Natural Resources Conservation and Development

Level – III

Based on March 2018, Version3 Occupational standards (OS).

Module Title: - Conducting Forest Inventory

LG Code: AGR NRC3 M 19 LO (1-5) LG (82-86)

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Adama ,Ethiopia

East Arica Skills for Transformation and Regional Integration (EASTRIP) Project

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LG #82	Lo # 1- Operate measuring tools and equipment

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Identifying OHS requirements • Procuring tools and equipment • Identifying and using relevant sources of information • Identifying and preparing materials, tools and equipment • Training and acquainting technicians • Storing tools and equipment This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Identify OHS requirements • Procure tools and equipment • Identify and use relevant sources of information • Identify and prepare materials, tools and equipment • Train and acquaint technicians • Store tools and equipment
Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Identifying OHS requirements

1.1. Introduction to forest inventory

Protection and rational utilization of natural resources become more and more important in order to meet the increasing demand for raw wood material and agricultural crops. Among the resources, forests are important not only as a source of wood but as the means of protecting the hills thereby regulating stream flow, and reducing the rate of soil erosion, among many others. Sound forest management depends on the quantity and quality of information available on the forest.

Forest inventory: is the systematic collection of data and forest information for assessment or analysis. Inventory is the activity of data collection that helps generating the required information base on the forest resource within an area of interest. Forest inventory is a tool that provides the information about size and shape of the area as well as qualitative and/or quantitative information of the growing stock. Is the tabulated, reliable and satisfactory tree information, related to the required units of assessment in hierarchical order. It is an attempt to describe quantity, quality, and diameter distribution of forest trees and many characteristics of land upon which trees are growing. In the very narrowest sense, a forest inventory can be defined as, “the counting of one or more species, generally above a specified size limit; and their classification by size, condition or any other prescribed quality”. Usually, forest inventory is used to obtain estimates on the quantity and quality of forest trees. This must also include a description of the characteristics of the land upon which the trees are growing e.g. topography drainage patterns, soil types, etc.   A complete forest inventory from a timber point of view could include estimates on the quantity and quality of timber volume and other parameters of the standing trees; description of the forested land, ownership patterns, accessibility, transportation facilities and rates of growth and losses of standing trees.

Forest inventory information is obtained either from measurements of individual trees or stand. The information may be obtained from measurements taken from ground or on remote sensed imagery (aerial photographs, satellite imagery, etc.). Forest inventory information obtained from the entire forest is called complete or 100% inventory.

The objective of the inventory is to:

- provide information on state level for the purpose of medium-term forest management planning,
- serve as a control mechanism for sustainable forest management,
- provide further information for the development of growth and yield functions,

Types of inventory

The basic information required for timber evaluation varies depending on the emphasis put on different aspects. Based on the type of data to be collected, six types of forest inventory are given hereunder as an example

- National Forest inventory
- Land use recreational and watershed studies
- Reconnaissance survey
- Logging plan survey
- Working plant survey
- Industrial Feasibility study

Levels of forest inventories

There are two levels of forest inventories

1. Planning inventories

- For the whole or substantial part of a forest mgt unit

Example: An inventory of wood or non-wood resource

2. Operational inventories

- At the level of compartments Example: Pre-harvest inventories

Occupational health and safety (OHS): Occupational health and safety (OHS) relates to health, safety, and welfare issues in the workplace. OHS includes the laws, standards, and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders. Improving a company's occupational health and safety standards ensures good business, a better brand image, and higher employee morale. Occupational health and safety standards are in place to mandate the removal, reduction, or replacement of job site hazards. OHS programs should also include material that helps minimize the effects of the hazards.

Safety is the safe of being free from danger. As always we should be aware of safety requirements and attempt to observe safety rules in order to eliminate serious injury to ourselves or others. Personnel working with machines must be aware of the risks involved and follow safe work practices. Basic cause of accidents is faulty attitude toward safety, Failure to recognize danger and Emotion. Machine operator should follow safety precautions required in terms of personal safety, work shop safety, and tools and equipment safety to avoid injuries. Employers and company management are obliged to provide a safe working environment for all of their employees. In addition, specific items may be needed to address workplace specific activities. Examples of such items are:

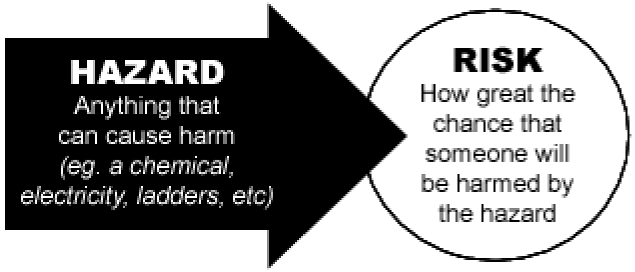
- Workplace Hazardous Materials Information System.
- Lockout procedures.
- Hot-work permits.
- Working at heights.
- Material handling rules.
- Plant maintenance.
- Fire safeguards.
- Vehicle safety rules.
- Working alone guidelines.
- Personal protective equipment requirements.
- Engineering standards.
- Preventive maintenance.

1.2. Hazard Identification and Risk Assessment

There should be an individual involved with the program who is qualified to assess dangers associated with the use of animals and to select safeguards appropriate to the risks. Health and safety specialists with knowledge in the appropriate disciplines should be involved in the assessment of risks associated with hazardous activities and in the development of procedures to manage those risks. What is the difference between a 'hazard' and a 'risk'?

A **hazard** is something that can cause harm, e.g. electricity, chemicals, working up a ladder, noise, a keyboard, a bully at work, stress, etc.

A **risk** is the chance, high or low, that any hazard will actually cause somebody harm. For example, working alone away from your office can be a hazard. The risk of personal danger may be high. Electric cabling is a hazard. If it has snagged on a sharp object, the exposed wiring places it in a 'high-risk' category.



Occupational health and safety is concerned with addressing many types of workplace hazards, such as:

Chemical hazards: Chainsaws and brush cutters are sources of exhaust emissions, which include the suspected carcinogens benzene and formaldehyde. Aerosols from the oils used in chainsaws and brush cutters can cause irritation to skin, eyes and the respiratory system, which can be reduced by the use of goggles and gloves and by regular washing. Exposure to herbicides and pesticides in forestry can lead to a variety of health problems. Personal protective equipment, such as overalls, boots, gloves, and, for toxic agents, respiratory devices, should be used. Smoking and eating should be avoided when working with chemicals.

Biological hazards: Biological hazards include allergic reactions to plants, pollen, wood products and insect bites, as well as snakebite and diseases that can be contracted from, for example, mosquitos and ticks. The risks posed by many biological hazards can be reduced through adequate training, effective management (e.g. by reducing mosquito breeding grounds in the vicinity of camps and the use of mosquito nets), and an adequate level of personal hygiene.

Physical hazard: is an agent, factor or circumstance that can cause harm with contact. They can be classified as type of occupational hazard or environmental hazard. Physical hazards include ergonomic hazards, radiation, heat and cold stress, vibration hazards, and noise hazards.

Risk assessment is the process where you:

- Identify hazards and risk factors that have the potential to cause harm (hazard identification).
- Analyze and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).
- Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control).

Requirement of (OHS): Occupational health and safety requirements through safe work practices at any on or off-site construction workplace. It requires the performance of work in a safe manner through awareness of risks and work requirements, and the planning and performance of safe work practices with concern for personal safety and the safety of others. The Occupational Health and Safety in Forestry is aimed at all forest workers, particularly forest managers and supervisors. It provides basic and more detailed information on the dangers to human health and safety posed by some forest activities and identifies measures that can be taken to mitigate these. OHS materials required during forestry were:

- Personal Protective Equipment-PPE should be provided to include dedicated clothing (where appropriate), bonnets, masks, gloves, and shoe covers. Protective clothing should not be worn outside the immediate animal area (e.g., cafeteria, rest room).

- Use kit bags and helmets
- Be far away from home range of wild animals
- Take care of landslide at hilly areas.

Self-check 1	Written test

Name…………………………………………… ID………………………… Date…….
Directions: Answer all the questions listed below.

Test I: Choose the best answer (5 point)

1. _________Is the safe of being free from danger?

A. OHS B. Safety C. A & B

2. From the given choose which one is personal protective equipment.

A.Safety goggles B. Safety shoes C. Clothes D. gloves E. ear protection F. all

Test II: Short Answer Questions

1. List materials required during occupational health and safety (OHS) (5 point)

____

2. Describe occupational health safety (OHS) and safety? (3 point)

____

3. Write between Hazards and risk? (3points)

____

4. What is forest inventory?

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 2- Procuring tools and equipment

In planning for field work, decisions should be made on the kind of instruments to be used for each of the required measurements. It is best to settle upon a standard set of instruments and have all field measurements made the standard instruments. The use of several kinds of instruments to make the same type of measurements should be avoided. To avoid systematic errors, the chosen instruments should be periodically checked to see that they are in adjustment. It is best to settle upon a standard set of instruments and have all field measurements made the standard instruments. We're now firmly in the era of cloud computing and automation tools. Companies everywhere understand that they can get more done, more quickly and cheaper, with a little help from modern technology.

And yet this doesn't seem to have caught on among procurement managers: Fewer than 10% of companies have deployed procurement solutions based on key technologies such as the Internet of things, Big Data, and block chain technology. This simply shouldn't be the case any longer. Procurement tools are too useful and much too readily available to ignore. The chief goal for your new tool should be to make life easier. The procurement process involves a lot of moving parts: procurement orders, supplier details, budget management, and the actual purchases themselves. You should endeavor to manage as many as these steps as possible from one place - your procurement platform. Of course, this is usually easier said than done. And the more your business relies on procurement, the more you’re going to need help.

Where to buy: The tools below are available from local logging or civil engineering supply stores as well as online forestry supply retailers.

Self-check 2	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Short Answer Questions.

Test I: Description

1. Define procuring? **(**5 point)

____

____

2. How can buy required procuring tools for forest inventory? (5point)

____

____

3. Write the process of procurement involved? (5 point)

____

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 15 points Unsatisfactory - below 15 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 3- Identifying and using relevant source of information

Forestry Source of information

Forest inventory information is obtained either from measurements of individual trees or stand. Basic data and information is required if a renewable natural resource such as forest is to be managed in a reasonable and sustainable manner. This information is obtained from forest inventories. The information may be obtained from measurements taken from ground or on remote sensed imagery (aerial photographs, satellite imagery, etc.). Forest inventory information obtained from the entire forest is called complete or 100% inventory. In contrast, when the measurements are taken from a representative sample of the forest it is a sampling inventory. The information requirements regarding the forest resource are as manifold as are the interests in forest as an ecosystem. Interested parties are above all decision makers and researchers in forestry and related fields. A forest inventory will help you quantify what you have and identify needs and opportunities for forest health, wildlife habitat, timber production, aesthetics, and carbon storage. It also records the conditions of the forest, which might include (for example) geology, site conditions, tree health and other forest factors. Forest owners, forest managers and forest politicians are those who demand information about the forest resource, but also regional planners, the wood industry, conservation biologists, tourism people, etc. When the group of actually and potentially interested parties can clearly be identified, it is straight forward to plan an inventory in a flexible manner to serve many different potentially interested experts without yet knowing all of them exactly. The basic information required for timber evaluation varies depending on the emphasis put on different aspects.

The objective is to:

- Provide information on state level for the purpose of medium-term forest management planning.
- Serve as a control mechanism for sustainable forest management,
- Provide further information for the development of growth and yield functions.

Self-check 3	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 point)

1. What are the objectives of forestry source of information?

A. provide information on state level for the purpose of medium-term forest management planning

B. Serve as a control mechanism for sustainable forest management

C. Provide further information for the development of growth and yield functions

D. All

Test II: Short Answer Questions

2. Where you obtain forestry inventory information? (5 point)

____

____

3. Write the objective of forest inventory?

____

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 4- Identifying and preparing material tools and equipment

4.1. Materials, tools and equipment's of forest inventory

Measuring tape: - Preferably 100 feet long or longer. Is used measure distance between two point e.g. during measuring height using clinometers.

Figure 1: Measuring tape

Ranging pole –used to correct slope reading using water level or clinometers.

Calliper - Diameter is usually measured with calliper; more recently optical instruments to measure diameter at points out of reach of normal calliper have been developed. Calliper normally record diameters (in cm or mm) but may also be calibrated so that cross sectional area (m^2) can be recorded directly.

Colored ribbon- For marking trees and plot boundaries. Also referred to as flagging.

Figure 2: colored ribbon

Hand compass:- For establishing your plot grid in the woods.

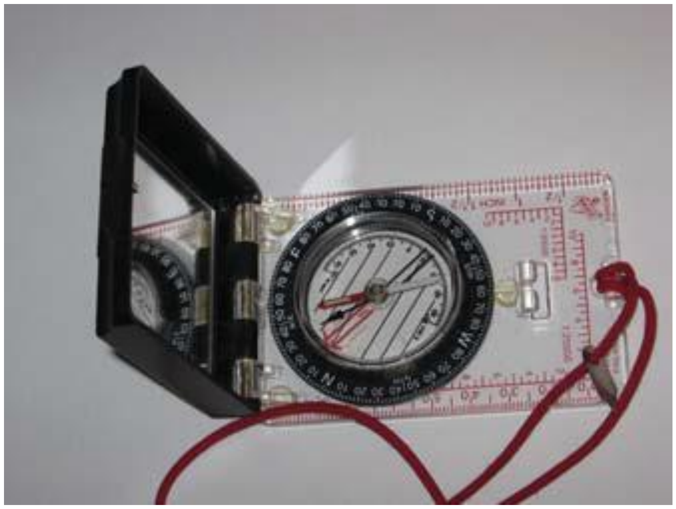


Figure 3: Hand compass

Woodland stick:- Also called a Biltmore stick or a cruiser stick. This inexpensive tool resembles a yardstick and will allow you to measure tree heights and diameters quickly and easily. You can also use a diameter tape and clinometer instead of a woodland stick to perform these functions with greater accuracy. Woodland sticks may be available for purchase for a nominal fee from your local Extension Forester.

Figure 4:woodland stick

Acreage measuring grid:- A grid or series of evenly spaced dots that are often printed on clear plastic and used to measure area on a map.

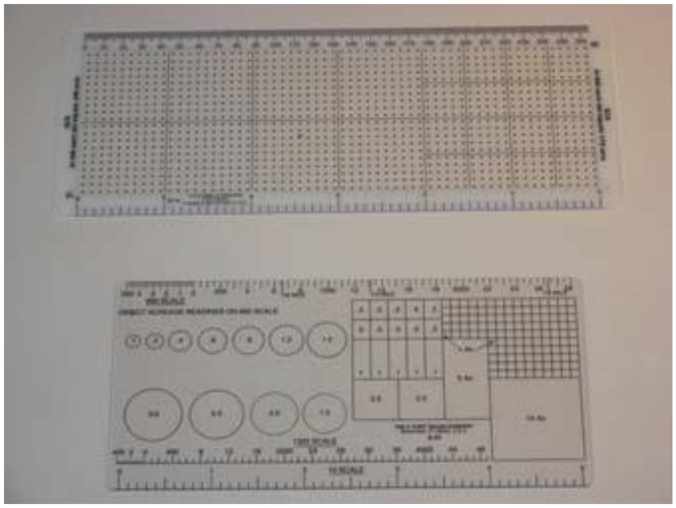


Figure 5: Acreage measuring grid

Calculator:- This will simplify a variety of calculations that you may come across. A basic hand calculator is all that is needed.

Hypsometer – all instrument's used for measuring tree height are called hypsometers. Most hypsometers are based on trigonometric principles – even the lazer hypsometers that are gaining lots of use today.

- Professional, ultrasonic hypsometer for quick and easy tree height measurement
- Bluetooth connectivity for data transfer
- Red dot hair cross sight for more precise measurements
- Proven accuracy and reliability
- Can be used in difficult terrain with thick vegetation

Figure 6: Hypsometer

Remarks about Hypsometer;-

- The base of the image and the top must be visible (clearly).
- Always keep both eyes open.
- Try to be at same elevation as the base of tree.
- Leaning trees should be measured at about right angles to the lean.
- Usually best to take two readings to verify it. Always use the second.
- Keep eyes and hypsometer at same level for both shots.

Clinometer:- This instrument is used to determine tree heights by measuring vertical angles between your eye and the top and bottom of the tree. A clinometer is more accurate than a woodland stick but also more expensive. Different clinometers measure slope in different units (e.g., percent or degrees). The steps described in this manual correspond with a clinometer that measures percent slope.

Figure 7: Clinomater

Sunto clinometer: - measure inclination angle in degree or percent. It follows the same principles as above, but in this case we measure/read the inclination angle and then calculate height after knowing the horizontal distance between the observer and the tree.

