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FOREST MANAGEMENT WORKING PLAN

Paper – 2 | Section – A

EDITION : 2025

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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

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].

[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].
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

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

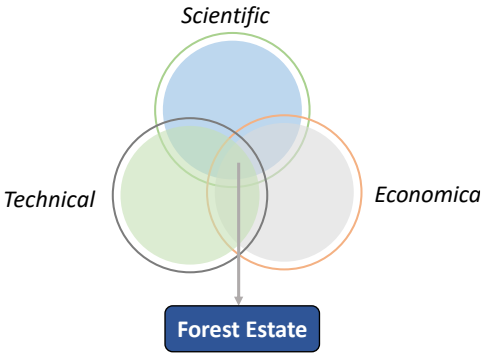
no more.

- Achieved food security after the success of the green revolution. Therefore, the need to prioritize food production over forestry remains no more.
- The emergence of new threats like Global warming and climate change, Deforestation, increasing the destructive effect of exotic species, watershed destruction, flooding issues, etc.
- Policy-related changes like the promotion of Participatory Forest management and forest rights acts.
- Biodiversity conservation and forest genetic resources.

All of these lay down the foundation of our policy shifting from a *production forestry* point of view to *protection forestry*. And even in the case of production forestry areas, we *started considering the impact of harvest practices on the local ecology and biodiversity, Wildlife, watershed, Tribal livelihood, and Carbon sequestration ability of forest*. These lay down the foundation for more smooth and sustainable regulation of forest resources with *strategic* and *Tactical harvest planning*.

1.2 DEFINITION

Forest management is the *practical application* of the *scientific*, *technical*, and *economic principles* of forest estate to achieve *certain objectives*.



In the broadest sense, forest management is a process that effectively integrates the biological, social, and economic factors which influence the decisions leading toward the implementation of one or more specified objectives.

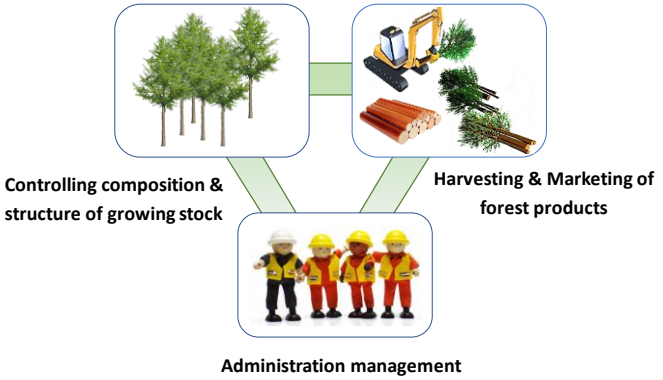
[FAO define - Forest Management deals with the overall administrative, economic, legal, social, technical, and scientific aspects related to natural and planted forests. It implies various degrees of deliberate human intervention, ranging from actions aimed at safeguarding and maintaining the forest ecosystem and its functions to favouring specific socially or economically valuable species or groups of species for the improved production of goods and services].

1.3 SCOPE

Controlling the structure & composition of growing stock - through Site-selective tending operations, Choice of species, Regeneration methods, stand manipulation and Protection measures, etc.

Harvesting to the marketing of produce : by preparing a proper Logging Plan, adopting suitable transportation methods, Marketing / Auctioning of produced, and Revenue management.

Administration of forest property : Monitoring and control of works, Labour management and their welfare, Economy efficiency.



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 5

INCREMENT

Chapter Outline

5.1 INTRODUCTION

An increase in growth (or volume) of a tree or crop during a given period is called increment.

This increment means an increase in plant diameter, height, or basal area but remember; this does not mean an increase in the price of timber due to changes in monetary value or demand-supply fluctuations

TYPES OF INCREMENT

- **Current Annual Increment (CAI)** : The increment in the volume or size of a forest crop during a particular year, for example, in the 10^{th} year of growth.
- **Mean Annual Increment (MAI)** : MAI is the total annual increment up to a given age divided by that age is our MAI, *i.e.*, MAI in the volume of Teak plantation up to 30 years is 30 m^3/hac/year.
- **Periodic Annual Increment (PAI)** : An average annual increment for any given short period of time, such as height growth in a teak plantation in the 10^{th} to 15^{th} year of growth, is 0.5 meter per year.
- **Final Mean Annual Increment** : Mean annual increment at rotation.
- **Quality increment** : When a tree/crop's price rises per unit volume because of a change in the quality or a specific property of the wood, and not because of changes in demand and supply (money value), *i.e.*, The price of a 30-year-old sandalwood tree is much higher than that of a 20-year-old tree, not because of its increase in volume, but because hardwood formation increases with age and this hardwood is the source of sandalwood oil.
- **Price increment** : The increment in price, independently of quality increment, resulting from fluctuations in the market value in general and the demand and supply position in particular.

