizes diameter measurements of trees overall the world.

corresponding to different angles of depression or elevation to be applied to the sloping distance for finding out the horizontal distance.



ADVANTAGES OF SMYTHIES' HYPSOMETER

- It is easy to construct and carry.
- It avoids the measurement of horizontal distance.
- The instrument may read heights up to 30 meters

DISADVANTAGES

- Rain may wash away the graph paper, so difficult to use during monsoon
- Wind may disturb the plumb line and result in creating an error in the angle to be measured

► **IMPROVISED CALLIPERS** : It is simply a caliper with scale marking on the movable arm and a plumb-bob mounted at the edge of the fixed arm.

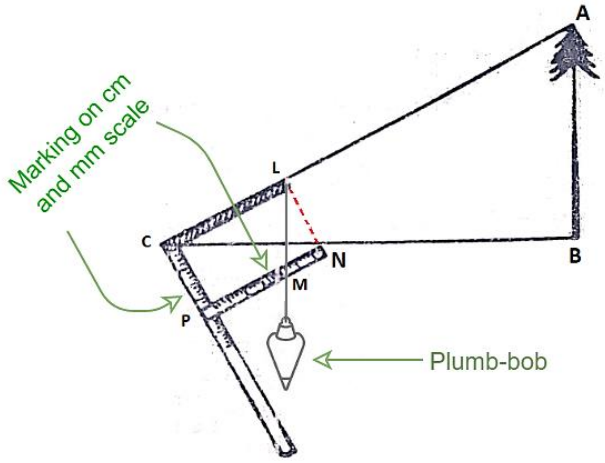
Advantage : It can be made in the forest if no other instrument is available.

Let's see in the given figure,

∠CAB = ∠CLM = ∠LMN

Therefore, $\frac{AB}{BC} = \frac{MN}{LN} = \frac{MN}{CP}$

$$AB = \frac{BC \times MN}{CP}$$



INSTRUMENTS BASED ON TRIGONOMETRICAL PRINCIPLES

With the advancement in technology, gradually, more complex equipment started being used in

S = basal area at breast height

h = Is the height of the tree in a linear unit.

CLASSES OF FORM FACTORS : depending on the height of measurement of basal area and the part of the tree considered –

- ***Artificial form factor*** or ***Breast height form factor*** : The basal area is measured at Breast height and the volume refers to the whole tree both above and below the point of measurement.
  - University accepted and *most commonly used**** form factor.
  - Issue : Because the diameter measurement point is fixed, it didn't give a true picture of tree form

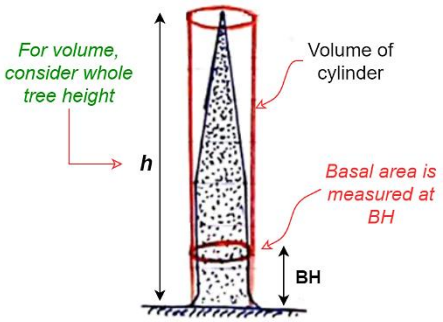


Figure : Breast height form factor.

- ***Absolute form factor*** : for this, the basal area is measured at any conventional height and the volume considers only above that point of measurement.

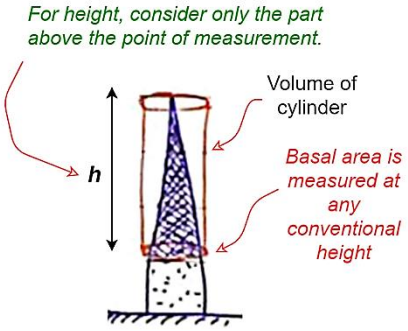


Figure : Absolute form factor.

- ***Pressler's Normal*** or ***true form factor*** : under this, the basal area is measured at a specific proportion of total height, *i.e.*, 1/10th, 1/20th etc. of total height, and for the volume, we consider the whole tree above ground level.
  - Issue : (a) needs to measure tree height before deciding measuring point, (b) Point of measurement is very inconvenient for very large size and very small size trees.