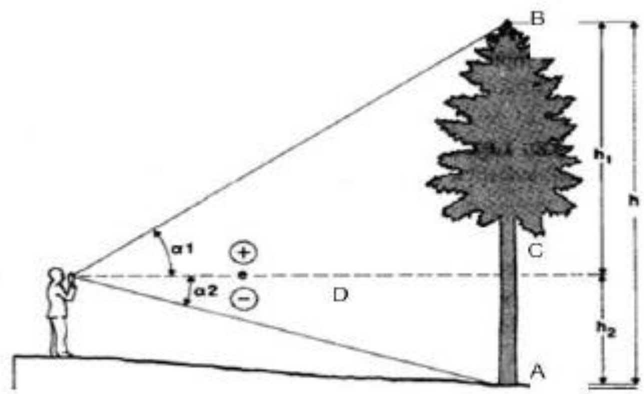


Figure 8: Tree height measurement using sunto clinometer

If measured in percent:

Ht = (TR − BR) x D*100 or if measured in degree:

H = D (tan α1 +/- tan α2)

One technique for specific type of instrument, the Suunto Clinometer, follows:

1. Measure the horizontal distance from the base of a vertical tree (or the position directly beneath the tree tip of a leaning tree) to a location where the required point on the tree (e.g. tree tip) can be seen.

2. Sight at the required point on the tree

Using one eye: Close one eye and simultaneously look through the Suunto at the scale and 'beside' the Suunto at the tree.Judge where the horizontal line on the Suunto scales would cross the tree.

Both eyes: With one eye looking at the Suunto scale and the other looking at the tree, allow the images to appear to be superimposed on each other and read where the horizontal line on the Suunto scale crosses the tree. Note: If you suffer from astigmatism (a common situation where the eyes are not exactly parallel), use the one eye approach.

3. Read from the percent scale and multiply this percentage by the horizontal distance measured in step one.

4. Site to the base of the tree and repeat steps 2 - 3.

5. Combine the heights from steps 3 and 4 to determine total tree height: Add the 2 heights together if you looked up to the required point in step 2 and down to the base of

the tree in step 2 Subtract the height to the base of the tree from the height to the required point if you are on sloping ground and had to look up to both the required point and the base of the tree.

6. Check all readings and calculations.

Diameter tape;- This special measuring tape has been calibrated such that when you wrap it around the circumference of the tree, you are actually reading the measurement in diameter units (i.e, the measurements have been divided by the constant Pi, or 3.14). A diameter tape is more accurate than a woodland stick but also more expensive.

Figure 9: Diameter tape

Peg ;- it is used to mark different point on the ground

Increment borer:-This tool is used to extract a core sample from a tree, which will allow you to count annual rings and determine tree age in a non-destructive manner.

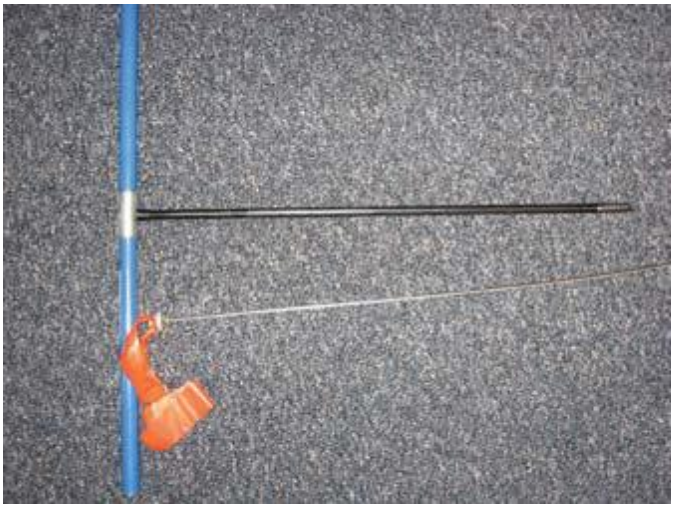


Figure 10:Increment borer

Rope;-Pre-measured lengths of rope can simplify the establishment of fixed plots.

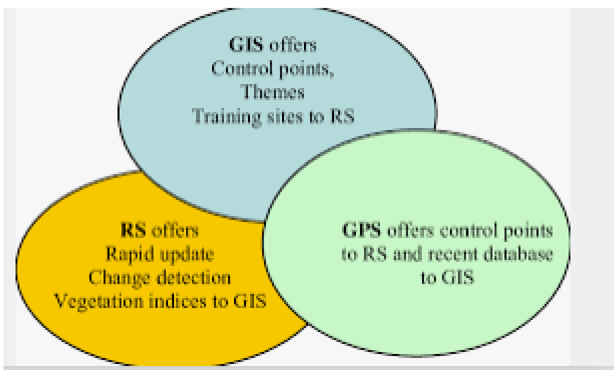
Staff or stakes;- You can use these to mark plot centers.

Figure 10: staff or stake

Global Positioning System (GPS):- GPS uses satellites that orbit Earth to send information to GPS receivers that are on the ground.

Figure 12:GPS

Geographical Information System (GIS);- GIS is a software program that helps people use the information that is collected from the GPS satellites.



Topographic map:- The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface. Elevation contours are imaginary lines connecting points having the same elevation on the surface of the land above or below a reference surface, which is usually mean sea level. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes. USGS topographic maps also show many other kinds of geographic features including roads, railroads, rivers, streams, lakes, boundaries, place or feature names, mountains, and much more. Older maps (published before 2006) show additional features such as trails, buildings, towns, mountain elevations, and survey control points. Those will be added to more current maps over time. The phrase "USGS topographic map" can refer to maps with a wide range of scales, but the scale used for all modern USGS topographic maps is 1:24,000. That covers a quadrangle that measures 7.5 minutes of longitude and latitude on all sides, so these are also referred to as 7.5-minute maps, quadrangle maps, or “quad” maps (modern topographic maps for Alaska have a scale of 1:25,000 and cover a variable distance of longitude). Each topographic map has a unique name.

Figure 13: Topographic map

Miscellaneous supplies;- Pencils, pens in several colors, ruler.

Self-check 4	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 point)

1. _____________is Instrument used to determine tree heights by measuring vertical angles between your eye and the top and bottom of the tree A. Caliper B. clinometer C. Diameter tape D. Ranging pole D. all

2. Which one of the following are tools and equipment's used for forest inventory (4)? A. Ranging pole B. Pencil C. Pen D. all E. None

Test II: Short Answer Questions

3. List tools and equipment's of forest inventory? (5 point)

____

4. Describe caliper and clinometer r(5)?

____

5. What is global position system(1)?

____

6. What is the difference between Global Position System (GPS) and Geographic Information System (GIS)(1)?

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Training and acquainting is prepared to give insight into forest inventory (forest resource assessment) from planning and implementation point of view. Hence it shall help everyone to understand the principles of forest inventories. It is believed that at the end of the training participants should be able to plan a forest inventory in a methodologically sound manner and also according to statistical principles. They should know also how to write a good inventory reports; how to critically read inventory reports of others.

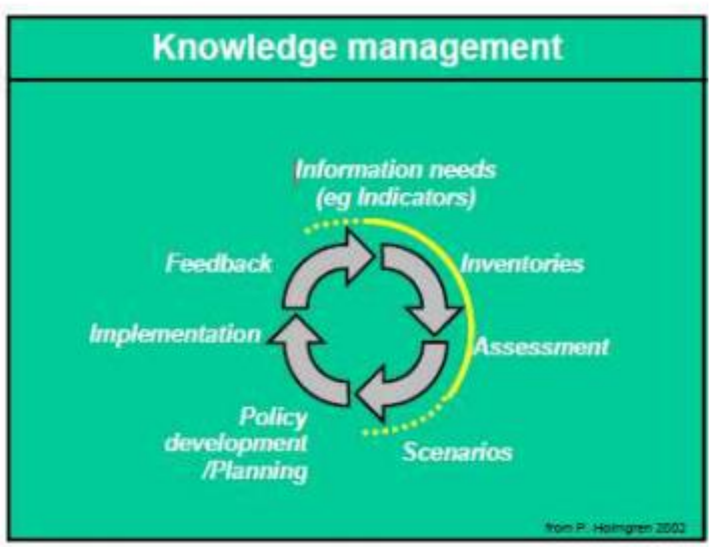


Figure 14: knowledge management in forestry.

Self-check 5	**Written test**

Name………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is the importance of training and acquainting forest inventory? (10 point)

____

____

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 6- Storing tools and equipment

To sustain your gardening tools and equipment's and keep them in good condition for years to come, you should take the proper steps to make sure the metal tools maintain their durability and do not accumulate rust. Where and how you store your tools can make all the difference. Whether you need a place to store your tools for the want to clear out space in your garage, a self-storage facility can be a helpful solution. The season can significantly age and, perhaps, damage your tools if they are not properly cared for. Electric tools of all sorts, especially, should be attended to regularly. Smart storage can save you the burden of purchasing a new machine since time weather can quickly age tools that are not properly taken care of. Prior to storing tools, you should be aware of a few things when purchasing and caring for garden tools. Remember to wear safety goggles and gloves when working with sharp tools. Regardless of the location in which you store your tools, you may want to consider storing them in a sand/oil mixture, which can be used for years. This can be done by using a five-gallon bucket filled with sand and a half gallon of mineral (or motor) oil. Shovels, hoes, pitchforks, etc., can all be stored in this mixture. These buckets may be used year after year as long as they are kept away from rain. Simply add oil each year as needed. In addition to buckets containing a sand/oil mixture, other methods can be used to preserve your tools.

Some more storing tools and equipment

- Put clean tools in an empty plastic container, such as a trashcan.
- Hardware stores offer strong adhesives to hold tools that will not leave residue when you decide to remove the bonding agents.
- Keep your tools off of the ground, away from dirt and bugs, and out from underfoot.
- Gloves should always be kept in a closed container so your hand will not get eaten by visitors when you put them on.
- Hoses should be drained before storage. .
- Put chemicals and fertilizers in a locked case away from children and pets.

- Inspect your tools each season and take the proper steps, some of which are mentioned above, to keep them in good condition.
- Special care should be taken to store larger machines such as lawn mowers and big power tools in accordance with manufacturer directions.

Self-check 6	Written test

Name………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Where you store your tools and equipment's (5 point)

____

____

2. What is the importance of storing tools and equipment's (5)?

____

____

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

LG #83	LO# 2- Survey and delineate forest area

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Conducting preliminary survey • Mapping forest area • Classifying mapped area into blocks and compartments • .Conducting formal survey This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Conduct preliminary survey • Map forest area • Classify mapped area into blocks and compartments • Conduct formal survey
Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
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Information Sheet 1- Conducting preliminary survey

Preliminary survey: Preliminary survey is the foundation that the rest of the project is built from, Accuracy matters. Minor measurement errors pushed out over a long distance may lead to regulatory and trespass issues. Preliminary survey includes gathering geospatial data about the proposed route and the project requirements for data outputs. This includes the establishment on the ground of the proposed route and location of terrain and physical features (both man made and environmental).The preliminary survey is more than just survey; it understands the appropriate horizontal and vertical datum, the standard data libraries and building the foundation for future work on the project.

Preliminary survey is carried out:

- To identify the topographic condition, vegetation, local boundaries of the forest land
- To know the location and extent of forest area.
- To know whether condition of the area and to decide time of demarcation.
- For planning, budget, material, manpower and time.

Survey: Survey Refers to a technique and science of accurately determining the terrestrial or three-dimensional space position of points and the distances and angles between them.

Figure 15: preliminary survey

Field survey: In a field survey, forest inventory teams collect data on the ground. For a relatively small forest area, such as a logging coupe, it is possible (and often required) to conduct 100 percent inventories (also called full-cover or wall-to-wall inventories) in which all trees in the stand (usually above a specified minimum diameter) are measured. For larger-area inventories, such as at the landscape, provincial or national level, a 100 percent inventory is likely to be impractical and prohibitively expensive. A sampling strategy is therefore required whereby measurements are made in permanent and/or temporary sampling units, and those measurements are used subsequently to estimate values for the entire forest area. The sample area is the total area of all sampling units in which measurements are made.

Remote Sensing survey: A remote sensing survey (e.g. using data from air-born or satellite-born sensors) can be used for either full-cover or sampling approaches. In a sample-based approach, observations are made in sampling units (sample area), while in a full-cover approach the entire area of interest (e.g. a landscape, province or nation) is surveyed. Remote sensing observations can be used in particular to determine the extent of different land-cover (or land-use) classes. This can greatly assist in extrapolating volume and biomass densities generated by field-based measurements over large areas and over time in repeated assessments to estimate changes in total volume and biomass stocks, and to stratify the analysis of field data.

Demarcating and maintenance of external and internal forest boundaries

External boundaries

- External boundaries should be clear of busy vegetation for a width of 2 meters in order that neighbors may easily recognize a boundary and to allow it to be patrolled.
- Boundaries should be defined and marked using beams which may be durable wooden poles, stones or concrete pillars painted using two contrasting colors such as broad red and white bands. The poles should be between 1.5 to2m tall.
- Continuous line of live trees or shrubs can also be used as boundary. These trees or shrubs be fast growing and distinctively different from surrounding forest vegetation.

Internal boundaries

- The boundaries of biological, wild life, watershed, forest community or other reserves should be ac clearly defined as are external boundaries.
- Roads, cut lines, pillars, painted standing trees and poles should be used to define internal boundaries. Internal compartment boundaries would be surveyed and mapped.

Methods of Forest Demarcation

- If the area is small homogenous and the terrain is gentle to flat forest demarcation is done by chain survey;
- If the area is big, heterogeneous and the terrain is undulating, forest demarcation is done by the help of GPS, Arial photo and topo map.

Field Procedures for Forest Demarcation

Field Work

- The starting point and other station should be on a permanent and easily identifiable objectives
- Natural features should be chosen to indicate the position of the boundary;
- Walk around the boundary from one side of the kebele to other discussing, where the boundary should be.
- Select a place and construct a pillar on the ground of the 1st station;
- Plot station No. 2 by comparing the map of the station and actual ground;
- Plot all consecutive station in the same manner as prescribed above;
- Record all basic information required under the forest demarcation;
- Avoid very short station;
- The GPS readings will be taken at the time of agreeing the boundary position with the community and then the boundary is drawn later on the map;
- The map is later shown to the community representatives,
- PAs socio-economic will be surveyed and recorded along forest boundary demarcation

Self-check 1	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose Answer Questions

1. Preliminary survey is carried out for?

A. To identify the topographic condition, vegetation, local boundaries of the forest land

B. To know the location and extent of forest area.

C. To know whether condition of the area and to decide time of demarcation.

D. For planning, budget, material, manpower and time.

E. All

Test II: Short Answer Questions

1. What is preliminary survey? (5 point)

____

____

2. What is survey? (3 point)

____

____

3. Write the method of forest demarcation? (2points)

____

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 8 points** **Unsatisfactory - below 8 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 2- Mapping forest area

The forest area is heterogeneous in terms of various characteristics that are relevant for management planning and implementation. Therefore, classifying the forest management unit into homogeneous units with regard to these characteristics is necessary. Classifying land in to strata also allow us to generalize results from observed or studied areas to similar but unstudied areas. Map is a graphic expression of land areas. Maps fulfil a wide range of functions in forest management depending on the type, the amount of detail of features represented and their scale. Map interpretation is the art of extracting from a map all of the information it contains for management purposes so that a picture can be drawn in the planner's or manager's mind of the shapes and slopes of the ground, the pattern of streams and rivers, the vegetation cover, and the location and nature of man-made features.

Mapping

- Map is a graphic expression of land areas.
- It is possible to describe various sizes of land areas in a convenient paper image.

E.g. A large area of one region or one stands in the plantation

- The scale of the map expresses the relationship between the horizontal distance of two points in field and the distance of the same points on the map.
- Common scales of maps used in forestry are 1:50,000, 1:20,000 and 1:10,000.
- The distance of two objects in the field can be calculated Scale 1:20,000

Map reading is best learnt by experience, in a forest or outdoors by comparing the detail of map symbols with the actual area of country they represent. Once an appreciation of a map and its symbols has been built up by comparison with a known landscape, this knowledge can be used to gain an understanding of an unknown area from a map. For example, by comparing the spacing of contour lines in a known locality with those in an unknown area, the relative steepness and alignment of slopes may be determined.

Primary map types and scales for planned forest management

Detailed mapping requirements for planned forest management will depend upon the goal and objectives for each forest management unit. As a general guide, the primary map types to be purchased, or drawn if they do not exist, for planning sustainable management for wood production should include the following:

Types of map

- Topographic map- showing primary geographic features, including contours; 1:50,000 or 1:25,000.
- Land use planning map- showing the forest management unit together with settlement, agriculture and other land uses; 1:50,000 or 1:25,000.
- Forest zoning map- showing zones for watershed protection, wood production, specific non-wood products, biological diversity conservation, recreation (or amenity) and any other primary forest zones; 1: 50,000 or 1:25,000. This map should be drawn as a part of the planning process, especially to determine the net productive area for wood production.
- Strategic planning forest harvesting map- 1:50,000 or 1:10,000.
- Tactical planning forest harvesting map- 1:10,000, 1:5,000 or 1:2,000.
- Forest inventory map (for continuous forest inventory), showing sampling strata/blocks; 1:50,000 or 1:25,000.
- Cadastral map, showing legal ownership of land; 1:50,000.
- Geology map; 1:100,000, or less.
- Soils map; 1:50,000, or less.
- Contour map; 1:5,000 or 1:10,000. It is possible to describe various sizes of land areas in a convenient paper image. E.g. A large area of one region or one stands in the plantation
- The scale of the map expresses the relationship between the horizontal distance of two points in field and the distance of the same points on the map.
- Common scales of maps used in forestry are 1:50,000, 1:20,000 and 1:10,000.
- The distance of two objects in the field can be calculated Scale 1:20,000

Land classification is done by considering some relevant features of the forest area related to physical characteristics, vegetation characteristics, and development characteristics.