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 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 10

FOREST COVER MONITORING

Chapter Outline

SYLLABUS

Forest cover monitoring. Approaches *viz.*, (i) site-specific planning, (ii) strategic planning, (iii) Approval, sanction, and expenditure. (iv) Monitoring (v) Reporting and governance.

10.1 INTRODUCTION

Forest Cover : All lands more than 1 hectare in an area with tree canopy density of 10 % or more, irrespective of land ownership, use, and legal status.

Forest Cover Monitoring : it is the process to check or record forest cover regularly by using modern tools to understand the scenario and effects of various causes over forest cover.

Remote Sensing : This is the technique of acquiring information about some property of an object with the help of recording devices such as a camera, laser, radiofrequency receiver, radar system, etc., without any physical contact with them.

METHODS OF FOREST COVER MONITORING

- **Traditional Methods** : Collecting and assessing data manually. The use of airborne remote sensing, including balloons and Dakota aircraft, has been limited. We relied on this method until 1981 when FSI began developing and using space-based remote sensing.

  Issues with this ?

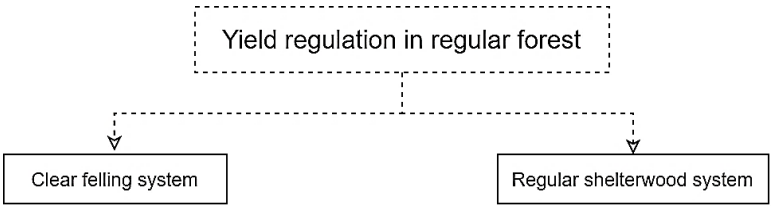
  - Less effective, time-consuming, and too expensive.
  - The majority of aerial remote sensing data is recorded in the black and white spectrum. Because of this, it is virtually impossible to identify invasive species, detect stress on the forest ecosystem, and trees species these days.

CHAPTER 12

YIELD REGULATION IN REGULAR FOREST

Chapter Outline

Even-aged management deals with forests composed of even-aged stands. In such stand, individual trees originate at about the same time, either naturally or artificially. In addition, stands have a specific termination date at which time all remaining trees are cut. This complete harvest is called a *cleat-cut*.



12.1 YIELD REGULATION IN CLEAR-FELLING SYSTEM

- **Annual coupes by gross area** : Under this, a forest area is divided into a number of *equi-extensive* annual coupes. The number of coupes is equal to the rotation age, so we can cut one coupe every year.

  The *simplest and oldest method*. *Suitable for coppice forests and high forests* that are managed under a clear-fell system. Except for the first rotation where crops are usually irregular both in composition and density, this method ensures a sustainable yield from the second rotation onward.

- **Annual coupes by reduced area** : Site quality and crop density may vary from coupe to coupe. Hence, felling of *equi-extensive* annual coupes may not guarantee equal volume of timber every year. In order to achieve this, we adjust the boundaries of an annual coupe in a way to get areas of equal productivity.

ADVANTAGES OF YIELD REGULATION BY AREA

- Easy to apply
- Site preparation and planting can be done economically over large areas, using machinery and fire.

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.

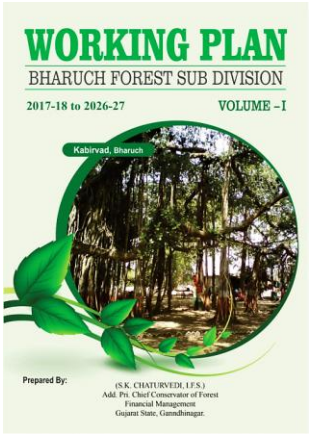
CHAPTER 14

WORKING PLAN [INTRODUCTION]

Chapter Outline

14.1 INTRODUCTION

CONCEPT : Let's suppose we wanted to start a commercial forest enterprise, similar to an agriculture one. In that case, we would need systematic planning for it, right from the preparation of the site and regrowth of the vegetation to the final felling and marketing of the harvested products. Since forest crop is not a seasonal or annual crop like wheat and its rotation can be less than 40/50 years + Apart from this production, we also have other protective, socio-economic development for tribals and wildlife conservation purposes. To accomplish all these goals, we need a brief but detailed fact-based plan that can manage, regulate, control, and direct our operations for at least the next 10 to 15 years.



