TROPICAL
FORESTRY
PAPERS
38

Participatory Inventory

A Field Manual Written with Special Reference to Indonesia

by
M.C. Stockdale
J.M.S. Corbett

OXFORD FORESTRY INSTITUTE
DEPARTMENT OF PLANT SCIENCES
UNIVERSITY OF OXFORD
1998

FORESTRY RESEARCH PROGRAMME

Addendum by authors

The strength of this manual lies in the overall process it describes for conducting a participatory inventory, and in the many practical tips it provides for working with communities.

However, in retrospect, we feel the manual is too prescriptive in promoting one sampling design (i.e. the use of inventory lines, also known as 'strip sampling'). We urge you to explore other sampling designs that might be better suited for your particular situation (such as stratification, multi-stage sampling, simple random sampling, systematic line plot sampling…). The range of options available to you will be outlined in any standard forest inventory manual.

In the sampling design promoted in this manual, an error was made in calling contiguous plots along the inventory line 'plots'. If they are lined up end to end like this, they cannot be considered as distinct 'plots'. To be statistically correct, you should use the lines as the plots, in other words, each inventory line is a separate 'plot'. Just call all 10 x 10 m subplots along the line 'subplots' and don't sum them up into five-subplot 'plots'. Using the lines as plots (rather than groups of five subplots) will considerably reduce the total number of plots completed in a given inventory, this will decrease (but reflect more accurately) the level of precision of the estimate.

Errors in participatory inventory manual

p. 71: Para 3/Figure 6.3 heading: delete 'or reduce'

p. 86: Para 1 of Example 7.1; delete 'over' in the sentence 'amounting to (over) 314 gardens'

p. 87: Delete: '(if enumerating timber species only, the lines should be spaced 20 metres apart)'

p. 88: Delete: '(2.0 hectares if lines are 20 metres apart)' and '(3.0 hectares if lines are 20 metres apart)'

p 96: para 2: 'as outlined in Box 7.1' (not 7.2)

p. 99: Numerical errors in Example 7.6: '70 plots have been…gives a total length of 3500 metres (70 x 50 = 3500). The map scale… allocated plots (3500) metres….

p. 174: Figure 13.7 has the wrong figure, the correct one is attached

p. 176: Figure 13.9 has the wrong figure, the correct one is attached

p. 191: Figure 15.5 has the wrong figure, the correct one is attached

p. 223: First point (5): At the beginning, cut 'The sum of the number of plants in all plots is squared, then': 'Consult the compilation form or set of forms and find the final row, titled 'total for area or forest type'. This row contains the sum of the plants in all the plots in the area or forest type. This value is symbolised by (sum symbol)y. This value should be squared, then'

p. 223: Third point (7): change 'symbolised by V' to 'symbolised by Vy' (with a line over the y)

p. 224: in point 13: insert after '…size of each plot, a.' 'this is symbolised by C.'

p. 318: In the example used, the number of positions after the decimal are not consistent. It should be '10.0' plants per plot, rather than '10'.

p. 337: Box M.1 (para 3) and p. 338 (Figure M.1: on figure and in heading) change 'number of fruit' to 'root biomass'.

TROPICAL FORESTRY PAPERS

No.38

Participatory Inventory

A Field Manual Written with Special Reference to Indonesia

by

M.C. Stockdale and

J.M.S. Corbett

Oxford Forestry Institute

Department of Plant Sciences

University of Oxford

1999

Cover photo:
Villagers doing inventories in Jambi and East Kalimantan provinces, Indonesia.

Cover photo and all illustrations:
Jon Corbett

Design and desktop publishing:
Diane Braithwaite and Ken Josephson

Indonesian version of manual available upon request from the authors:
Mary Stockdale and Jon Corbett
1241-McKenzie Street
Farifield, Victoria,
B.C. V8V 2W6, Canada

Telephone: (250) 398-6139
Email: maryandjon@pacificcoast.net

The authors are forestry consultants who specialize in providing training in participatory inventory, mapping, GIS and digital multimedia.

English version of manual distributed by:
Oxford Forestry Institute
Department of Plant Sciences
South Parks Road
University of Oxford
Oxford OX1 3RB, UK

Telephone: (01865) 275000
Fax: (01865) 275074
Email: library@plant-sciences.oxford.ac.uk
WWW address: www.plants.ox.ac.uk/library

ISBN 0 85074 149 1
ISSN 0141-9668

Printed by Oxuniprint, Oxford University Press, Walton Street, Oxford, OX2 6DP

Acknowledgements

The authors have great pleasure in acknowledging the support provided by the project manager Nick Brown of the Oxford Forestry Institute, University of Oxford. We also appreciate the reviews and sound advice given by Howard Wright of the Oxford Forestry Institute and Michael Philip of the Department of Forestry, University of Aberdeen.