1.Physical characteristics includes the set of attributes used to characterize the permanent, physical nature of forest land, including topography, soils, bedrock, climate, hydrology, etc. Example: Slope: Gentle (G), moderate (M), steep (S)

2.Vegetation characteristics are the set of attributes used to characterize tree and other vegetation currently growing on forestland, including height, age, basal area, volume, diameter, etc. example:Natural Forest vegetation: closed (NC), disturbed (ND), open (NO), Plantation forest Vegetation: Cupressus (PC), Eucalyptus (PE), mixed (PM

3. Development characteristics include the set of attributes used to characterize the organization, development and accessibility of forest land for human use, including ownership, roads, building etc. The combination of these set of attributes can give rise to huge number of unique classes. As a result it is important to decide on the number of classes to be made by selecting only those attributes that have great influence on the outcome of prescriptions: example: accessibility to roads: close (<1km) (RC), far (> 1km) (RF), Settlements: close (<5km) (SC), far (>5km) (SF)

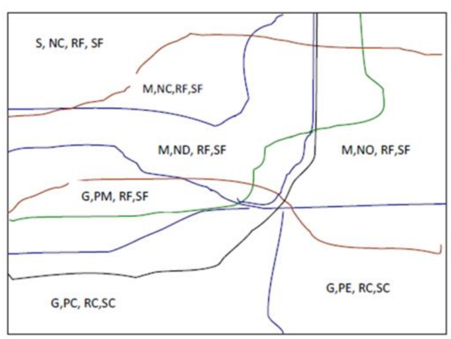


Figure 16: mapped forest

Materials needed for mapping forest:-

Aerial photographs: are helpful for identification of geographic features and for orientation in the field. They are a practical tool for mapping rivers, ridges, coastlines, swamps and other geographic features. Where vegetation patterns are distinct, aerial photographs are valuable for recognizing and interpreting forest types for zoning and stratification at an early stage in inventory planning. Aerial photographs are also useful for locating permanent sample plot positions, for reading, silviculture, forest protection, community settlement planning and for ecological research. A trained interpreter can thus utilise aerial photographs to analyse the land-use changes. Eye view of large areas, enabling us to see features of the earth surface in their spatial context. Surface features at an instance of exposure. It can, therefore, be used as a historical record.

Figure 17: Aerial photography

Global Positioning System (GPS): is a system of satellites orbiting the Earth which transmits precise time and geographic position information. Positions are updated continuously thus enabling speed and bearings to be computed with considerable accuracy, usually less than 30 meters in both latitude and longitude. Position information can be obtained quickly using a range of small, hand-held GPS receivers that can be operated anywhere on Earth, day or night, under any weather conditions. A limitation however is that GPS technology cannot be easily used beneath a forest canopy; "open- to-the-sky" conditions are necessary for the reception of satellite signals.

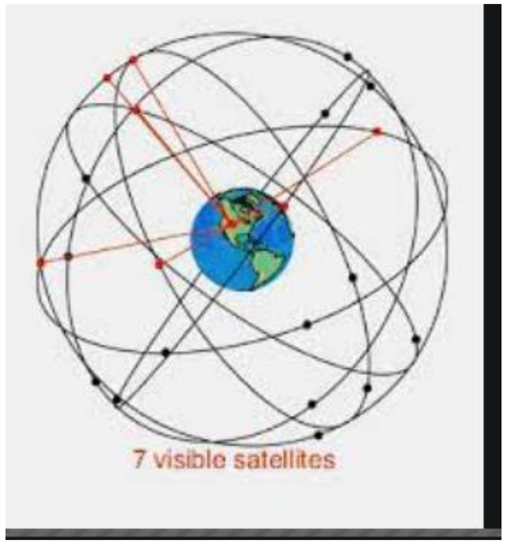


Figure 18: GPS Imaginary

Geographic Information System (GIS): is applied to the computerized storage, processing and retrieval of geographically referenced spatial data, such as various types of maps, and the corresponding statistical and other attribute information. The capability of combining different maps, known as "overlaying", is one of the most important GIS functions. Three-dimensional images can be generated from contours. Training of operational and planning foresters in the use of GIS is necessary in order to gain maximum value from this powerful planning tool.

Planimeter: Is a measuring instrument used to determine the area of an arbitrary two-dimensional shape. A planimeter is an instrument for accurate measurement of irregularly shaped map areas. Older types have a fixed or adjustable pole, a tracer arm and a recording meter showing readings read on a vernier scale at the beginning and end of each measurement. Recently developed planimeters are electronic and show area data automatically for each measurement. Some digitise the measured area which can be transferred to a computer. Map readings are scaled up according to the map scale, as follows:

$MA = PU * Ms^2 * 0.00001$ where,

MA= mapped area in square metres Pu = planimeter reading (number of units), Ms = map scale.

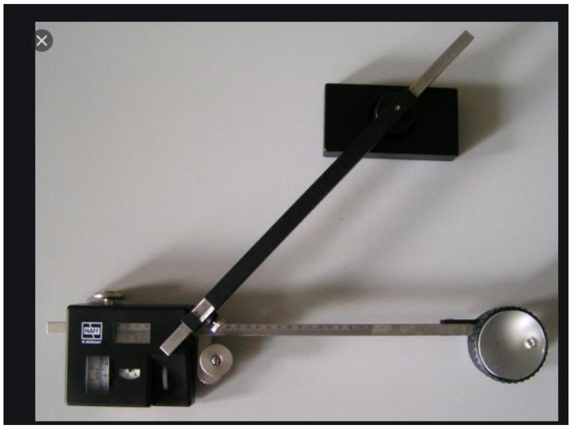


Figure 19: planimater equipment

Dot Grid Area Measurement: A dot-grid is a simple and easily used technique for measuring map areas quickly, either in an office or a forest. The transparent dot-grid sheet is placed on an irregularly shaped part of a map, such as a forest type, and the numbers of dots which occur within the area to be measured are counted. The map scale must be known. There are two procedures for converting an average dot count to area, as follows: Where a square grid has been printed on a map Derive the area of each grid-square from the scale of the map. The area, in hectares, of a dot-grid count on a map is calculated as follows: MA= $(D/d_c)*$ G where, MA = mapped area in hectares D = the average number of dots counted on the map, d_c = number of dots per cm^2 on the dot grid G = grid-square area (hectares).

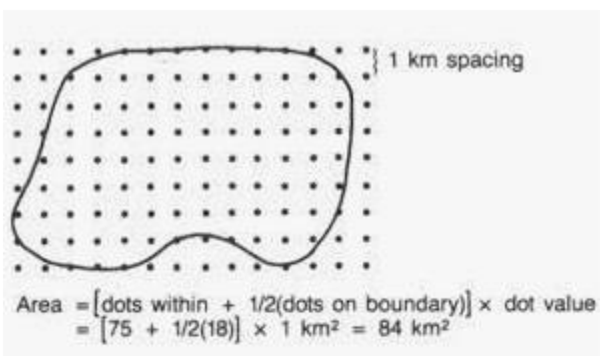


Figure 20: Dot grid instruction

Others not limited:

- ✓ Computer with Internet access and a printer (if you do not own a computer, try the ones available at your local library)
- ✓ Pencils and/or pens in several different colors
- ✓ Ruler
- ✓ Calculator (recommended)
- ✓ Acreage measuring grid (recommended)
- ✓ Graph or grid paper (optional)

Self-check 2	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 point)

1. Which one of the following is the material needed for the mapping of the forest?

A.GPS B. GIS C. Planimater D. Dot grid measurement

2. Land classification is done by considering some of the relevant features of the forest area related to_________?

A. Physical characteristics B. Vegetation C. Characteristics, D. Development characteristics. E. All

Test II: Short Answer Questions

3. What is mapping (2)?

____

____

4. What is the difference between Arieal photo graph and top map? (5 point)

____

____

5. Write the example of physical and vegetation characteristic (3)?

____

____

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating - 5 points Unsatisfactory - below 5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 3- Mapped area is classified into blocks and compartments

3.1. Management unit/Block

Management unit the largest unit of forest stands. An area of forest for which an approved forest management plan is in operation. It is a geographically contiguous parcel of land containing one or more stand types and usually defined by watershed, ownership, or administrative boundaries for purposes of locating and implementing prescriptions. It also means a contiguous area of forest in any stage of succession and not currently developed for non-forest use. It is a permanent portion of the forest used mainly for administrative purposes. Blocks organize the forestland into logical spatial units for purposes of implementing the plan and to deal with concerns or impacts that are inherently spatial in character. They are more autonomous unit with a separate technical unit. Usually very large forest will be divided into blocks (not more than 500 ha) to facilitate management activities.

Where ever it is practicable to do so, natural geographic features should be selected to define the boundaries of a forest management unit. These include rivers, streams and ridges. Permanent and clearly defined roads, railways and tracks may also be used. On flat country not having clearly recognisable natural features boundaries can be defined using straight lines that have a N-S, E-W orientation to enable them to be shown as true or magnetic coordinates on maps. The number of corners on straight line boundaries should be kept to a minimum.

3.1.1. Demarcation and maintenance of external forest boundaries

External boundaries should be kept clear of bushy vegetation for a width of two metres in order that neighbours may easily recognise a boundary and to allow it to be patrolled. Trees located on a boundary should not be removed. Cost sharing between forest neighbours in the maintenance of common boundaries is desirable. This approach confirms agreement on the line of a common boundary and is cost-efficient.

3.1.2. Demarcation and maintenance of internal forest boundaries

The boundaries of biological, wildlife, watershed, forest community or other reserves should be as clearly defined as are external boundaries. Roads, cut lines, pillars, painted standing trees and poles should be used to define internal boundaries. Internal compartment boundaries should be surveyed and mapped.

- Notices should be erected showing boundaries of watershed and other reserves where wood harvesting is not allowed.

3.2. Compartment: Compartment refers to the smallest unit of forest stand. A compartment is a permanent, geographically recognisable unit of forest land forming the basis for planning, prescription, implementation, monitoring and recording of forest operations. To the extent that it is practicable, areas of forest that are to be managed for different purposes, or have clearly different functions or values, should be placed in separately defined compartments. Compartments are permanently defined for the purpose of locating, describing, and record keeping and as a basis for the planning and management of all forest activities. A Forest compartment is a permanent, geographically recognizable unit of forest land forming the basis for planning, prescription, implementation, monitoring and recording of forest operations. To the extent that it is practicable, areas of forest that are to be managed for different purposes, or have clearly different functions or values, should be placed in separately defined compartments.

Practical guidelines for defining forest compartments are:

- Boundaries should be geographically recognisable, such as rivers, streams, ridges, permanent roads and gullies. Compartments should as far as possible comprise uniform forest types and be physically recognisable on the ground.
- Numbering should be sequential, usually commencing at a forest headquarters. Compartment numbers should not be changed.

- Compartments should not be so large that sub-division into numerous sub-compartments is required in order to achieve effective implementation of forest operations. Sub-compartmentation should be minimised.
- Flexibility is required in determining compartment size; a practical size range for many management situations is between **100 ha and 500 ha**, depending upon the physical features of the forest and land.

There is not any constant size definition for compartments. Their size depends on the size of the forest, the intensity of management and the holding, whether it is a scattered or contiguous forest. However, it is preferable that compartments should not be less than 10 hectare in size. Being a permanent unit the compartment should be clearly demarcated on the ground and its boundaries should, as much as possible, follow natural features such as roads, rides, main ditches, banks or other surveyed lines. The shape of compartments should preferably be compact and in flat, featureless country where artificial delineation is necessary, compartments may usefully be rectangular or square and have convenient area. A compartment is not necessarily a unit of treatment even though treatments can be planned per compartment basis. Therefore, different parts of a compartment may be subjected not only to different methods of treatment but also different objects of management. Such parts of a compartment are called sub-compartments.

The sub-compartment is a subdivision of a compartment, generally of a temporary nature, differentiated for special description and treatment (preferably designated by small letter a, b, c, etc). Variety of site and treatment of the growing stock results in the formation of different stands which can be defined as collections of trees or other vegetation which are sufficiently homogenous in specific composition, structure age and rate of development or health to differentiate them from each other for purposes of description or treatment. Compartment records may both be constructed and maintained manually in a register, or on a personal computer using database software.

Each record should have four main components, as follows:

- A summary of site conditions (soils, slopes, rainfall),
- Pre-harvest inventory data (species, tree numbers and volumes expressed by stem diameter classes).
- Dates and details of harvesting and silvi-cultural operations (selective harvesting, shelter-wood cutting, thinning, climber cutting, enrichment planting, release weeding)
- Post-harvest inventory data (poles, saplings, seedlings, nucleus trees).

Self-check 3	Written test

Name…………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 point)

1.__________Refers to the largest unit of forest stands.

A. Management unit B. block C. compartment D.A&B

2. The smallest unit of forest stand is called?

A. Management unit B. block C. compartment D.A&B

Test II: Short Answer Questions

3. Write the difference of block and compartment? (5 point)

____

____

4. Write the component of compartment recording. (3 point)

____

____

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating - 8 points Unsatisfactory - below 8 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 4- Conducting formal survey

Formal surveys are surveys in which data are collected by means of a questionnaire; which is administered by enumerators to a randomly selected sample of farmers. Formal surveys can be used to collect standardized information from a carefully selected sample of people or households. Surveys often collect comparable information for a relatively large number of people in particular target groups.

Surveying: Surveying is an art and science of making measurements of relative positions of an object on or above the surface of the earth and drawing them on to appropriate scale.

Purpose of surveying

Sound planning for the development and management of any land based resource; be at national, regional, or local levels, required a wide range of information. Much of this information concerns spatial location of points on the surface of the earth. The purpose of surveying is the acquisition and portray of such spatial information in the form of maps, satellite data, aerial photograph from which a great deal of qualitative and quantitative information are obtained. surveying also provide such sort of information for infrastructure development such as roads, bridge, water supplies, sewage, building etc. without which efficient utilization and sustainable development of resource couldn't be possibly constructs. Surveying helps the planning, design, layout and construction of physical structure.

We can use for?

- Providing baseline data against which the performance of the strategy, program, or project can be compared.
- Comparing different groups at a given point in time.
- Comparing changes over time in the same group.
- Comparing actual conditions with the targets established in a program or project design.
- Describing conditions in a particular community or group.

- Providing a key input to a formal evaluation of the impact of a program or project.
- Assessing levels of poverty as basis for preparation of poverty reduction strategies.

Advantages:

- Findings from the sample of people interviewed can be applied to the wider target group or the population as a whole.
- Quantitative estimates can be made for the size and distribution of impacts.

Disadvantages:

- Results are often not available for a long period of time.
- The processing and analysis of data can be a major bottleneck for the larger surveys even where computers are available.
- Household surveys are expensive and time-consuming.
- Many kinds of information are difficult to obtain through formal interviews.

Self-check 4	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is formal survey? (5 point)

____

____

2. What is the purpose of formal surveying? (2 point)

____

____

3. Write the advantage and disadvantage of formal survey (5)?

____

____

Note: **Satisfactory rating - 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 1- Surveying and mapping of large planting sites and forest inventory

- **Procedure of surveying and mapping of large plantation site**

1. Wear Safety clothes
2. Collect all materials, tools and equipment used for forest inventory
3. Record field data and drawing of field sketch including
   a. General orientation of the site
   b. Gathering of field data
   c. Drawing the field sketch of the site
   d. Transfer all important details from the field sketch to the final sketch
4. Estimate the volume of trees
   1. Collect all tools and materials for forest inventory
   2. Use the line-plot method in which plots are located at equal intervals along parallel lines running through the forested tract.
   3. To set up your first line, pick a corner of your tract that is a convenient starting point.
   4. Set your compass to a direction that will send you into your tract on a line perpendicular to your boundary (i.e., turn 90 degrees from the direction of your boundary line).
   5. Then, pace one chain into your stand and place your plot-center marker.
   6. On the map prepared, locate sample plots of 0.01ha by using transect line (line-plot method) procedure. Use 5% sampling intensity.
      Note: 1 chain is equal to 20.1168m
   7. Measure all the required stand parameters for volume estimation
   8. Estimate the number of trees per hector using:
   9. Calculate the average volume of the sub-sample tree (¯) in each plot
   10. Estimate the total volume (TV) by using:
   11. Calculate the volume (V) per hector.

Table 1; Data collection sheet format

Plot		1		2		3			
		Height	Voolume (M3)	Height (m)	Volume (M3)	Height (m)	Volume (M3)		
Volume m3/tree	1								
	2								
	3								
	4								
	5							Total	Average
	6								
	7								
	8								
	9								
	10								
	11								
	12								
Total for the									

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 1 hour. The project is expected from each student to do it.

Task-1 Within your group/team makes sure that you are able to conduct forest inventory and submit your output in 1 day.

Task-2 Collect, identify and check tools and equipment used for conducting conduct forest inventory.