NEED

- It is common for foresters/IFoS officers to get transfer after 2/3 years (± promoted, retired, or die); then who would remember which treatment they have already given to the local forest stand and which is not?
- Forests are also facing high biotic pressure, soil erosion, climate change, and fire incidences. Therefore, they must also be managed in a certain way (in a sustainable manner) with long-term planning.
- Wildlife is also a component of the forest ecosystem; we cannot leave them or drive them out of the area.
- CAMPA plantation and REDD^{+} type initiatives give much attention to the prevention of forest degradation.

Therefore, we needed a written document to establish a sustainable plan based on ground-based observations, all needed facts, and scientific principles, so no one can affect our continuity of operation, whether officer

CHAPTER 15

PREPARATION OF WORKING PLAN

Chapter Outline

The preparation of the working plan is a highly technical and time-framed scheduled operation and is usually based on stock maps prepared through ground surveys. However, after advancements in remote sensing, GIS and GPS, the way of data collection and analysis changed.

Working plans of yesteryears are drafted to exploit the commercially viable forest areas to generate revenue. As of now, no forest areas of India are commercially managed after a Supreme Court rule ban of green felling with effect from 1996. Keeping this in the backdrop, many methodologies adopted in the past plans are now worthless. The preparation of the entire working plan can be conveniently divided into the following stages [As per the National working plan code 2014].

- Preparation of preliminary working plan report (PWPR)
- Approval of PWPR by the Standing consultative committee
- Drafting working plan by WPO
- Approval of the plan
- Printing of the plan
- Amendments & Monitoring

15.2 PREPARATION OF PRELIMINARY WORKING PLAN REPORT (PWPR)

(as per national working plan code 2023)

The *head of the WP wing* (not below the rank of *Add. PCCF*) in the State Forest Department shall initiate the revision of the working plan *at least 28 months before* the current Working Plan ends. This was previously set at 30 months (2 and a half years). The head will direct the *head of the territorial circle* (CF_T) to submit a *Preliminary Working Plan Report (PWPR)* in the prescribed format within *3 Months*.

The CF (T) will then instruct the Divisional Forest Officer (DFO) to start preparing the *preliminary working plan notes*. These notes should briefly review the results of past systems of management, accompanied by a set of related quantitative, qualitative or descriptive attributes and suggest necessary improvements. The DFO must complete these notes within the specified time frame (previously it was two months) and submit them to the CF (T). The CF (T) will inspect the relevant forests, write the

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 : 2025

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Module - 4

SYLLABUS

Indian Forest Service (IFoS) [Paper 1 | Section A] **Jharkhand PSC (ACF) 2024 – 25** [Paper 1 | Section A]	***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.
Jharkhand PSC (RFO) 2024 – 25 [Paper 2]	***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].

<table>
<tr><td>2016</td><td>

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].

</td></tr>
<tr><td>2015</td><td>

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].

</td></tr>
<tr><td>2014</td><td>

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].

</td></tr>
<tr><td>2013</td><td>

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].
<table>
<tr><td>Ht. of Section (m)</td><td>01.37</td><td>04.24</td><td>07.24</td><td>10.24</td><td>13.24</td><td>14.74</td></tr>
<tr><td>Diameter (cm)</td><td>29.5</td><td>25.2</td><td>21.0</td><td>16.00</td><td>10.40</td><td>06.60</td></tr>
</table>
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.

</td></tr>
<tr><td>2012</td><td>

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

</td></tr>
</table>

CHAPTER

1

INTRODUCTION

The term mensuration has traditionally been defined as a branch of mathematics that deals with the measurement of lengths, areas, and volumes. In forestry, it encompasses determining dimensions, form, weight, growth, volume, health, and age of trees, individually or collectively.

► **Definition :** Forest mensuration is the branch of forestry that deals with the determination of dimensions (*i.e.*, diameter, height, volume), form, age, and increment of a single tree, stand, or a whole forest, either standing or after felling.