The authors would like to thank Alix Flavelle for her support for this project and her excellent advice when reviewing the manual. She also provided the impetus for the NGO training workshop held in East Kalimantan. Gordon Storey of the EEC - Pt. Inhutani I Berau Forest Management Project has provided invaluable support and advice at various stages of this project and an invitation to the government workshop, also held in East Kalimantan. Sara Cooke and Nunuk Kasyanto also deserve special mention for their help in reviewing and translating the Indonesian version of the manual.

We would like to acknowledge the groups and organisations with which we collaborated in Indonesia. These included (in alphabetical order) the EEC - Pt. Inhutani I Berau Forest Management Project, the ODA (now DFID) UK-Indonesia Tropical Forest Management Project, and the WWF-Indonesia Kayan Mentarang Nature Reserve Project.

This work could not have been done without the excellent assistance received in the field from Indonesian counterparts associated with some of the above organisations. Of particular mention are Trivina Adjang, A. Alvin D. Puspita, Herman Sanusi, Dedi Setiyawan, Mulya Shakti, Sijabat Muhtar, and Evi Widayati.

We would also like to thank the participants of the two participatory inventory workshops we conducted in East Kalimantan. They provided straightforward and helpful feedback that went a long way to shaping this manual. From the NGO workshop we would like to thank participants from LATIN, Lembaga Adat Asmat, PLASMA, PPSDHK, SHK, WALHI, WATALA, WWF-Kayan Mentarang, WWF-Lorenz, YTM and YKPHM. From the government workshop we appreciate the help of the participants from BAPPEDA, BLK, the Forestry Department, Pt. Inhutani I, and five villages from the Pt. Inhutani I concession.

Although their names are too numerous we would especially like to thank all the people of the three villages in which the research for this manual was based, notably Long Tebulo of East Kalimantan province, Semambu of Jambi province and Punan Malinau of East Kalimantan province. This manual could never have been completed without their enthusiasm for and evaluation of this work.

This publication is an output from a project funded through the Forestry Research Programme of the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed here are not necessarily those of DFID. Project code R6352 Forestry Research Programme.

Table of Contents

Introduction **1**

How to Use This Manual **5**

SECTION I: DECISION MAKING IN THE VILLAGE

Chapter 1: Introduce Participatory Inventory to the Villagers **9**

1.1. Prepare to introduce participatory inventory to the villagers 11
1.2. Hold a preliminary meeting with the village leaders 12
1.3. Hold an introductory general village meeting 12

Chapter 2: Determine the Inventory Purpose **25**

2.1. Prepare a general village meeting to determine the inventory purpose 27
2.2. Facilitate a general village meeting to determine the inventory purpose 27

Chapter 3: Determine the Inventory Objectives **31**

3.1. Prepare for the small group meetings to discuss the inventory objectives 33
3.2. Facilitate the small group meetings to discuss the inventory objectives 35
3.3. Prepare for a general village meeting to decide upon the inventory objectives 44
3.4. Facilitate a general village meeting 45

Chapter 4: Select the Inventory Team and Work Dates **47**

4.1. Ask the villagers to select representatives who will form the village's inventory team 49
4.2. Ask the villagers to determine the dates when the inventory work will take place 50

SECTION II: PLANNING THE INVENTORY WORK

Chapter 5: Assemble Equipment Unavailable in the Village **53**

5.1. Assemble equipment that might be difficult to find in a village 56

Chapter 6: Prepare the Planning Map **63**

6.1. Decide whether you need to make a planning map, and if so, how you will make it 65
6.2. Option 1. Making a planning map by copying, modifying and building on a map, aerial photograph or radar image 67
6.3. Option 2. Make a planning map by ground surveying 74

Chapter 7: Use the Planning Map to Plan the Inventory **83**

7.1. Decide whether you will use 100% enumeration or sampling with inventory lines 85
7.2. Option 1. Use the planning map to plan a 100% enumeration 87
7.3. Use the planning map to plan the location of the inventory lines 88

Chapter 8: Plan How to Gather Information on Plants and Their Environment ... 103
8.1 Plan how to gather information on the plants ... 105
8.2. Plan how to gather information on the environment ... 118