Task-3 Write purpose of conducting forestry

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

LG #84	**LO # 3- Use appropriate sampling techniques**

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Applying random, systematic and cluster sampling techniques • Determining sample size This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Apply random, systematic and cluster sampling techniques • Determine sample size

Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. 4. Accomplish the "Self-checks" which are placed following all information sheets. 5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks). 6.If you earned a satisfactory evaluation proceed to "Operation sheets 7.Perform "the Learning activity performance test" which is placed following "Operation sheets" , 8.If your performance is satisfactory proceed to the next learning guide, 9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet 1- Applying random, systematic and cluster sampling techniques

1.1. Introduction

There are four basic aspects of forest sampling for the measurement of growth and yield which should be considered during management planning and in plan implementation. These are:

- Define the "Yield"
- Permanent Sample Plot Design
- The Sampling Pattern for Permanent Sample Plots
- Regular re-measurement of Permanent Sample Plots

Sample- is a group of units selected from a larger group (the population).

Sampling- is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population.

Reasons for sampling (Advantage of sampling)

- Economic factor
- Time factor
- Detailed information
- Inaccessibility

Sampling design: Sampling design refers to the method of selecting sampling units to be included in a sample. There are many forest inventory designs. As such there is not a specific pattern of design, which can be used in all inventories as each forest area varies.

Types of sample design;-

1. Probability sampling

1) Simple random sampling

2) Systematic sampling

3) Stratified sampling

4) Cluster sampling

1) Simple random sampling: It is the basic theoretical sampling technique. All sampling methods have their roots in simple random sampling. They are modification of simple random sampling method designed to achieve greater economy or precision. Every possible combination of sampling units from the population has an equal and independent chance of being selected. The fundamental idea in simple random sampling is that, in choosing a sample of **n** units every possible combination of **n** units should have an equal chance of being selected. To state it in another way, the selection of a particularly unit should be completely independent of the selection of all other units. The best way to do this is to assign every unit in the population a number and then draw **n** number from a table of random digits**.** Most sampling is without replacement. This is an easy sampling technique to implement as long as there is an explicit sampling frame (list or map). Simple random sampling design is used when:

- The population is finite
- There is frame (sampling frame refers to the list of sampling units that might be drawn in the population and sampling units are units from where we are going to collect information)
- The characteristics of the population we are interested in is homogenous
- There is no much emphasis on precision.

Advantage

- Simple and easy method
- Assures good representativeness of sample (particularly if the population is large and homogenous)
- Allow us to make generalization
- Avoids biases

2) Systematic sampling: It is a sampling technique in which selection of sample is following a systematic pattern. In these types of design the sampling units are spaced at fixed intervals throughout the forest area. They provide good estimates of population means and totals. They are faster and cheaper to carryout than random designs since the choice of sampling units is mechanical and uniform. Three of the most common variations are give as follows:-

i) Strip sampling

The forest area is covered by a series of parallel survey lines each of a predetermined width and each line spaced equidistant from the others. The width of the strip and the interval between the strip determine the <u>intensity of the cruise</u> or the percentage of the total area tallied. <u>The intensity of a strip</u> cruise can be conveniently calculated from

$$I = (W/D) * 100$$

Where: I = intensity of cruise in percent

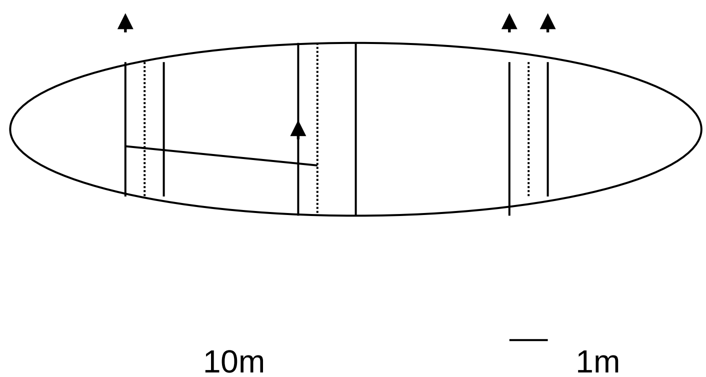
W = width of strip in a given unit

D = distance between strips in same unit as W.

Example

Cruise intensity for a systematic design, using 1m - wide strip space at intervals of 10m, is

$$I = \frac{W}{D} * 100 = \frac{1}{10} * 100\% = \underline{\mathbf{10\%}}$$



ii) Line plot sampling

Instead of measuring all the trees along a strip the measurements are confined to small sample plots which are located at pre-determined distances along the parallel survey lines. These plots may be square, rectangular or circulars and of any convenient size depending on the size and spacing of the trees being measured. A systematic line plot cruise is similar in its manner or application to a strip cruise. Instead of continuous strip, plots are established at intervals on the line and the tree on the plots is flashed. For a given intensity, numerous possible systematic distributions can be designed depending on the size of plot, distance between plots on a line, and distance between lines. A line plot design can be drawn up, using the following relationship.

$$A_P = IA$$

$$N = A_P/a$$

For a given I, a, and L with linear dimensions in chains and area in acres.

$$B = a/0.1\ LI$$

For a given I, a, and B

$$L = a/0.1BI$$

Where

: A_P = area of stand tallied in plots

I = Intensity of cruise as a decimal

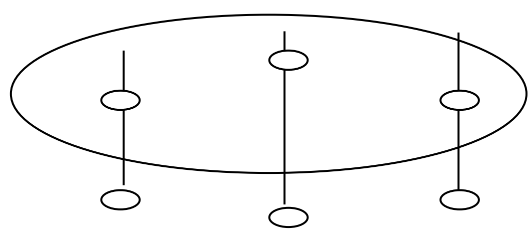
A = total stand area

a = area per plot

n = number of tallied plots

L = Spacing between cruise lines

B = Spacing between plots on cruise line



Km or m

Chai

Figure 17: systematic (line plot) sampling technique

Example;-

For a 10- percent cruise using 0.2-acre plots, and choosing a 5 – chain spacing between cruise lines, the distance between plots is B = 0.2/ (0.1) (5) (0.10) = **<u>4 chain</u>**

It is the most frequently used sampling technique in forest inventory because:

- The procedure is easily applied in the field and it is easily explained to the field crew;
- It is also easy for those who are interested in the results to understand the sampling procedure
- It yields more precise results than simple random sampling with the same number of sample points.

In systematic sampling, we divide the population size (N) by the sample size (n) to obtain the range (k) $k = \frac{N}{n}$

Steps:

1. Researcher needs sampling frame.
2. Researcher needs 5 students (sample size, n =5) out of 15 students (population size, N=15).

$$k = \frac{15}{5} = 3$$

3. Select starting point. Since k = 3, random number between 1 or 2 or 3 will be selected. Type = rand between (1,3) and press Enter.
4. Let say number 2 is chosen, start with number 2 and take every k = 3.

Advantage

- Simple

Disadvantage

- Need list/sampling frame that is numbered

3) Stratified sampling: In many forests there is great variability in timber volumes throughout the forest area. We describe such a forest as being heterogeneous. If random samples were taken in such a forest the standard error would be very large due to the large range of volume and as a result the estimation of volume in the forest could not be precise. In such instances it is useful to subdivide (stratify) the population in to subpopulation (stratum). In fact the stratification can be done either for practical or statistical reasons. The corresponding sampling technique is called stratified sampling.

Stratification criteria could be:

- Forest types,
- Ecozones
- Site conditions
- Political or property boundaries
- Tree sociological classes
- Species, etc

Stratified random sampling design is used when:

- The population is finite
- There is frame
- The characteristics of the population we are interested in is heterogeneous
- High precision is required

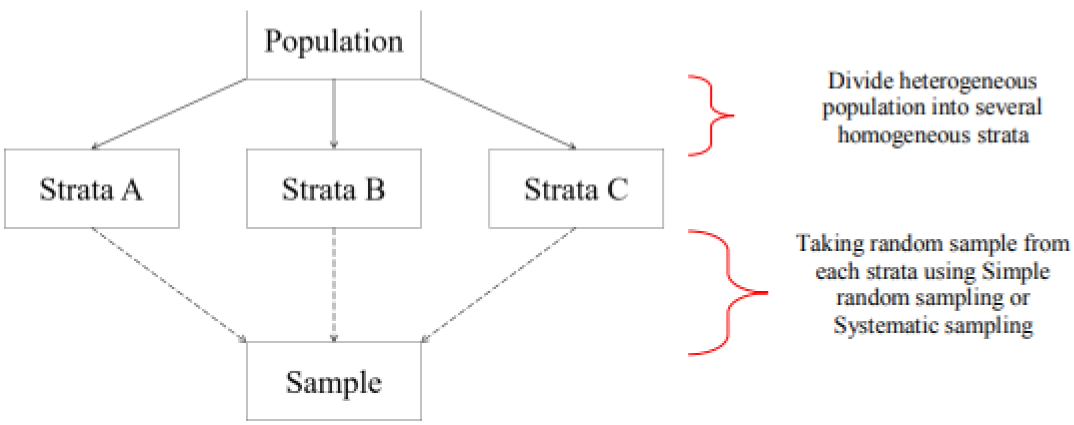


Figure 18: Stratified random sampling design

Advantage

- Increased accuracy at a given cost
- In certain cases it becomes not only essential but also unavoidable. A case in point can be comparative studies.
- Enables use of different methods in different strata

Disadvantage

- One must know the characteristics of the population so as to apply stratification
- Mostly costly and time consuming (expensive)

4) Cluster sampling:- Cluster sampling is used when the population of interest is scattered widely across systematic clustered sampling. When it is not possible to make strata for stratified sampling, there may be some knowledge about the forest where it can be said that small groupings are possible. These small groupings of plots if they are near to each other form a cluster. These clusters are then randomly sampled with the belief that they are representing the actual mix of the forest. As they are close to each other there is less walking needed and so it is more efficient certain geographical area and the sampling frame is available.

Steps:

- Cluster sampling divides the target population into several clusters based on geographical areas.
- A random sample of clusters is selected based on probability sampling technique such as simple random sampling to represent the total population.
- No units from non-selected clusters are included in the sample because they are represented by those from selected clusters.
- With stratification, we sample from each of the subgroups but in cluster sampling, we sample from selected subgroups only.
- Cluster sampling is most applicable when sampling frame is not available or incomplete.

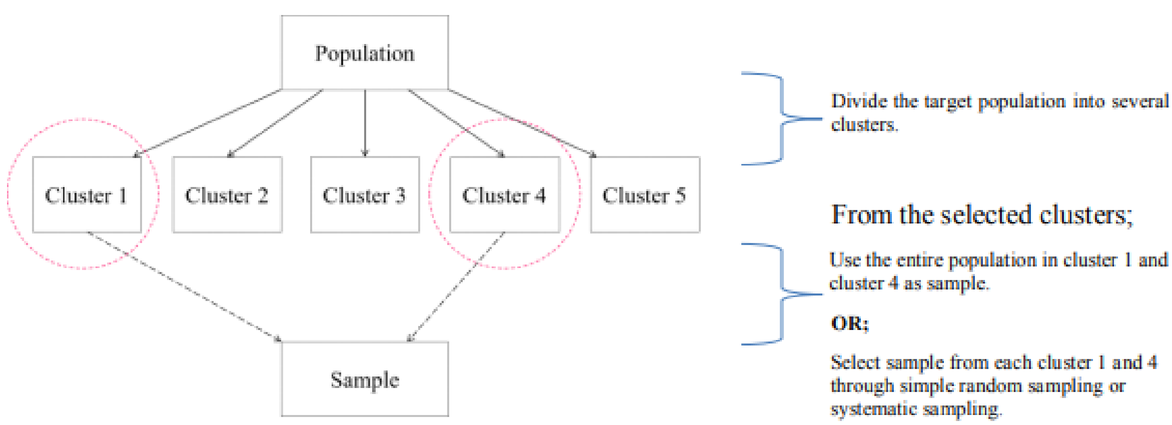


Figure 19: Graphic representation of cluster sampling

Advantage

- Reduced costs
- No need of having complete sampling frame

Disadvantage

- Less accurate result

2. Non-probability sampling

With non-probability sampling, not every unit has a chance of selection in the sample and the process involves some amount of subjectivity instead of following predetermined, probabilistic pathways.

- Convenience sample
- Quota sample
- Judgemental sample

Self-check 1	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 point)

1. Types of common sampling designs in forest inventory are given below.

A. Simple random sampling B. Systematic sampling C. Stratified sampling D. Cluster sampling.

2. _____________ sampling is used when the population of interest is scattered widely across systematic clustered sampling.

A. Simple random sampling B. Systematic sampling C. Stratified sampling D. Cluster sampling.

Test II: Short Answer Questions

3. Write the steps used in cluster sampling (5 point)

____

____

4. Stratified random sampling design is used when (8)?

____

____

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 10 points **Unsatisfactory - below 10 point**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 2- Determining sample size

While thinking of forest crop/stand measurement there are some central questions to be dealt with:

- How many samples?
- How to select the samples?
- How to take what observations?
- How to calculate the estimations?

Sampling size: Sample size is a frequently-used term in statistics and market research, and one that inevitably comes up whenever you're surveying a large population of respondents. It relates to the way research is conducted on large populations. When you survey a large population of respondents, you're interested in the entire group, but it's not realistically possible to get answers or results from absolutely everyone. So you take a random sample of individuals which represents the population as a whole. The size of the sample is very important for getting accurate, statistically significant results and running your study successfully.

- **If your sample is too small**, you may include a disproportionate number of individuals which are outliers and anomalies. These skew the results and you don't get a fair picture of the whole population.
- **If the sample is too big**, the whole study becomes complex, expensive and time-consuming to run, and although the results are more accurate, the benefits don't outweigh the costs.

If you've already worked out your variables you can get to the right sample size quickly with the online sample size calculator below:

Confidence Level:

95%

Margin of Error:

5%

Population Size:

10000

Ideal Sample Size:

How to determine sample size?

To choose the correct sample size, you need to consider a few different factors that affect your research, and gain a basic understanding of the statistics involved. You'll then be able to use a sample size formula to bring everything together and sample confidently, knowing that there is a high probability that your survey is statistically accurate. The steps that follow are suitable for finding a sample size for continuous data i.e. data that is counted numerically. It doesn't apply to categorical data i.e. put into categories like green, blue, male, female etc.

Stage 1: Consider your sample size variables

Before you can calculate a sample size, you need to determine a few things about the target population and the level of accuracy you need:

1. **Population size**

How many people are you talking about in total? To find this out, you need to be clear about who does and doesn't fit into your group.

2. **Margin of error (confidence interval)**

Errors are inevitable – the question is how much error you'll allow. You can set how much difference you'll allow between the mean number of your sample and the mean number of your population. If you've ever seen a political poll on the news, you've seen a confidence interval and how it's expressed. It will look something like this: "68% of voters said yes to Proposition Z, with a margin of error of +/- 5%."

3. **Confidence level**

This is a separate step to the similarly-named confidence interval in step 2. It deals with how confident you want to be that the actual mean falls within your margin of error. The most common confidence intervals are 90% confident, 95% confident, and 99% confident.

4. **Standard deviation**

This step asks you to estimate how much the responses you receive will vary from each other and from the mean number. A low standard deviation means that all the values will be clustered around the mean number, whereas a high standard deviation means they are spread out across a much wider range with very small and very large outlying figures.

Stage 2: Calculate sample size

Now that you've got answers for steps 1 – 4, you're ready to calculate the sample size you need. This can be done using the online sample size calculator above or with paper and pencil.

5. Find your Z-score

Next, you need to turn your confidence level into a Z-score. Here are the Z-scores for the most common confidence levels:

- 90% – Z Score = 1.645
- 95% – Z Score = 1.96
- 99% – Z Score = 2.576

If you chose a different confidence level, use our Z-score table to find your score.

6. Use the sample size formula

Plug in your Z-score, standard of deviation, and confidence interval into the sample size calculator or use this sample size formula to work it out yourself:

Estimation design

1. Estimations of the variable(s) of interest (point estimates) and
2. Estimations of the precision of the point estimates (interval estimates)

Example:

- Volume = 200 m3/ha ± 15%
- 200 m3/ha ± 30 m3/ha

Plot size: The most efficient plot in any particular forest will depend on:

- Inventory objectives
- Level of precision required
- Forest variability

Establishing a sample plot

Because measuring trees can be a time consuming and costly operation, most forest owners only measure a sample of trees as an estimate of the growth of different parts or blocks of the forest. An absolute minimum of 3 plots should be established in any uniform section, unless one or two plots cover most of the site, in which case all trees should be measured. For very large uniform forests, the total area of all plots should be an absolute minimum of 2% of the total forest area. For example, in a forest of 10 hectares, a total area of 0.2 hectares should be measured. If the plots were to be 0.04 hectares in size then at least 5 plots would be required for a sufficient sample.

Circular plots-Circular plots are preferred in mature stands where stocking rates are lower due to thinning and original planting rows are harder to identify.

Plot size:-Plots can be either temporary (a one-off measure) or permanent (i.e. measured over time). It would be preferable to set up several permanent plots so they can be measured over time to determine growth rates and allow the grower to become familiar with tree growth. The size of a permanent plot should be determined by the expected final stocking.