► **OBJECTIVES**

- **The basis for sale** : Before any sale, the forest department estimates the quality and quantity of timber and other forest products and prices them accordingly.
- **For research** : (a) quantifying stand characteristics (volumes, weights, etc.), measuring past growth, and predicting the future growth of individual trees or stands. (b) To obtain a specific size or quality timber as per the requirement of our industries, after giving them a type of silvicultural treatment. Mensuration here helps us in assessing the effects of silvicultural treatments on stand growth, its quality, and productivity.
- **For forest management** : To properly manage the forest land at the ecosystem level, we have to know how much wood is standing in the forest, its structure, composition, productivity, carrying capacity, and carbon sequestration. We also need to measure them for carbon trading, *forest certification,* and making a *"zero-carbon" economy* based.
- **For planning** : For the future need of the nation and its industries, *i.e.*, working plan.
- Prediction also is an important aspect of forest measurements. For instance, the weight of a standing tree cannot be measured directly, but it can be predicted using easily measured tree attributes such as diameter at breast height and total tree height.

► **SCOPES**

- For contractors, Sawyers, Transporters, and millers – to know the volume and quantity of timber.
- For a forester – for better wildlife management, estimating the carbon sequencing capacity of the forest.
- Recreational and eco-tourism purposes.

► **ACCURACY-RELATED ISSUES DURING MEASUREMENT** : Accuracy depends upon -

Dis-advantages

- Tape elasticity
- If the tree has rough bark, the tape exaggerates the Diameter or Girth.

IFoS 2010 : Comment on the comparative significance of *caliper* and *tape* for *dbh measurement* (8m)

Hints : Tape and caliper both are used to measure the Girth and Diameter of trees, logs and stumps in order to calculate their basal areas and/or log volume. Both have their practical advantages and issues during fieldwork, so we need to compare them to understand their significance.

- If we consider a circular cross-section of a tree/log, then both tape and caliper give us almost the same result. However, as is the case with elliptical or inflated stems, errors in basal area calculations are slightly higher in the tape than in the caliper.
- Garth is about three times the diameter. Suppose we measure the circumference for calculating the diameter by tape and an error of 1 cm occurs; this is an error of just 1/3 cm in the diameter calculation compared to an error of 1 cm in the diameter calculation through the caliper.
- For both Circular and elliptical cross-sections, one measurement is sufficient for tape, but we require two measurements for the caliper.
- In the case of a felled tree, It is easier to use tape than to use a caliper.
- Usually, caliper gives both +ve and –ve errors, so they neutralized each other and gave a better accuracy than the tape, which showed only +ve errors.

► **BILTMORE STICK** : The Biltmore stick is occasionally used to obtain quick and rough estimates of the mean diameter of standing trees. It consists of a straight stick, usually *60 to 90 cm long,* with the graduated rule that is held perpendicular to the axis of the tree stem. It is usually calibrated for a distance of *25 inches* (63.5 cm) between the operator and the tree. The observer aligns the *zero mark* of the stick with the left edge of the stem (at point A), and the diameter of the tree can be read at the intersection at the other end of the stick on the line EB that is tangent to the tree cross-section at B. [Note : Its accuracy decreases with increasing tree size].