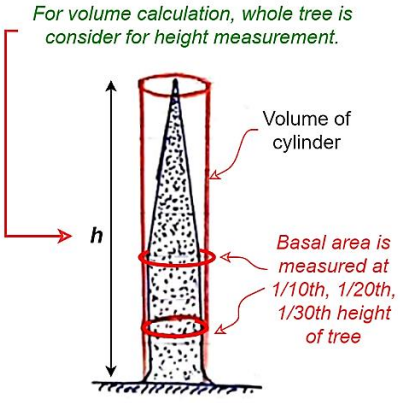


Figure : True form factor

TYPES OF FORM FACTORS : depend upon the volume represented by them –

- Tree form factor
- Stem timber form factor
- Stem small wood form factor

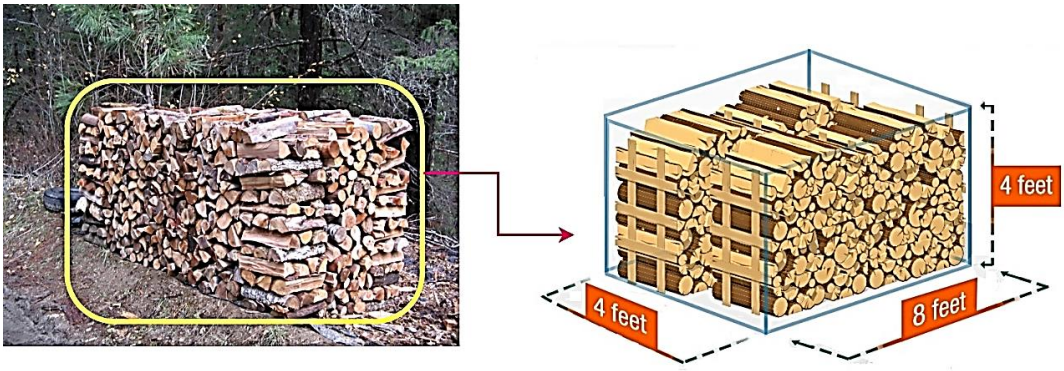
IMPORTANCE OF FORM FACTOR : (a) Estimate volume of standing trees - Form factor table can be used to estimate the volume of standing tree by putting data of dbh and tree height. (b) It helps to understand competition and growth conditions [Study law of growth].

IFoS 2009 : What is the importance of estimating *form factors* of a tree ? Write common formula(e) used to estimate the form factor (10 m) [Same Q asked in 2007].

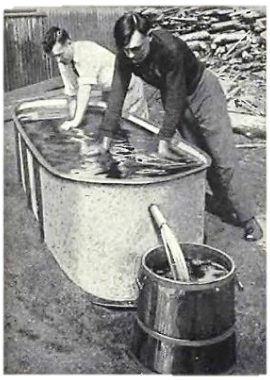
5.1.3 VOLUME MEASUREMENT OF STACKED SMALL WOOD

In addition to the round timber, a large amount of small size timber and firewood are also produced during the felling operations and have commercial importance. Therefore, we need to measure them as well. As it is not possible to assess the volume of each piece of firewood, called billet, it is customary to stack them in the form of rectangular parallelepipeds and calculate the cubic volume.

- **Billet** : It is a unit of measure widely used in India to express the volume of stacked fuelwood. A standard billet is a rectangular parallelepipeds pile of stacked wood of 12 ft × 3ft × 5ft.
- Smaller stacks are called *Chatties* (Size – 1.8 m × 1 m × 1 m).
- For a similar thing, the term "Cord" is used in North America to express the pile of stacked wood of 8ft long, 4 ft high, and 4ft in width (The standard cord occupies 128 ft^3).