Simple allocation in stratified random sampling

Having decided the total number of sample size (e.g. n observation), the way how many of these observations be distributed in each stratum need to be determined. There are two common procedures to do this:

a) proportional allocation and
b) optimum allocation

Proportional allocation

Sample plots are distributed based on the area of each stratum or generally one may say that if a stratum contains half of the units in the population then half of the sample observations would be made in that stratum.

Assume: n = number of sample unit's total

Nh = size of stratum (h = 1- - - - -n)

N = total population size

n_h = sample plots to be laid dawn in stratum h

Then $n_h = (N_h/N) * n$

Optimum allocation:-In optimum allocation the observations are allocated to the strata so as to give the smallest standard error possible with a total of n observations. For a sample of size n, the number of observations (nh) to be made in stratum h under optimum allocation is

$$n_h = \frac{(N_h S_h)}{N_h S_h} * n$$

It defines what the "observation units" are and what is observed. Observations are taken on observation units. Basic types of observation units in forestry include:

- Individual objects: trees, stands, properties, etc
- Points (no dimension): area estimation with dot grids.
- Lines (one dimension): transects.
- Areas (two dimensions): fixed area (circular, square, rectangular) or variable area (nested plots, relascope sample, distance methods).

Establishing a sample plot

Because measuring trees can be a time consuming and costly operation, most forest owners only measure a sample of trees as an estimate of the growth of different parts or blocks of the forest. An absolute minimum of 3 plots should be established in any uniform section, unless one or two plots cover most of the site, in which case all trees should be measured. For very large uniform forests, the total area of all plots should be an absolute minimum of 2% of the total forest area. For example, in a forest of 10 hectares, a total area of 0.2 hectares should be measured. If the plots were to be 0.04 hectares in size then at least 5 plots would be required for a sufficient sample.

Circular plots-Circular plots are preferred in mature stands where stocking rates are lower due to thinning and original planting rows are harder to identify.

To set up a circular plot:

- Mark the plot centre with a peg. The measured distance to the plot becomes its plot centre. Locate the plot centre at the measured distance. Locating the plot centre at a more convenient point nearby may bias the result.
- Using a measuring tape, identify the trees that are within the predetermined radius and mark the boundary trees with spray paint. For a tree to be included within the plot, the centre of the tree (usually where the diameter at breast height over bark (DBHOB) is measured) must be within the plot radius.
- The tree nearest to the plot centre should have the plot number marked on it and underlined. When marking out the plot boundary it is important to account for slope when measuring the distance from the plot centre. On moderate slopes it is possible to adjust for slope by holding up the measuring tape horizontally from the plot centre.

Rectangular plot- Rectangular plots are preferred in stands where plantings rows are well defined, for example in un thinned stands.

To set up a rectangular plot:

- Identify the mid row point, which is the measured distance to the plot.
- From the mid row point, measure across three rows to the mid row in either direction. This distance becomes the plot width.
- Calculate the plot length, which gives plot length for a measured width where the plot area is 0.04 hectares, or use the formula below:

Plot length (m) = ***plot area (ha)***

Plot width (m) x 10,000

- At each end of the plot determine whether border trees are in or out by estimating the right angle to the row direction.

Plot Size and Shape

The most efficient plot area is a compromise between the total forest area sampled and the physical effort needed to establish, maintain and regularly remeasure plots. The aim is to minimise the plot edge to area ratio. The most efficient plot size in any particular forest will depend on inventory objectives, the level of precision required, forest variability and the costs of PSP establishment, maintenance and remeasurement

Plot size

Plots can be either temporary (a one-off measure) or permanent (i.e. measured over time). It would be preferable to set up several permanent plots so they can be measured over time to determine growth rates and allow the grower to become familiar with tree growth. The size of a permanent plot should be determined by the expected final stocking. In order to obtain a representative sample, between 15 and 30 trees per plot is required (12 being the absolute minimum). Plot size will therefore depend on the stocking rate. The more sparse the trees, the larger the plot will need to be to include sufficient trees. Tree stocking can be quickly estimated from average spacing or, alternatively, the size of the plot can be gradually increased until it includes sufficient trees. Shape of a plot in forest inventory could be circular, square or rectangular/strip plot.

Most relevant characteristics when comparing circular, square, and rectangular/strip plots are: The practical aspects: laying out the plots, border trees, etc.

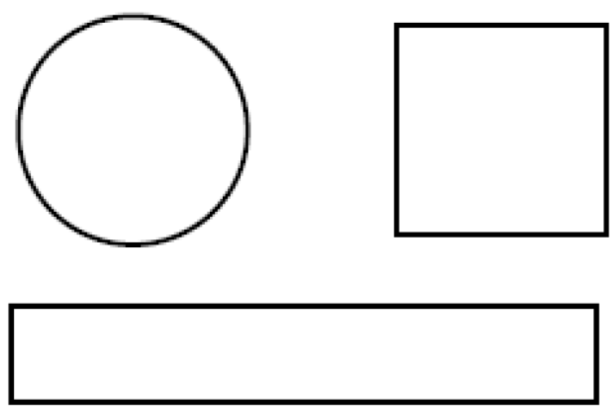


Figure 20: Various plot shapes

Calculating plot area: Plot area for each shape is calculated as follows:

Rectangular plots: Plot area (ha) = Length (m) * width (m)/10000

Circular plots: Plot area (ha) = [Radius (m)]2 * 3.142/10000

Table: stocking rates and plot size for sample plots that will include about 20 trees			
Stocking rate (Stems/hectare)	Sample plot size (hectares)	Dimensions of rectangular plot	Radius for circular plot
100	0.2	50m×40m	25.2m
200	0.1	40m×25m	17.8m
400	0.05	25m×20m	12.6m
600	0.033	20m×16m	10.2m
800	0.025	20m×12.5m	8.9m
1000	0.02	16m×12.5m	8.0m
	0.01		5.64m

Establishing a plot;- Establishing a plot means marking out a known area within a stand of trees. (Trees within the plot then become the sample). Within a particular section of the forest the plots are randomly located or, more commonly, evenly distributed throughout the area. To avoid bias in the location of plots it is common to systematically mark the plots on a forest map prior to entering the forest. For large forest areas it is also common practice to locate plots away from the edge of the forest due to edge effect.

Self-check 2	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: True or false

1. Sampling is an important for forest inventory
2. Establishing a plot means marking out a known area within a stand of trees.
3. Shape of a plot in forest inventory could be circular, square or rectangular/strip plot.

Test II: Short Answer Questions

1. What is sampling size (5 point?)

____

____

3. How to determine sample size? (3 point)

____

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

LG #85	LO# 4- Estimate volume and yield of stand

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Measuring diameter and height of stand • Calculating mean annual and current annual increment of stand • Determining cost-benefit analysis This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Measure diameter and height of stand • Calculate mean annual and current annual increment of stand • Determine cost-benefit analysis
Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. 4. Accomplish the “Self-checks” which are placed following all information sheets. 5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks). 6.If you earned a satisfactory evaluation proceed to “Operation sheets 7.Perform “the Learning activity performance test” which is placed following “Operation sheets” , 8.If your performance is satisfactory proceed to the next learning guide, 9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Measuring diameter and height of stand

4.1. Introduction

Forest Stands are measured for a variety of reasons including forest management planning, forest health monitoring and timber appraisal. Each objective requires different information and level of detail. Because it is not practical to measure an entire forest, most land managers use sampling techniques or small sample plots to gather information about an entire forest. Since it is unlikely that we can measure every tree in a plantation we usually collect information by measuring only a proportion of all the trees in the stand—this is known as sampling. Sampling is usually carried out by establishing plots within the forest. Plot is an area in which all trees are measured. The most common plots have a fixed area and are circular or rectangular in shape. The shape will not affect the number of same-sized plots used.

Measuring of stand has the following procedures:

- Describing the forest-types and areas
- Establishing a sample plot
- Plot measurements

4.2. Describing the forest-types and areas

The starting point for forest measurement involves developing a good map of the area that shows the type of forest, age (if planted and past management. If growth is affected by topography or soil types these should also be shown. Inspect the forest and make a judgment as to the different forest blocks. If tree management, performance, age, soil types or environment are quite clearly different and have affected growth in parts of the forest, these should be treated as separate areas and marked on the map. This stratification of the forest in to uniform bits is critical if a true picture of the forest is to be estimated.

4.3. Forest stand

Forest stand is a distinct, recognizable area of the forest that is likely to be managed as a unit. Age, tree species composition, soil types, topography, or other natural features will differentiate stands. For instance, an area of hardwoods could be considered a different stand than an area of conifers. Similarly, an area of 80-year-old trees would be considered a different stand than an area of newly planted trees. Characterizing stands is a subjective process; different people may look at the same forest and describe different stand boundaries. Stand boundaries have been drawn on the aerial photo, which can now serve as a stand map. All forestland that has the same defined combination and attribute range of the physical, vegetation, and development characteristics chosen to classify the forest into homogeneous types with regard to some basic land characteristics in order to predict timber yield and other responses of the land to treatments with confidence. e.g., Land type, site type, forest type. All open natural forests situated on gentle slope area (at the foot of the mountain) that are close to the roads and surrounded by settlements All closed natural forests located on the mountains sides situated in the remotest parts of the forest and away from the surrounding communities. Notice the difference in both color and texture between the different stands. Once you have identified your stands, give each one a name or number to reference it. Some people simply number their stands. Others give descriptive names, such as 2006 plantation stand or derosa pine stand." Others may name a stand after a specific feature or something of personal significance, such as "Billy's hillside stand" or "family picnic area stand." It is possible that your property incorporates .only one stand, especially if your property is small.

Figure 21: Forest stand

4.4. Stand measurements

Estimating the number of trees/ha

The tree density or stocking rate of a forest is described as the number of trees per hectare. This can be easily calculated for each plot as follows:

Stocking rate (stems/ha) = Trees in plot/Plot area (ha)

Stand height

Measuring the heights of trees can be difficult and time consuming. Fortunately, the heights of the tallest trees in a plantation or native forest are usually quite uniform and therefore, rather than measure the height of all trees in the sample plot, it is common to select a sub-sample. In most cases a number of the fattest trees (largest DBH) of good form are measured for height, this is called the mean dominant height. To estimate the mean dominant height, select the three fattest trees of good form in each plot and measure their height, averaging the height of the three tallest trees to calculate the mean dominant height. Where there is more than one species or age class, it will be necessary to determine a mean dominant height for each.

Estimating stand basal area/ha

Normally we use the term basal area to represent the whole stand, not a single tree, and so use the unit m^2/ha. Stand basal area (SBA) is simply the basal area of all the trees at breast height per hectare of forest or plantation (m^2/ha). Stand basal area can be used to estimate stand volume or as a useful measure of the degree of competition in the stand. SBA is often quoted when planning thinning prescriptions.

Stand basal area can be determined by summing the tree basal areas or by using a basal area sweep. The most accurate method of assessing stand basal area is to measure all tree diameters in a plot, calculate the individual tree basal areas and add these up, then divide by the plot area.

SBA (m2/ha) = (Sum of the basal area of each tree in the plot)

(Area of the plot)

Estimating stand volume/ha

Total forest volume can be calculated from the plot measurements:

Standing forest volume (m3/ha)= plot volume(m3)

Plot area (ha)

Volume calculations:-

Tree volume (m3) = (TBA x HT)

3

Where TBA = tree basal area (m2)

HT = tree height.

Sum the volume of each measured tree to get the sample volume. The results for the sample can then be multiplied to get the total stand results.

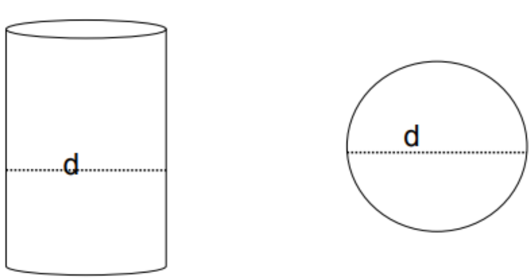
Stand volume = Total number of trees x sample volume

Number of trees measured

Example: The number of trees in a plantation is counted and found to be 1,500. A suitable sample would be 133 trees located by selecting every 15th tree. Measure their heights and diameters and use the form factor equation to estimate their volumes. If the sum of their volumes were found to be 24 m^3, the stand volume would be: (1,500/133) x 24 = 271 m^3.

4.5. Measure diameter of tree

Diameter of a stem is a length from the outside of the bole through the centre to the opposite side of it.



A. Longitudinal/side view B. Cross-sectional view

Usually diameter is measured with bark so that a reduction needs to be applied if only the wood is of interest. Sometimes instead of diameter tree girth is measured. It is the circumference/perimeter of the stem. **$C = 2\pi r$ $C = \pi d$.** Tree diameter and girth measurement are the most important tree variables because:

- They are in most cases easily and directly measured
- From the diameter the basal area (which is closely correlated to tree volume) is directly calculated.
- The diameter distribution of a stand gives a good insight to the stands structure and potentially necessary silvicultural treatments.

Tree diameter is the most common and important measurement made on commercial trees. By convention, the diameter of a tree is measured in centimeters at 1.3 m above the ground on the uphill side and is termed the diameter at breast height (DBH). Because trees are measured with the bark on this is also called the diameter at breast height over bark (DBHOB). When measuring live trees most information is presented as over bark dimensions and volume models include a correction to provide the under bark volume used to describe most high-value products.

To measure DBH:-Determine where 'breast height' or 1.3 m is on you or use a stick 1.3 m long.

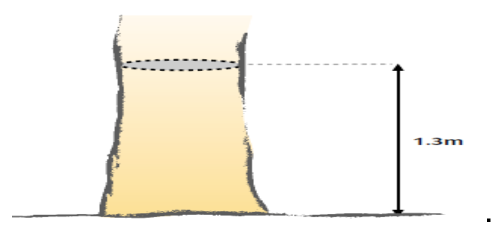


Figure 21: Position for diameter measurement at breast height in flat terrain

There are four reasons why the diameter di or the circumference **C**i at breast height is of particular importance among all the tree information collected in the course of a forest inventory:

1) It is a characteristic, which can be easily assessed. In comparison with other characteristic diameter measurements are the most reliable

2) The dbh is the most important measurement element and provides the basis for other computations. It serves for the derivation of the tree cross sectional area at breast height.

$$gi = \frac{\pi}{4} di^2$$

- Volume is the product of basal area, height and form factor:

$$Vi = \frac{\pi}{4} di^2 hi \text{ if}$$

3**)** At breast height the instrument is easily handled (convenience and ease). Also on most trees the influence of buttress on the stem form is already much reduced at breast height. However, irregularities of tree stems do sometimes prevent the measurement of diameter at breast height.

The followings are some of the cases:-

Trees on slope:- measure dbh at the standard height above the floor/ground on the uphill side of the tree.

Leaning tree:- measure parallel to the lean on the lower side of the lean.

Buttress tree:- if the buttress height is more than one meter then measure dbh from the point where buttress ends, otherwise measure normally.

Abnormalities at breast height:- swellings, knots, crooks, etc Measure the dbh above or below the abnormalities and indicate the height at which diameter is measured. Sometimes measurement is done at equal distance above and below breast height and then dbh is estimated by taking the mean of the two readings.

Bifurcation:- If a tree bifurcates above breast height then measure dbh as usual. But, if a tree bifurcates below breast height then measure dbh on each stem separately.

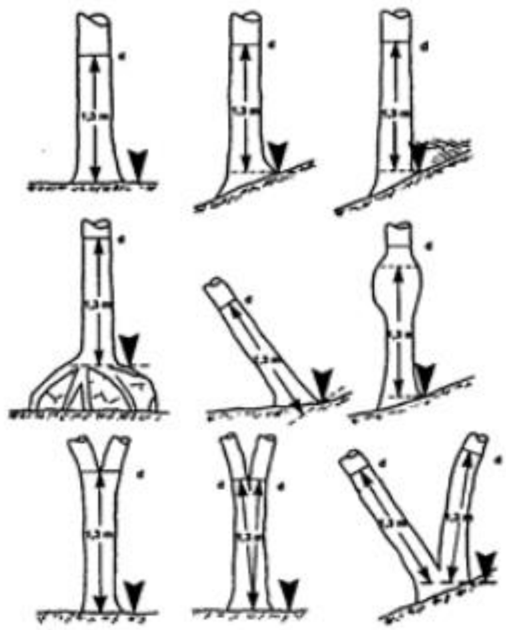


Figure 22: Positions of diameter measurement different conditions

Instruments used for measuring are **Calipers** and **diameter tape**.

Caliper:- is the most efficient to measure dbh directly whenever there is direct access to the tree. It can be made of wood, metal or aluminum. It has two arms one fixed and a graduated bar/beam on which the second arm slides. To measure with a caliper, hold it firmly and horizontally as well as perpendicular to stem axis at the same time. Usually two readings are taken perpendicular to each other at breast height and then the average value will be recorded. In areas where vines are prevalent, getting a d-tape around a tree or finding a flat side on which to lay a Biltmore stick can be nearly impossible. In these circumstances, a tree caliper is useful (Figure below). A graduated scale corresponds to the width of the caliper teeth. Again, two measurements should be made, at right angles to each other, in order to alleviate error that would occur in trees that are rather elliptical. The average of the two measures is recorded. Tree calipers are somewhat heavy, and can be cumbersome to carry around all day, especially in heavy brush. Therefore, these are not as popular in the Pacific Northwest as they are in other regions.