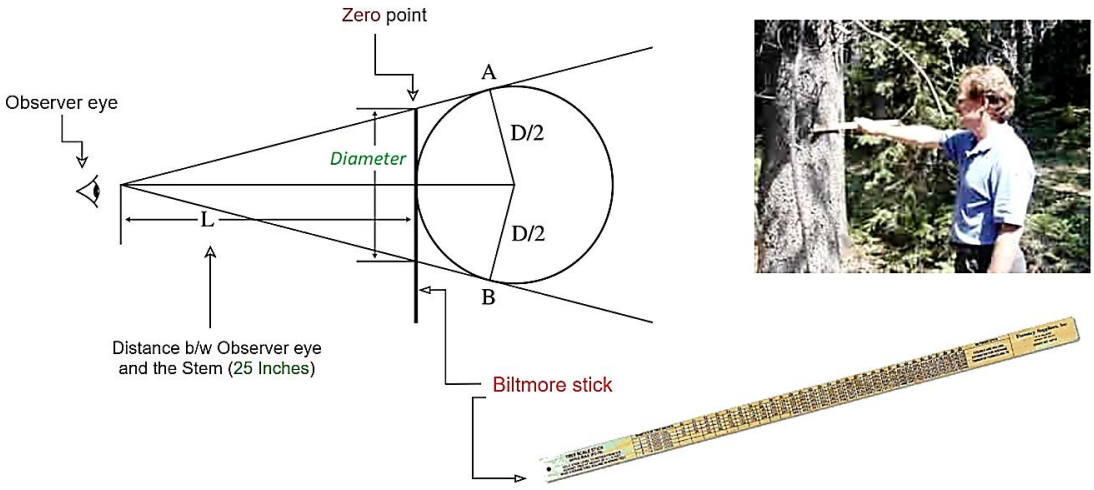


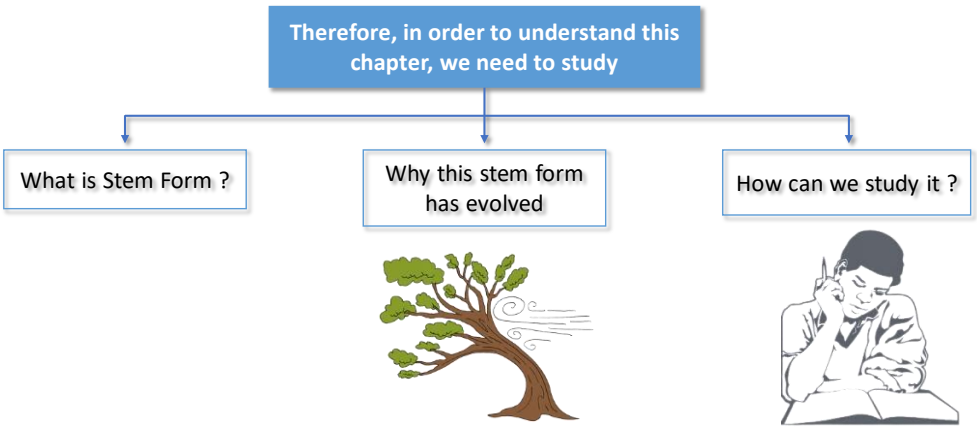
Figure : Working principle of Biltmore stick

CHAPTER

4

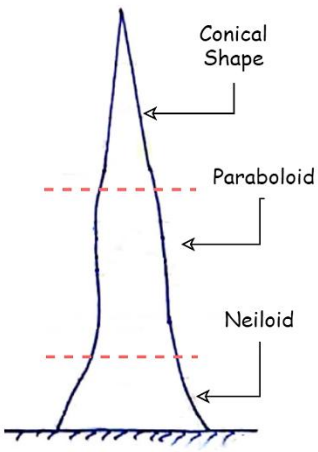
STEM FORM

The primary purpose behind the development of this subject, “Forest mensuration,” is to estimate the timber volume of standing tree crops. Whereby a government, manufacturer, or contractor can set its price according to the market value for taxation, royalty, and auction purposes. But, simply multiplying the tree height data by its basal area (diameter) will not give us the actual volume. Why? Because the tree is not a cylinder, its thickness (diameter) continuously decreases from bottom to top. Therefore, we need to consider this rate of tapering to get a real answer.



4.1 STEM FORM

Stem form is the characteristic shape of the tree bole, which is usually tapered from the base to the top. Generally, a stem is divided into three parts – (a) The lower one is neiloid in shape and covers about 10% part, (b) The central section is represented by a paraboloid, and (c) the upper one is a conical section.



Although this general pattern is apparent in both the open-grown and stand-grown trees (In group). The stem profile of the individual tree is affected by its social position within the stand as well as the site, silvicultural treatments, such as stand density, planting espacement and fertilizer, and genetic parameters.

Note : **Tapering** is the rate of decrease in the diameter of a tree or a log per unit increase in height from the base. For practical purposes, it is expressed in centimetre per meter stem length