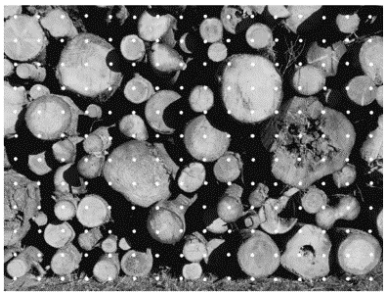


METHODS OF VOLUME MEASUREMENT



- **Xylometric or water-immersion method** : Xylometer*** is used to calculate the volume of billets, and the volume of wood is calculated based on the principles of water displacement in a graduated vessel. The vessels are filled with water and a reading is taken. A second reading is taken after the wood pieces are submerged. The difference between the two readings is the volume of submerged timber.
- **Specific gravity method** : If the specific gravity of wood is known, then volume can be calculated from the weight of the billet

$$Volume = \frac{weight\ of\ wood\ (in\ grams)}{Specific\ gravity\ of\ wood}\ in\ cc$$



Issues with this method : (a) moisture content, (b) Density decreases from lower portion to upper part of wood.

- **Photographic method** : By taking photos of the ends of the sticks piled up, one can calculate the volume. The camera is located at a fixed distance from the pile and the optical axis of the lens is perpendicular to the pile's side.

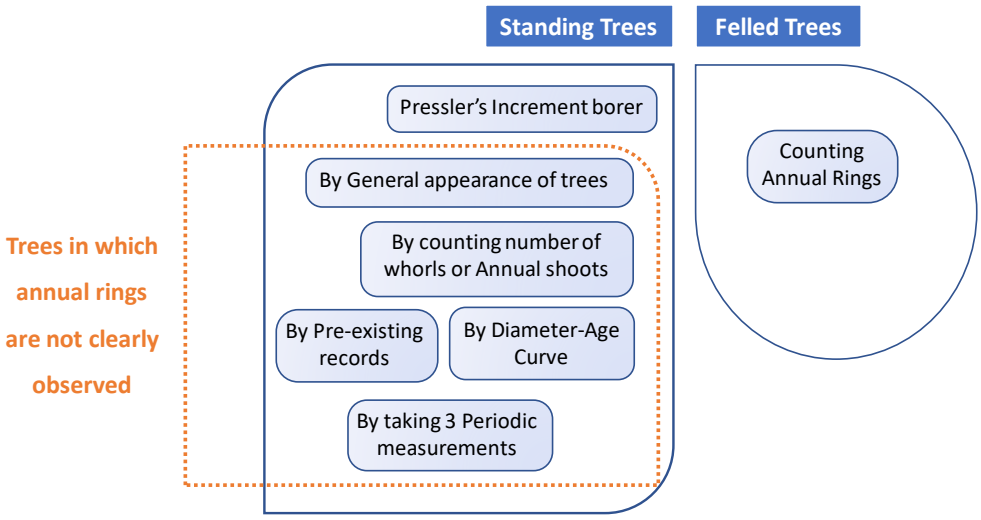
CHAPTER 7

AGE OF TREES

► **WHY DID WE REQUIRE TO ESTIMATE AGE ?**

- To estimate the rate of forest wood capital formation.
- To determine the time required for particular volume formation

► **METHODS**



7.2 CALCULATING AGE OF STANDING TREE

► **From existing records** : in the case of trees raised by plantation, the records of the year of such operations are very helpful in finding the age of trees.

► **From general appearance** : the age of a standing tree can also be found by ocular estimation, but it requires the skill of a high level.

- *Size and shape of the crown* – in some species size and shape of the crown changed with increasing age, *i.e.*, *Pinus roxburghii* has a conical crown in the early stage, and it became rounded as the tree grows older.

Figure : A record board of plantation work. Which give us information about the species sown or planted, year and time of planting, method of planting and various given treatments.

- Younger has a high *tapering rate* while older have low tapering + *Size of the stem*.
- *Colour and condition of barks* – in Shorea robusta, younger trees have rough, crooked and darker bark than the old one which has lighter and smooth bark.