Figure 23: A tree caliper is held at right angles to the tree trunk.

Use of Calipers:-

- Use at right angles to the tree with scale touching the tree
- Two measurements should be taken if tree circumference is anything but circular.
- Calipers should be wiped with solvent oil and a rag at the end of every day to prevent a build-up of resin and prevention of rust – ensuring that the sliding arm will continue to slide.
- Read the caliper at the point where the sliding arm touches the scale.
- Say aloud the reading to the Note keeper. Most calipers are designed for tallying, so there may have to be some interpretation of the measurement(s) to put it into classes for tallying purposes.

Diameter tape: A diameter tape, or d-tape, is the most common tool. The tape is wrapped around the tree, measuring its circumference. The tape is graduated to reflect a conversion from tree circumference to tree diameter. Thus, circumference is measured, but diameter can be recorded to the nearest 0.1 inch (Figure below). Granted, most trees are not perfect circles, so there is some error in this method. However, except on extremely irregular trees, this method seems to "average out" the tree's shape to an acceptable estimate. There are diameters tapes from which the tree diameter can be directly read. Tree diameter can also be determined from circumference measurement which can be done by diameter tape or any tape since circular tree stem shape is assumed. Many diameter tapes also have a nail or hook on the end that you can stick into the tree to hold the end of the tape in place while you wrap it around. If the tree is markedly leaning, measure at an angle perpendicular to the axis of the tree to ensure that you are measuring the minimum diameter around the stem. If the tree is forked, measure it as one or two trees based on whether the fork is above breast height (one tree) or below (two trees).

Figure 24: A diameter tape is graduated so that diameter can be read from measuring the tree’s circumference.

Use of D-tape

- Wrap tape around tree at BH or ascribed location
- Overlap such that “0” end crosses the tape
- Ensure tape is not wrapped below or above the ascribed location
- Try not to measure at branch stubs, burls or any abnormalities where possible
- Read the tape to 0.1cm

Recording of Diameters:-Diameters can be measured and recorded in

- Decimal centimeters or inches (0.1cm, 0.1in) – fairly precise measurement
- Whole centimeters or inches (1cm, 1in) – relative to precision sought
- Larger classes/intervals (2cm, 2in) – less precision required

The most common diameter measurements required in forestry:

- Main stem – standing tree
- Branches of standing tree – not common in our part of the world
- Cut portions – scaling

Diameter is the most important measurement in both standing and felled trees. Errors made are very serious. As an example a tree is 10cm at DBH, is measured as 9cm DBH and recorded at 9cm. The following errors result: DBH – if off by 10%, could result in errors of:

- Basal Area (area at the diameter) – 18.9% difference
- Volume – 23.1% difference

The terms **precision** and **accuracy** have been used extensively and they may need clarification.

- The term precision means how small or fine the measurements are, i.e. are they 1mm or 1cm or 10cm or 100m. For example, if a tool has graduations (markings indicating measurements) that are 5 graduations for 1cm, then each graduation is 2mm – meaning it is precise to 2mm or 0.2cm or 0.002m.
- Accuracy means how close the measurement is to the true value. In the case of calipers versus D-tapes, the D-tape will always overestimate the diameter when compared to the caliper. This means that the caliper is more accurate than the D-tape.

Measuring upper stem diameter: Upper stem diameter of a tree is measured for instance to describe the shape of a stem (derive taper curve). It is measured at various heights. Upper stem diameters are most easily observed on felled trees; however there are situations in which upper stem diameter need to be measured on a standing tree. Upper stem diameter is measured either at a fixed point (X meter) or at relative height (X% of height).

Methods;-

1. Using Finn caliper (Finnish parabolic caliper)
    - Used to measure diameter up to 7m
    - Difficult to carry mostly beyond this height

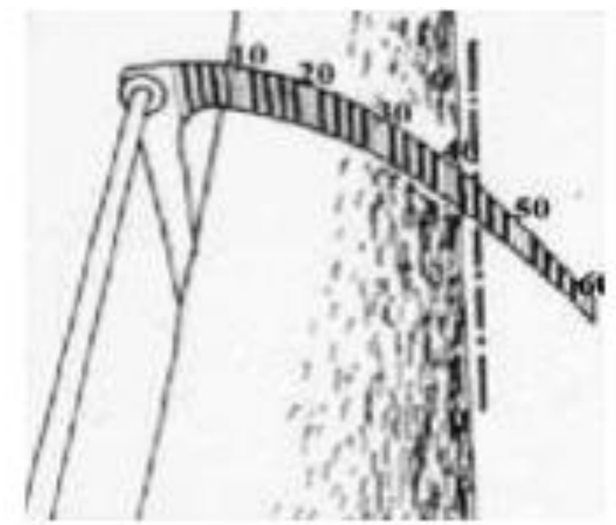
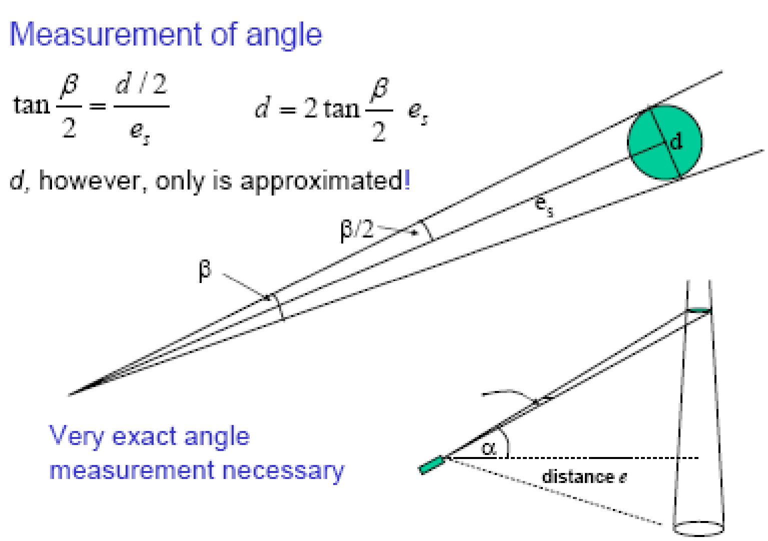
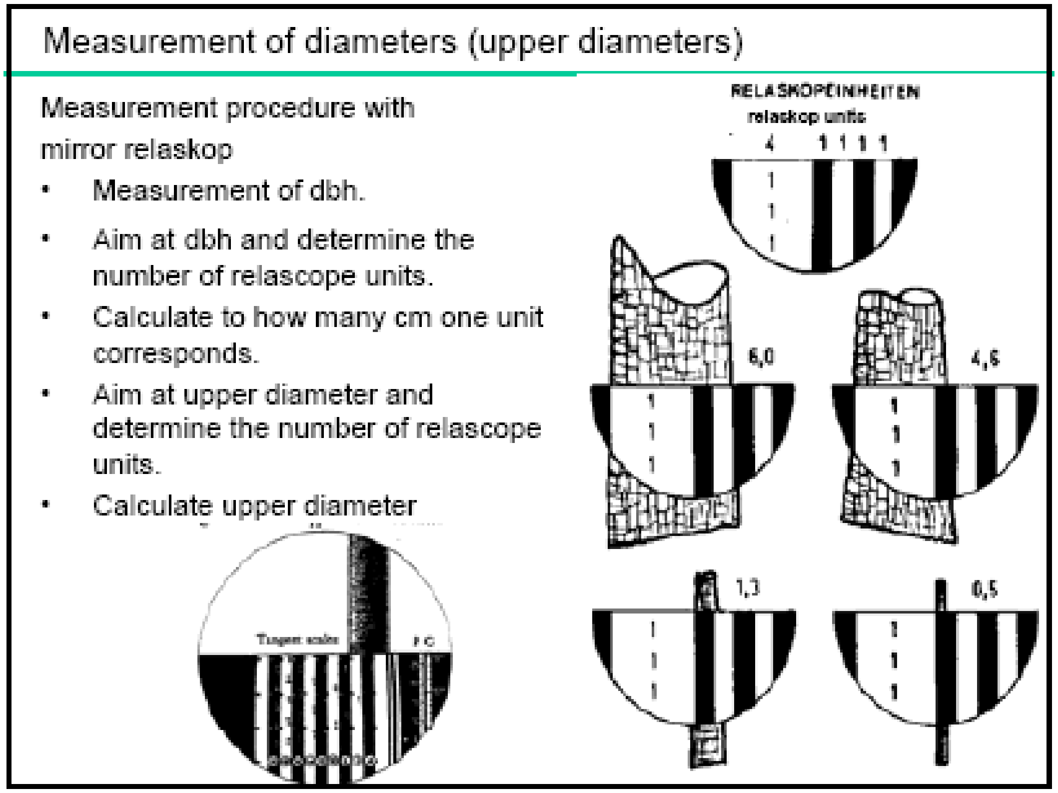


Figure 25: Upper stem diameter measurement with Finn Caliper

2. Measuring upper diameter with angle measurement technique





Calipers Vs diameter tape

- Tapes are easy to carry than calipers (especially in dense forest).
- Measuring with caliper is faster than with tape.
- Bigger trees can be measured with tapes easily (calipers have an upper bound) tapes can be extended by joining them.
- Tapes are good to maintain consistency in measuring diameter regularly.

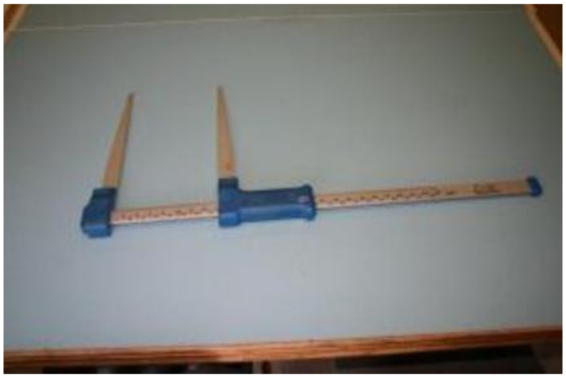


Figure 26:- Caliper and D-tape

4.6. Tree Height Measurement

Why tree height is needed to be measured? Height is a tree variable that is used to estimate or determine the volume of a tree. It also helps to deal with the issues of site classification. Tree height is defined to be the perpendicular distance between the ground level and the top of the tree. While, Tree length is the distance between the stem foot and the top along the stem. Most forest applications use one of two types of tree height measurements:

4.6.1. Total height. Total height is the height of a tree from its stump to its tiptop (Figure 27 below). A one-foot stump is standard, although there are times when another base is used.

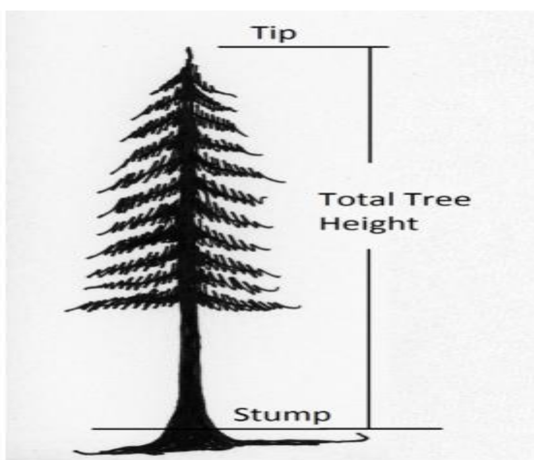


Figure 27: Total tree height, measured from a one-foot stump.

4.6.2. Merchantable height. Merchantable height is the height of a tree from its stump to a diameter at which the trunk is too small to be marketable (Figure 28 below). This "merchantable top" diameter is commonly six inches or some percentage of a diameter low in the tree, such as diameter at breast height (DBH). Taper height is very similar, without the emphasis on the top diameter being the end of merchantability.

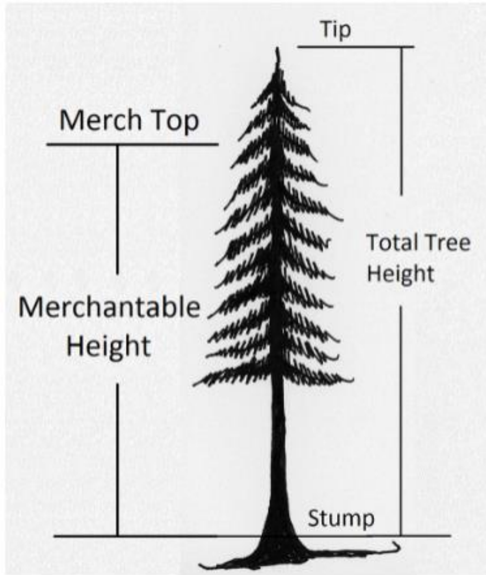


Figure 28: Merchantable height is the height from the stump to a trunk diameter at which the tree can no longer be cut into logs for sale.

A simple, accurate, and rapid measuring method is needed to make tree height a feasible part of our inventory data. Here is the easiest way for good precision: n determining tree height, a tree is presumed perpendicular to the ground (Figure below). Therefore, the tree makes a right angle with the ground, and a right triangle can be drawn from it. The triangle's three sides are: 1) the tree 2) a horizontal distance along the ground, and 3) an imaginary diagonal line running from the top of the tree to the ground. Likewise, the tree's height can be considered the rise and the horizontal ground distance the run. If a horizontal distance from the tree to a place where we can see the tree's top can be measured, the tree's height can be determined using %slope.

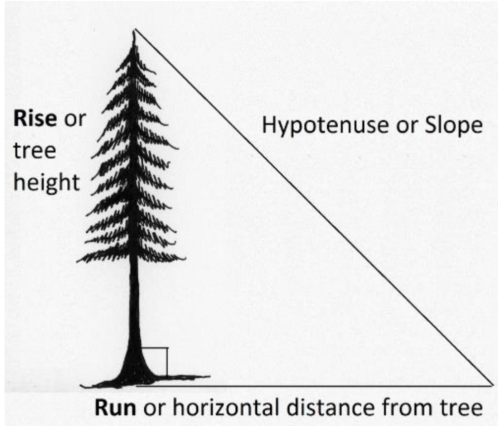


Figure 29: A tree makes a right angle with the ground.

Types of tree height:-

Total height: - the distance between the ground and top of the tree.

Bole height: - the distance between the ground and the Crown Point.

Stump height: - the distance between the ground and the position where a tree is cut.

Merchantable length:- is the distance between the top of the stump and the terminal position of the last useable portion of the tree stem.

Dominant height: - is the average height of 100 thickest trees per hectare.

Methods of tree height measurement;-

1. Direct method:

It involves climbing or using height measuring rods. It is rarely used and only for small trees.

2. Indirect method:

2.1. Using geometric principle

2.2. Using trigonometric principle

2.1. Geometric principle

A christen hypsometer or ruler of a certain length (30cm for example) and a pole of constant length/height used to estimate/measure tree height.

Technique used:-

- Place a pole of known length at upright position against the tree to be measured.
- Hold ruler (of known length) vertically and parallel to the tree to be measured.

- Find the sighting position by moving back and forth and/or right and left so that the top of the ruler exactly aligned with the tip of the tree and the bottom of the ruler with the base of the tree.
- Take ruler reading in line with the top of the pole. Then apply the following formula.

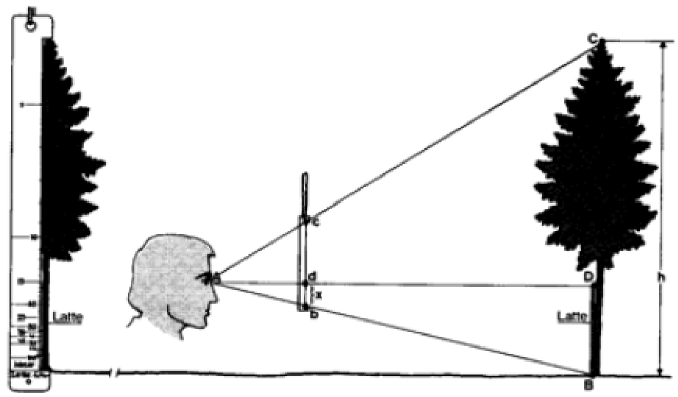


Figure 29: Tree height measurement technique by geometric principles

Δ ABC = Δ Abc

(BD/BC) = (bd/bc); (bc/BC) = (bd/BD)

Tree height (BC) = Known ruler length (bc) X Known length of pole (BD)

Ruler reading on the pole (bd)

Advantages:-

- no distance measurement is required
- height reading is not influenced by slope

Drawbacks:-

- In dense forest it is difficult to find suitable point of observation
- Only with a steady hand can serious misreading be avoided.