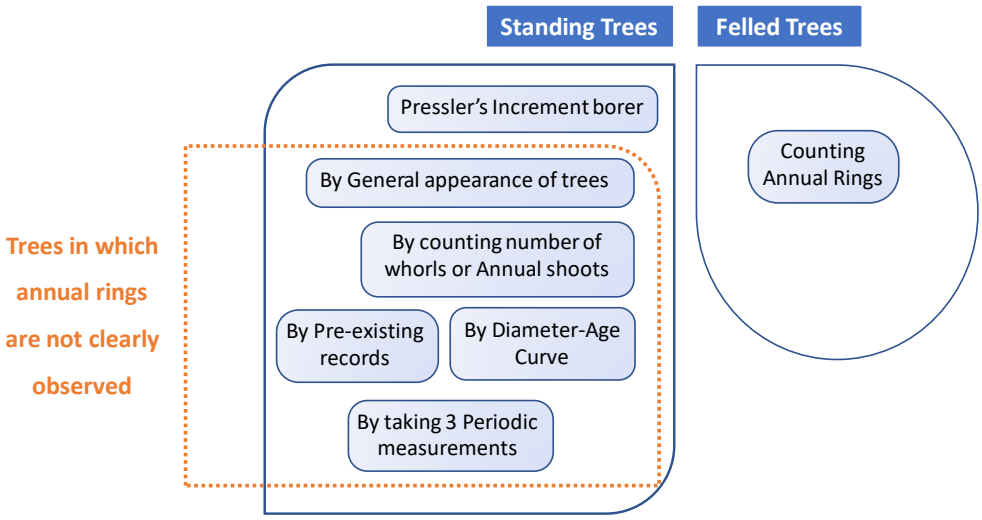
CHAPTER 7

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 10

POINT SAMPLING

Since the inception of this subject, our primary objective has been to measure stand volume, and it's always a difficult task. Because, for this we need to measure the basal area and stem height of each tree in a forest stand.

Therefore, forest scientists always try to develop an alternative method that can give almost the same results with very little effort and time. Such a successful effort was first made by the Austrian forester *Bitterlich*, in 1948……..that is, *point sampling*.

Bitterlich has proved that counting from a random point the number of trees whose breast height cross-section exceeds a certain critical angle when multiplied by a constant factor gives an unbiased estimate of basal area per ha.

► **Definition** : *Point sampling is a method of quickly estimating basal area per hectare directly by standing at a point to selecting trees on the basis of their size rather than by their frequency of occurrence through using angle gauge or wedge prism of known basal area factor (BAF).*

Point sampling is also known as - *angle-gauge cruising*, *Angle count sampling*, *pointless cruising*, *plotless sampling*, *variable plot cruising*, *Bitterlich sampling,* and P.P.S. (probability proportional to size) sampling, etc.

► **TYPES**

- Horizontal point sampling : Given by *Bitterlich*, and useful in the estimation of basal area or diameter.
- Vertical point sampling : given by *Hirata*, and useful for Tree height measurement [by Conimeter***]

HORIZONTAL POINT SAMPLING

► **Concept** : In horizontal point sampling, a series of sampling points are selected randomly or systematically distributed over the entire area. Trees around these points are viewed through an angle gauge (wedge prism) at breast height and all trees forming an angle bigger than the critical angle of the instrument are counted.

It may be noted in the below figure that even though all the trees are of the same basal area, some are counted in the tally while others are not because being far away from the sampling point they did not form an angle higher than the critical angle of the instrument. On the other

CHAPTER

16

GIS & FIS

16.1 GEOGRAPHIC INFORMATION SYSTEM

The GIS is a computer-based information system used to digitally represent and analyse the geospatial data or geographic data. Geospatial means the distribution of something in a geographic sense; it refers to entities that can be located by geographic coordinate system

► **Definition** : Geographic information system is a systematic integration of computer hardware, software, and spatial data, for capturing, storing, displaying, updating manipulating, and analysing, in order to solve complex management problems.

or

Geographic information system (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyse, and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records.

► **KEY COMPONENTS OF GIS**

- **Hardware** : Physical component of which the GIS software will run. It includes the element of plotter computer hardware such as CPU, Monitor Printer, Scanner, etc.
- **Software** : Provides the functions and tools that are needed to share analysis and display geographic information.
- **DATA** : Geographic data or Spatial data and related tabular data can be collected in-house or bought from a commercial data provider. Spatial data can be in the form of a map/remotely-sensed data such as satellite imagery and aerial photography.
- **Users** : GIS technology is of limited value without the users who manage the system and develop plans for applying it. GIS users range from technical specialists who design and maintain the system to those who use it to help them do their everyday work.

16.2 GIS AND RELATED TERMINOLOGY

Common people, often, get confused with the terms *geographic information system*, *geographic information science*, *geomatics*, *geoinformatics*, *geoinformation technology*, and *geospatial technology*.

Congratulations

To all our successful candidates in

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17 AIR

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Forestry Comprehensive Course

75 AIR

Harveer Singh Jagarwar

Forestry Comprehensive Course

76 AIR

Akash Dhanaji Kadam

Forestry Comprehensive Course

78 AIR

Himanshu Dwivedi

Forestry Comprehensive Course

80 AIR

Sumit Dhayal

Forestry Comprehensive Course

82 AIR

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Akash Kumar

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Chandra Bhushan

Forestry Comprehensive Course

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Harsh Verma

Forestry Comprehensive Course + Test Series

134 AIR

Gaugin Gyanendra Singh

Forestry Comprehensive Course

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