CHAPTER

13

APPLICATION OF REMOTE SENSING

► **FOREST MANAGEMENT :** The main application of photo interpretation to forestry involves (i) preparation of a base map, identification of tree species, (ii) quantitative measurements about the density of trees in a given.

- Forest classification
- Forest certification
- Mapping stand structure, susceptibility and vulnerability.
- Wildlife management : habitat pattern and fragmentation analysis.
- Forest hydrology and watershed management –
- Monitoring Wetland Dynamics
- Carbon Cycle modelling for forest and terrestrial ecosystem.

► **MONITORING INVASIVE SPECIES** : The spectral information acquired by multispectral and hyperspectral sensors onboard satellites or aircraft has made it possible to –

- Papped and analyzed the abundance, distribution, and impact of invasive species on the local vegetation.
- Determine how they occupied the habitat.
- Determine the level of compositional changes in native ecosystems and prediction of what possible future dispersal at local, regional, and national levels.

Through analyzing key environmental parameters such as light, water, and temperature, with remotely detectable biophysical properties (Phenology) like – *Parthenium hysterophorus*, *Lantana camera*, *Argemone mexicana,* and *water hyacinth,* etc. shows a significant spectral variation (variation in leaf shedding, flowering & fruiting time, etc.), water blooming detection in wetland and coastal areas, etc.

Foresters and ecologists are now well aware of the problems caused by the invasive species into natural areas like displace native species, disrupt nutrient and fire cycles, and cause changes in the pattern of plant succession. So, they searching for answers to what types of biophysical traits make a superior invader and what types of communities are more susceptible to invasion. Ultimately, the goal of invasion research is to develop a unified and comprehensive framework that allows them (foresters, ecologists & conservation biologists) to make accurate predictions on the potential invaders even before their introductions and on the types of communities that are more vulnerable to invasions.

<u>Challenges</u>

- Mapping accuracy of our sensors.
- It is generally known that most understory invasive species are hard to detect and mapped by remote sensing since they could be completely hidden by the overstory canopy. However, there might be a temporal window

CHAPTER

15

PHOTOGRAMMETRY

Photogrammetry is the art and science of obtaining reliable information like Tree heigh measurement, Crown diameter, Tree volume, crown density, etc., through measurement over aerial photographs.

► **PHOTO INTERPRETATION** : An act of examining photographic Images and Judging their significance, *i.e.,* Identification of a species.

► **PICTORIAL ELEMENTS THAT WE USED FOR SPECIES IDENTIFICATION**

- **TONE** : Each distinguishable variation (Shade) From white to black in the tree's crown caused by the differential reflection of light. Tone may be affected by the angle of light.
- **SIZE** : crown size, shape and height may easily identify
- **SHAPE OF CROWN** : Conifers – Conical shape, babool – brood shape crown.
- **Shadow** - Help to the identification of Species by indicating the shape of the crown but depend upon the time of photography (means sun angle with tree).
- **TEXTURE** : Frequency of Change and arrangement of tones in an image
  Smooth texture → Young tree
  Coarse texture → Old tree.
- **PATTERNS** : Spatial arrangements of an object, *i.e.*, Linear arrangements mean plantation, and the irregular arrangement means natural forest.
- **LOCATION** : hills vs. Valley
- **ASSOCIATION** : associated species, if we identify one species, then we can identify other associated species more easily.

► **TREE HEIGHT MEASUREMENT**

STEREOSCOPE : A Binocular optical device for viewing overlapping images to attain a mental impression of 3D

Importance : (1) Photo – interpretation, (2) Measurement on Photograph, (3) help to transferring interpreted information Maps.

STEREOSCOPY : The science which deals with achieving 3D effect with Binocular vision and the methods by which these effects are produced.

PHOTOGRAMMETRY : The science of making measurements from photographs.

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