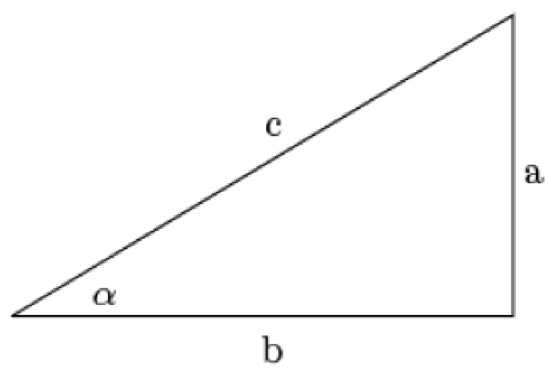
2.2. Trigonometric principles

The followings are some of the instruments used to measure tree height based on trigonometric principles.

1. Sunto hypsometer
2. Silva hypsometer
3. Haga altimeter
4. Blume-leiss
5. Sunto clinometers:

General steps (for the first 4 instruments mentioned above)

- Stand at a fixed horizontal distance from the base of the tree (usually 10, 15,20, 25 meters, and so on.
- Sight at the top of the tree and read the value 'A' (top reading)
- Again sight at the bottom of the tree and read the value 'B' (bottom reading)
- Then the total height of the tree is top reading 'A' minus bottom reading 'B'
- Bottom reading +ve or −ve (above and below eye level).



Sin α = opposite / hypotenuse; (a/c)

Cos α = adjacent / hypotenuse; (b/c)

Tan α = opposite / adjacent; (a/b)

Case 1: If the observer is on a flat terrain

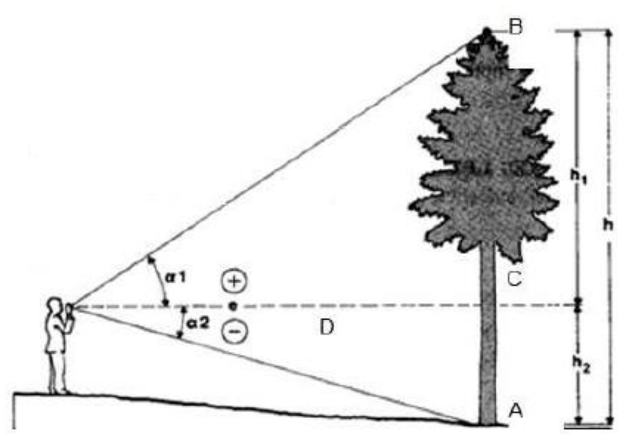


Figure 30: Tree height measurement on a flat terrain.

Tan α1 = BC / D

BC = tan α1. D

Tan α2 = AC / D

AC = tan α2. D

AB (height) = BC + AC

AB = tan α1. D + tan α2. D

AB = D (tan α1 + tan α2)

Case 2: upslope

AB = BC – AC

AB = tan α1. D - Tan α2. D

AB = D (tan α1 - tan α2)

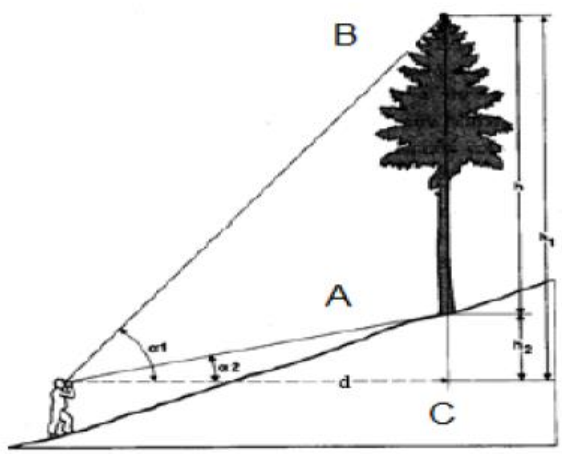


Figure 31: Tree height measurement on uphill terrain

Case 3: down slope,

When the tree base is below the eye level of the observer

AB = AC + BC

AB = tan α1. D + tan α2. D

AB = D (tan α1 + tan α2)

Example 2:

Terefa walks out a horizontal distance of 100 feet from the same tre. He looks to the top of the tree and reads "+62%" on his clinometer. He looks down to the stump and reads "-8." Find total hight of the tree? **(See Video)**.

..\Measuring Standing Trees_ Estimating.mp4

Possible sources of error in height measurement:-

1. Error from failure to correctly identify the top of the tree.

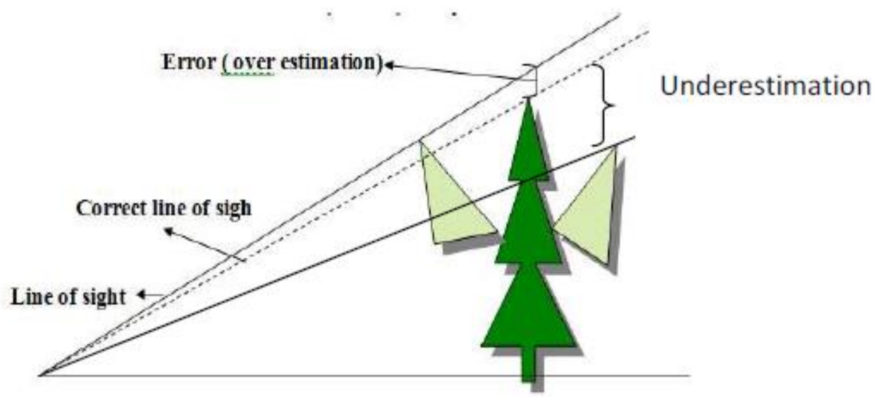


Figure 31: Error during height measurement (failure to detect correct tree top)

2. Lean tree. When the leaning is away from the observer then the value will be under estimation and the vice versa. The correct length/height BD can be calculated after the angle of the lean is determined.

BD = DB' / cosα

DB' is equal to the average of EB and FB

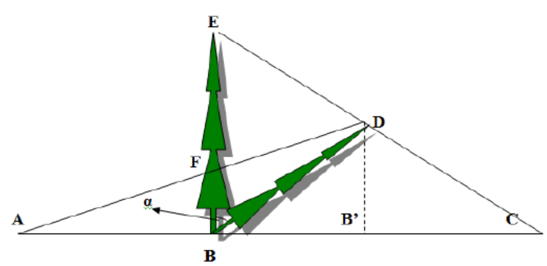


Figure 32: Error during measuring height of a leaning tree

3. If the distance is not correctly measured

4. If not reading is taken according to the scale

5. If slope distance is measured instead of horizontal distance.

Calculate volume of standing tree;-The volume of standing trees (V) is estimated using a standard formula as a function of three basic parameters i.e. Diameter at breast height (dbh), height (h) and form factor (f).

$$V (m^3) = \prod/4 * dbh^2 hf$$

The basal area is approximated by the product of ∏/4 and diameter at breast height square and multiplied with height and form factor to give volume. The form factor is used to reduce the cylindrical volume to realistic volume value that has taken the diameter changes of individual trees along the height. In circumstances where the form of individual trees is well taken into consideration, particularly when trees are felled, the actual tree or log volume could be estimated without the application of form factor. Hence, estimation of tree volume to an acceptable precision requires adequate knowledge on the shape and form of trees or logs.

Other important tree variables to be measured include:

- Bark thickness
- Crown attributes
- Form factor Etc

Self-check 1	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: True or False (4 point)

1. Clinometer and d-tape is one of the instruments used for tree height measurement

Test II: Choose the best answer (4 point)

1. The instrument commonly used for measuring diameter of tree is known as:

A. Clinometers B. Hypsometer C. Callipers D. All of the above

2. The possible sources of error in height measurement were:

A. If the distance is not correctly measured B. If not reading is taken according to the scale C. If slope distance is measured instead of horizontal distance. D. All

Test III: Short Answer Questions

1. How to calculate standing of volume of tree? (5 point)

____

2. Write advantage and dis advantage of tree height measurement? (3 point)

____

3. Write tools and equipment's used to tree height and diameter measurement? (2points)

____

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating – 15 points** **Unsatisfactory - below 15 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _____________________________ Date: _________________

Information Sheet 2- Calculating mean annual and current annual increment of stand

2.1. Mean annual and current annual increment

The mean annual increment (MAI) or mean annual growth refers to the average growth per year a tree or stand of trees has exhibited/experienced to a specified age. For example, a 20-year-old tree that has a diameter at breast height (dbh) of 10.0 inches

has an MAI of 0.5 inches/year. MAI is calculated as {\displaystyle MAI=Y(t)/t} where Y(t) = yield at time t. Because the typical growth patterns of most trees is sigmoidal, the MAI starts out small, increases to a maximum value as the tree matures, then declines slowly over the remainder of the tree's life. Throughout this, the MAI always remains positive. MAI differs from periodic annual increment (PAI) because the PAI is simply the growth for one specific year or any other specified length of time.

Volume of tree calculation:- **Tree volume** is one of many parameters that are measured to document the size of individual trees. Tree volume me**asurements** serve a variety of purposes, some economic, some scientific, and some for sporting competitions. Measurements may include just the volume of the trunk, or the volume of the trunk and the branches depending on the detail needed and the sophistication of the measurement methodology. Other commonly used parameters, outlined in Tree measurement: Tree height measurement, Tree girth measurement, and Tree crown measurement. Volume measurements can be achieved via tree climbers making direct measurements or through remote methods. In each method, the tree is subdivided into smaller sections, the dimensions of each section are measured and the corresponding volume calculated.

Calculation of the following variables including volume is important in undertaking inventories.

1. Average number of trees per plot
2. Number of trees per hectare (N)
3. Basal area of individual trees
4. Average basal area per plot
5. Basal area per hectare (G)
6. Volume of individual tree
7. Average volume per plot
8. Volume per hectare
9. Total number of trees, total basal area, total volume

Volume estimation:-

i. Calculate the volume of individual trees

Volume of individual tree= g*H*f

ii. Calculate average volume per plot

Let y_i = m^3 volume on the ith sample plots

$\bar{y}$ = estimated mean volume in m^3

n= number of trees per plot

Then $\bar{Y} = \frac{\sum y_i}{n}$

iii. Calculate number of trees per hectare (N)

$N = \bar{n} / \mathbf{a}$

Where: N = number of stems hectare

$\bar{n}$ = average number of trees in the plots

a = area of sample plot (in hectare)

iv. Calculate volume of trees per hectare

Volume per hectare = Average Volume/Area of each plot

v. Total

- Total number of trees= N*Total area
- Total BA= G*Total area
- Total volume= Volume per hectare*Total area

Method 1: Estimating volume per hectare using sample plots measurements.

- Measure the diameters of all trees in five 0.01ha sample plots and record the data.

Then calculate the basal area of the sample plots;

- Measure the mean height in the sample plots and calculate the volume;
- Estimate the volume using the formula given here under.

$$V = \frac{\sum_{}^{n} \left(\sum_{}^{mi} Vij \right)}{na}$$

Where V = Average volume per hectare, m^3 estimated from n samples each of a Hectares

Vij = Volume of an individual tree measured on the i^{th} plot felling or measured standing

Mi = Total number of trees in the i^{th} plot, 1 ---- i----n.

n = Number of plots

Growth refers to the increase of dimensions of one or more individuals in a forest stand over a given period of time, while yield refers to their final dimensions at the end of a certain period. Growth varies from year to year depending on the age of a stand and environmental variables such as rainfall. Determining the annual growth or increment of a stand allows the owner to forecast volume and productivity. Growth can be expressed as either the current annual increment (CAI) or the mean annual increment (MAI). CAI is the increase in volume at a particular age and is determined by measuring a stand annually over successive years. MAI is the average volume production per year of a stand of known age. It does not need measurements over successive years unless the point of maximum MAI is required. For growth rate to be determined, volume must be measured and put into the following formulas.

$$\textbf{MAI} = \frac{\textbf{Volume of stand (m3/ha)}}{\textbf{Age of stand (yrs)}}$$

CAI at age X = (Volume at age X) – (Volume at age X-1)

E.g. CAI at age 25 = Volume at age 25 – Volume at age 24

EXAMPLE:

Stand volume data collected annually can be used to determine how fast a plantation is growing. For the ages and measured volumes shown below and using the formulae above, the MAI and CAI are:

AGE	VOLUME (M^3/HA)	MAI	CAI
25	525	21	NA
26	620	23	95
27	705	26	85
28	755	27	50
29	790	27.2	35

A model is an abstraction, or a simplified representation (graphical, physical or mathematical) of some aspect of reality. It is often designed to represent but not to fully duplicate or imitate reality. In consequence modelling is an attempt to approach understanding of some aspects of the actual situation. A forest growth model, therefore, describes or portrays the development of tree crops as they increase in age, or as time changes. Regardless of the design, all forest models have one or more of the following objectives:-

- to predict the growth of the forest so that the manager may compare his harvesting and felling plans against the prediction of growth and conclude whether he is cutting more or less than, or an amount equal to growth;
- To predict the growth on a particular site to enable the land manager to make rational decisions following conversion into economic terms so enabling comparisons of a number of feasible investment options.
- to predict the growth of crops under different management regimes and silvicultural practices in order to make comparisons and a choice; for example to choose the best original spacing, rotation period, timing and intensity of thinning, etc. and to predict work programs, budgeting costs and revenues.

Self-check 2	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Write forest models objectives (5 point)

____

____

2. Write the difference between MAI and CAI?. (3 point)

____

____

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: _______________

Information Sheet 3- Determining cost-benefit analysis

Costs of a forest inventory are generally a costly undertaking, hence explicit planning and real need is a necessary. A cost–benefit analysis of the proposed forestry interventions was undertaken to assess economic efficiency over a period of ten years, taking into account the estimated woodfuel demand of each refugee camp, potential wood yields, the land area needed, returns on production, and the projected cost streams associated with the interventions. Various components of costs and benefits were identified and valued based on production potential and prevailing market prices. Table below presents a summary of the costs and benefits used in the cost–benefit analysis for each of the three forestry interventions. A cost-benefit analysis is a systematic process that businesses use to analyze which decisions to make and which to forgo. The cost benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action. Some consultants or analysts also build models to assign a dollar value on intangible items, such as the benefits and costs associated with living in a certain town.

The Cost-Benefit Analysis Process

A cost-benefit analysis (CBA) should begin with compiling a comprehensive list of all the costs and benefits associated with the project or decision.

The costs involved in a CBA might include the following:

- Direct costs would be direct labor involved in manufacturing, inventory, raw materials, manufacturing expenses.
- Indirect costs might include electricity, overhead costs from management, rent, and utilities.
- Intangible costs of a decision, such as the impact on customers, employees, or delivery times.
- Opportunity costs such as alternative investments, or buying a plant versus building one.
- Cost of potential risks such as regulatory risks, competition, and environmental impacts.

Benefits might include the following:-

- Revenue and sales increases from increased production or new product.
- Intangible benefits, such as improved employee safety and morale, as well as customer satisfaction due to enhanced product offerings or faster delivery.
- Competitive advantage or market share gained as a result of the decision.

a) Type of information Required: General information on areas of the important forest types can be obtained relatively cheaply from aerial photographs. In contrast terrestrial forest inventory is very expensive particularly if various detailed information is sought. Hence, the intensity and quality of the selection of representative samples requires careful supervision.

b) Standards of Accuracy: The greater the degree of accuracy required, the greater the percentage of the forest that has to be sampled. The reduction of the standard error by half requires approximately four times as many samples.

c) Size of Area to be surveyed: The cost per unit area for aerial photography will be less the larger the zone photographed. If individual estimates to a prescribed degree of accuracy are required then it is cheaper to have large blocks of forest rather than small ones. Assessment of financial costs of the proposed interventions was calculated using preliminary estimates of investment and operational costs.

Net present value

To calculate the NPV, all the annual net costs or benefits over the prescribed lifespan of a project or undertaking are first discounted at a preselected rate. These are then summed as a single indicator of project long-term value as estimated at the time of implementation. Sang (1988) presents the following formula for calculating the NPV:

$$NPV \sum_{t=0}^{r} (B_t - {}^{C}/_{t})/(1 + r)\, t$$

Where: B are the benefits in year *t,*

C are the costs in year *t,* and

r is the selected discount rate.

Benefit/cost ratio:- In the calculation of the BC ratio, all the significant effects of a proposed project are first identified and quantified. These effects are subsequently categorized as either benefits or costs, valued by year, and then discounted at the preselected rate. The total discounted project benefits are finally summed and divided by the sum of the discounted costs to obtain a BC ratio:

$$\frac{Benefit}{cost\ ratio} = \frac{Tatal\ discount\ benefit}{Total\ discount\ cost}$$

For example, a project with total discounted benefits of $30 million and $20 million in discounted costs would have a BC ratio of 1.5. If the ratio is greater than one, the project is estimated to provide a positive net return. projects of different sizes. There are also corresponding disadvantages. As with the NPV, the calculation of the BC ratio requires the controversial preselect ion of a discount rate. In addition, the criterion is very sensitive to the original definition and valuation of project benefits and costs. This is particularly so when there are associated costs outside the actual project boundary for such essentials as the development of marketing systems or road infrastructure construction.

Internal rate of return:-The internal rate of return (IRR) theoretically calculates the maximum rate of interest that a project can repay on loans while still recovering all investment and operating costs. Put in other words, the IRR determines the earning power of the money invested in a particular venture. In actual calculation, it is that discount rate which will make the discounted total benefits and costs of an enterprise equal. Randall (1987) mathematically defines the IRR as:

E (B t - C t / (1 + p)' = 0**,**

t = 0

Where: B are the benefits accruing in year *t,*

C are the costs accruing in year *t,* and

p is the internal rate of return.

Self-Check – 3	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Write factors, which influence the cost of an inventory?

____

____

2. Identify cost and benefit in forest intervention?

____

____

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 2- Field technique for measuring tree diameter

- **Procedure measuring DBH**:-

1. Determine where DBH is on your body and then use that point as a reference for locating DBH on each tree.
2. Make sure the d-tape is level, at right angles to the tree trunk.
3. Use a d-tape, "hug the tree" to wrap the tape around it.
4. Determine DBH, always record measurements to the precision of the instrument being used.
5. Guess the DBH before measuring it. You will be amazed at how quickly your eyes calibrate.
6. Work safely with the d-tape.
7. Brought data are back to the office, diameters may be placed into their appropriate diameter classes.
8. Collect field data, when working with a partner, echo back your measurements to make sure the correct number is written down or entered into the data collector.

Table 2: Table sheet format of DBH

plot 1.	dbh(cm)				Height(m)		Height(
Tree no.	dbh1	dbh2	average	g(m2)	TR	BR	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hour. The project is expected from each student to do it.

Task-1;- Identify and check tools and equipment used for diameter measurement?

Task-2;- Conditions or situation for the operation?

Task-3;- Precautions required for tree diameter measurement?

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 3- Field technique required for tree height measurement

- **Procedure of estimating total tree height of tree:-**

1. Walk to where one can clearly see the tree top.
2. Do not always rely on that magical distance of 100 feet.
3. Dense the canopy, it may be difficult to discern which top belongs to the tree you are trying to measure.
4. Walk good rule of thumb is to out a distance that is approximately equal to the tree's height.
5. Determine height, always record measurements to the precision of your instrument.
6. Make sure your run measurement is a horizontal distance, not a slope distance.
7. On slopes, walk out from the tree along the contour.
8. In a pinch, it may be necessary to walk either uphill from the tree or downhill from the tree.
9. Situations with very thick brush, it may be impossible to see the stump of the tree.
10. Collect data, when working with a partner, echo back your measurements.

Table 3: Table sheet format of tree height

plot 1.		**dbh(cm)**			**Height(m)**		**Height(**
Tree no.	**dbh1**	**dbh2**	**average**	**g(m2)**	**TR**	**BR**	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

LAP TEST	Performance Test

Name…………………………… ID……………………………..

Date……………………………………

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hour. The project is expected from each student to do it.

Task-1; - Identify tools and equipment for tree height measurement?

Task-2; - Write situation (precaution) the required for the operation?

Answer Sheet

Score = ____________

Rating: _____________

Name: _________________________ Date: _______________

LG #86	LO# 5- Record data in data base management system

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Collecting Data • Encoding , analyzing and interpreting Collected data • Available Information to users This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Collect Data • Encode , analyze and interpret collected data • Available Information
Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. 4. Accomplish the “Self-checks” which are placed following all information sheets. 5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks). 6.If you earned a satisfactory evaluation proceed to “Operation sheets 7.Perform “the Learning activity performance test” which is placed following “Operation sheets” , 8.If your performance is satisfactory proceed to the next learning guide, 9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Collecting Data

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. Data collection is a systematic process of gathering observations or measurements. Whether you are performing research for business, governmental or academic purposes, data collection allows you to gain first-hand knowledge and original insights into your research problem. Data collection is defined as the procedure of collecting, measuring and analyzing accurate insights for research using standard validated techniques while methods and aims may differ between fields, the overall process of data collection remains largely the same. Before you begin collecting data, you need to consider:

- The type of data that you will collect

The methods and procedures you will use to collect, store, and process the data. The most critical objective of data collection is ensuring that information-rich and reliable data is collected for statistical analysis so that data-driven decisions can be made for research. Inventory field work is to be implemented for all states within a period of 1.5 years to be in line with the ten-year-frequency of the NFIs. Field test has proven that the measurement of one sample unit can easily be done in 3 to 4 hours. Taking into consideration the time required to reach the unit, an average of 2-3 days per sample unit seems an appropriate estimate for calculating the overall time required for inventory implementation.

Taking into consideration:

- days working days per inventory unit
- 5 working days per week
- 40 working weeks per year the total number of inventory teams required is 16 teams15.

1.1. Primary information

A primary source of information is one that provides data from an original source document. This may be as simple as an invoice sent to a business or a cheque received. It may be more complex, such as a set of sales figures for a range of goods for a tinned food manufacturer for one week, or it may be a set of sales figures over several weeks and several locations. There are many examples of primary sources in many walks of life, but generally a primary source is defined as being where a piece of information appears for the first time.

1.2. Secondary information

A secondary source of information is one that provides information from a source other than the original. Secondary sources are processed primary sources, second-hand versions. Examples of secondary sources could be an accounts book detailing invoices received, a bank statement that shows details of cheques paid in and out. Where statistical information is gathered, such as in surveys or polls, the survey data or polling data is the primary source and the conclusions reached from the survey or the results of the poll are secondary sources.

1.3. Internal information

All organizations generate a substantial amount of information relating to their operation. This internal information is vital to the successful management of the organization. The information may be available from a number of sources within the organization, for example:

- Marketing and sales information on performance, revenues, markets shares, distribution channels, etc.
- Production and operational information on assets, quality, standards, etc.
- Financial information on profits, costs, margins, cash flows, investments, etc.
- Internal documentation such as order forms, invoices, credit notes, procedural manuals.

1.4. External information

An external source of information is concerned with what is happening beyond the boundaries of the organization. This covers any documentation relating to a subject area produced as a summary or detailed report by an agency external to an organization. Such information may be obtainable from government agencies or private information providers. Examples might include:

- census figures
- telephone directories
- judgments on court cases
- computer users' yearbook
- legislation, for example
- gall up polls the Data Protection A

Generally sources of information include: the internet, related books and related materials, newspapers, journals, transcripts from radio or TV programs, leaflets, photographs, Organizational rules, regulation and guidelines, Technical manuals, Workplace guidelines, Recorded documents/logo/history and other artefacts (man-made objects).

Self-check 1	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is data collection (5 point?)

____

____

2. Before you begin collecting data, what you consider (5)?

____

____

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 2- Encoding, analysing and interpreting collected data

2.1. Data encoding

Encoding is the process of converting the data or a given sequence of characters, symbols, alphabets etc., into a specified format, for the secured transmission of data. Encoding is the process of using various patterns of voltage or current levels to represent 1s and 0s of the digital signals on the transmission link. Decoding is the reverse process of encoding which is to extract the information from the converted format. In data encoding, all data is serialized, or converted into a string of ones and zeros, which is transmitted over a communication medium like a phone line. “Serialization must be done in such a way that the computer receiving the data can convert the data back into its original format,” according to Microsoft.

2.2. Data analysis and data interpretation: After identifying a research topic, doing a literature background research, focus problem, deciding on an appropriate methodology with specific purpose, designing a research plan and collecting sufficient data, the next step in the research process is data analysis and interpretation, which precedes reporting of research. Data analysis is, therefore, a process that involves examining, and molding collected data for interpretation to discover relevant information, draw or propose conclusions and support decision-making to solve a research problem. This involves interpreting data to answer research questions and making research findings is ready for dissemination. Data analysis also serves as a reference for future data collection and other research activities. During data analysis (Bala, 2005): data collected is transformed into information and knowledge about a research performed relationships between variables are explored meanings are identified and information is interpreted.

The usual step proceeding data analysis is interpretation. Interpretation involves attaching meaning and significance to the analysis, explaining descriptive patterns, and looking for relationships and linkages among descriptive dimensions. Once these processes have been completed the researcher must report his or her interpretations and conclusions” (Krueger, 1994).

Inventory Analysis: Data entry and inventory analysis shall be done in a centralized way by the FDPM in order to avoid any wrong doing or mismanagement. The contractor who does the field work must not be involved at all.

Data entry: AS already mentioned earlier, data entry is an important tool for control and a means to verify data validity. It is to be done periodically every end of the month by staff of the management unit. The data entry programme should include a plausibility test to identify wrong measurements and to avoid wrong data entry. At least two back-up files must be kept for all data recorded. One output of the data entry programme is intended to be a tree location map for each point sample.

Transformation of state-level inventory to national level

The transformation of the state-level inventory to the national level can be done in two ways: out of the total number of sample units measured a defined number of sample units are selected at random for each stratum the inventory results of each state and stratum are compiled area-weighted.

Self-check 2	Written test

Name…………………………………………… ID………………………… Date…….
Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is data encoding? (5 point)

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2. Write the difference between data encoding, analysis and interpretation? (3 point)

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You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 4 points Unsatisfactory - below 4 points**

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

Information Sheet 3- Available Information to users

3.1. Introduction

A database is an integrated collection of logically-related records or files consolidated in to a common pool that provides data for one or more multiple uses. A simple database might be a single file with many records but a database generally contains a group of files. Database management system (DBMS) is a collection of software programs that:

- Store data in a uniform way
- Organize the data in to records in a uniform way
- Allow access to the data in a uniform way

An information system (IS) is technically an integrated combination of computer hardware, software and databases used to view and manage information.

The overall objective for enterprise-wide information systems is generally to achieve a situation with

- Timely access to consistent, accurate data
- Sharing of data for collaborative decision-making
- Improved communications across departments and levels
- Reduced duplication of tasks and efforts
- Fast, efficient service to both governmental offices and the public

An information system is generally considered as a work tool. It is designed to help a user to perform certain recurrent tasks. A forest officer may have to keep track of a number of activities or events in his district and report them to a central office. The system provide tools to collect data about the activities, store the data in a database, edit data, search for and select relevant information to report and to design a report in a standardized format. A (computer-assisted) information system has four basic components: software, hardware, databases and user. The user is considered a component of the system since the users background knowledge helps to create "information" from "data". This generally means that an experienced and well educated user can get more support from a certain system than a less educated user.

3.2. Users of forest information systems

The users of information system can be found everywhere in an organization. If the systems are web based the users can be found in other organizations or in the general public.

3.2.1. Hardware:-The typical hardware for the ordinary user is a personal computer (PC). It is normally a desktop computer but lately laptops have become rather common. Officers that collect data in the field can be equipped with Pocket PCs (also called PDA, Personal Digital Assistant) combined with GPS's for collection of coordinates. Through the internal network the users generally have access to printers. A corporate system will also include one or several computers that act as servers for databases. Probably there will also be a web server.

3.2.2. Database:-A database might be one single file with many records, but a database generally contains a group of files. A meta-database is a type of database that contains data on existing databases. Information systems within a forest administration generally contain several different databases with both spatial and non-spatial data. Spatial data is information about the locations and shapes of geographic features, e.g. forest compartments, and the relationships between them, usually stored as coordinates or raster cells. Non-spatial data are data without inherently spatial qualities, e.g. tables containing timber prices. The difference between spatial and non-spatial data is not always obvious. Data collected from sample plots in a forest inventory are for instance "spatial" if they can be linked to a location of a geographic point with stored coordinates (and presented on a map), otherwise they are "nonspatial". Spatial data of the most common type (called vector), consists of a set of objects organized as thematic layers, e.g. forest stands, road net, topography, etc. The data describes both the geometry of the objects (boundaries of forest stands) and their attributes (species, age, height). A layer can be considered to be a separate database.

3.2.3. Software;-The software in an information system is generally some kind of data base management system (DBMS). Such software's have a number of modules for editing, processing and querying the database. They usually also have tools for further customization of the software for certain use cases. This means that it is possible to add scripts or program modules that support special types of queries, analyses and reports. Software that can be customized in this way is often called software platforms or a development environment. The components in an information system are generally designed according to the needs of the user or a certain group of users. Such a combination of software's, databases and hardware is called an application or just a system. A more advanced application (system) can in fact consist of several different software's as well as several databases and hardware components.

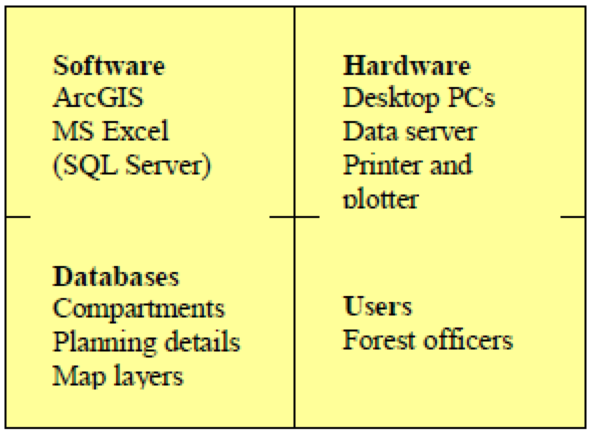

Figure33: The four components of an information system

The above figure is an example of the components of a Forest Information System Commercial applications of forest information systems are generally built with GIS platforms, e.g. ArcGIS, since a great deal of the data used in monitoring are spatial (maps of different kinds). Some applications are however built primarily on standard DBMS platforms, e.g. SQL Server. In both cases there is generally an interface to the other type of software. This means that GIS based applications have interfaces to a standard DBMS for storage of non-spatial data and that DBMS based applications have interface to a GIS or mapping software for display of maps. Systems based on GIS software were originally introduced in most developing countries as a tool for map production. Digital ortophotos and satellite images were used for interpretation of borderlines of forest types. These were digitized by the systems and the data became the starting point for cartographic databases.

The databases are generally the most important components of information systems. Without reliable data they are useless. Data collection is usually tedious and costly and system managers therefore try to access as much data as possible from existing relevant sources. For GIS applications it is usually possible to acquire useful spatial data from other authorities. Data accessibility has otherwise been improved for GIS users in most countries during later years thanks to various data sources that are available via Internet. Several portals have emerged from which GIS datasets and satellite images can be downloaded freely, for instance the GeoNetwork mentioned above. For ArcGIS users a service called ArcGIS OnLine was introduced recently. This service provides high quality base maps to GIS applications all over the world through a streaming dataflow. A disadvantage is that users of these base maps need a good connection to Internet.

3.2.4. Inventory and Database Administration

Administrative office support for forest inventories and database management should be as carefully organized as are other aspects of forest management. The planning and practical implementation of inventories and the processing of inventory data are a forest operation, comparable with protection, harvesting, silviculture and other forest operations. The practical steps required for inventory and database administration are:

- Appointment of a senior forester responsible for inventory, database management and yield modelling activities.
- Adequate long-term funding for salaries, logistical support, staff training, equipment and other arrangements to enable an inventory programme to proceed efficiently.
- Thoughtful planning of all aspects of inventory and database management, including objectives, technical design, staffing, logistical arrangements and time schedules.
- Appropriate in-company or external training of all personnel who are involved in inventory and database management.

Self-Check – 3	Written test

Name…………………………………………… ID………………………… Date……

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. List source of information (4)?

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2. Differ between primary and secondary source of information (4)?

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Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Reference Materials

Book:

1. [FS] The Forest Service. 1990. Timber cruising in the Pacific Northwest. USDA Forest Service Pub. R6-TM-TP-023-90. 87 pp
2. Dutrieux, L.P., Verbesselt, J., Kooistra, L. & Herold, M. 2015. Monitoring forest cover loss using multiple data streams: a case study of a tropical dry forest in Bolivia. ISPRS Journal of Photogrammetry and Remote Sensing, 107: 112–125. doi:10.1016/j. isprsjprs.2015.03.015.
3. Fletcher, R.A., W.H. Emmingham, and S. Woodard. 1993. Stand volume and growth: getting the numbers. In The Woodland Workbook, Forest Measurements. OSU Extension Cir. 1190. 23 pp.
4. Gray, H.R. (1956). "The form and taper of forest-tree stems" (PDF). Imperial Forestry Institute Paper No. 32, University of Oxford.
5. Howard, A. F. & Valerio, Juvenal. 1962. A Diameter Class Growth Model for Assessing the Sustainability of Silvicultural Prescriptions in Natural Tropical Forests. Commonwealth Forestry Review. Vol 71 (3/4).
6. Husch, B. 1971. Planning a Forest Inventory. FAO Forestry Series No, 4. and FAO Forestry
7. Kleine, M. Heuveldop, J. 1993. A Management Planning Concept for Sustained Yield of Tropical Forests in Sabah, Malaysia. In "Forest Ecology and Management". Vol. 61, pp. 277-297. Elsevier Science Publishers, Amsterdam
8. L. J. Moores; B. Pittman; G. Kitchen (1996), "Forest ecological classification and mapping: their application for ecosystem management in Newfoundland", Environmental Monitoring and Assessment, 39 (1–3): 571–577, doi:10.1007/bf00396169, PMID 24198030, S2CID 206779166.
9. Zeriihun Asrat and Yemiiru Tesffaye.2013. traiiniing Manual on:forest Iinventory and management Iin the Context Of Sfm and Redd+
10. , T. and Stephens, N.C. 2003. Tree measurement manual for farm foresters. Second edition, edited.
11. 4. Adlard PG, 1990. Procedures for Monitoring Tree Growth and Site Change. Oxford Forestry Institute Tropical Forestry Paper No. 23.

WEB ADDRESSES

1. Free eBook: The ultimate guide to conducting market research
2. ..\Measuring Standing Trees_ Estimating.mp4

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