Chapter 9: Design the Data Form and Field Reference Sheets ... 123
9.1. Design the data form ... 125
9.2. Prepare field reference sheets ... 127

Chapter 10: Organise the Work in the Forest ... 133
10.1. Assemble equipment and supplies to take to the forest ... 135
10.2. Discuss and assign daily duties in the forest ... 136
10.3. Plan the schedule for the forest work ... 137

SECTION III: INVENTORY WORK IN THE FOREST

Chapter 11: Train the Inventory Team ... 145
11.1. Plan a training session for the inventory team ... 147
11.2. Train the inventory team to use a compass ... 148
11.3. Train the inventory team to establish the inventory line ... 153
11.4. Train the inventory team to enumerate the plants and record information on the data form ... 155

Chapter 12: Locate the Starting Point in the Forest ... 157
12.1. Choose which method to use to find the starting point ... 159
12.2. Option 1. Find a starting point by walking from a reference point ... 159
12.3. Option 2. Find a starting point by walking from an inventory line that has already been completed ... 162
12.4. Option 3. Find a starting point by using Geographic Positioning System equipment ... 162

Chapter 13: Conduct the Inventory Work ... 165
13.1. Front person: clear the trail and number the plots along the inventory line ... 168
13.2. Compass person and rope person: establish the plots along the inventory line ... 169
13.3. Enumerators: Enumerate the plants and gather information on plants and environment ... 175
13.4. Recorder: record the information on a data form ... 177

Chapter 14: Check the Inventory Work ... 179
14.1. Plan checks of the inventory work ... 181
14.2. Conduct the checks ... 182
14.3. Assess the checks ... 182

Chapter 15: Collect Botanical Specimens ... 185
15.1. Collect the botanical specimens in the forest ... 187
15.2. Preserve the botanical specimens ... 197

SECTION IV: PRESENTING THE RESULTS OF THE INVENTORY

Chapter 16: Prepare the Final Maps 195

16.1. Prepare a final base map 197

16.2. Prepare the final map(s) 201

16.3. Calculate the size of the inventory area and its subdivisions from the final base map 204

Chapter 17: Compile Data and Make Calculations 215

17.1. Compile the inventory data 217

17.2. Calculate the density and quantity of the forest resources, as well as their precision, if desired 219

Chapter 18: Write the Final Report 227

18.1. Write the final report 229

Chapter 19: Present the Results to the Villagers and Plan Follow Up 233

19.1. Prepare a general village meeting to present the inventory results to the villagers and facilitate a discussion of follow up activities 235

19.2. Facilitate a general village meeting 235

APPENDICES

Appendix A: Planning and Facilitating Village Meetings 241

A.1. Two types of village meetings and when to use them in participatory inventory 242

A.2. Planning village meetings 243

A.3. Facilitating village meetings 245

Appendix B: Gathering Information About the Village 248

B.1. Decide what information you need to gather about the village 249

B.2. Gather this information using Participatory Rural Appraisal (PRA) techniques 251

Appendix C: Making a Sketch Map 260

C.1. Prepare to make a sketch map 261

C.2. Make a sketch map 261

Appendix D: Balancing Cost and Precision 263

D.1. A general procedure for balancing cost and precision 264

D.2. Make the approximations necessary for balancing cost and precision before the inventory work 266

D.3. (Optional) Make the calculations necessary for balancing cost and precision after one week of inventory work 268

Calculation Form D.1 272

Appendix E: Information and Analyses Needed for Some Inventory Purposes 273

E.1. Information and analyses needed for some inventory purposes 274

Appendix F: Five Features of Maps 281

F.1. Scale 282
F.2. Orientation 284
F.3. Grid reference and co-ordinates 286
F.4. Legend 287
F.5. Date 287

Appendix G: Scale Maps, Aerial Photographs and Radar Images 288

G.1. What are scale maps, aerial photographs and radar images? 289
G.2. How to find scale maps, aerial photographs and radar images 291

Appendix H: Surveying Techniques 293

H.1. Measuring horizontal distance 294
H.2. Measuring direction with a compass 299

Appendix I: Why We Have Chosen to Sample with Inventory Lines 309

I.1. Why we chose systematic strip sampling (i.e. sampling with inventory lines) 310
I.2. Why we chose our inventory line orientation 315
I.3. Why we chose our plot size 316

Appendix J: The Student's t-Table and How to Use It 317

J.1. What is the student's t-table? 318
J.2. How to use the Student's t-table 319

Appendix K: Measuring Plant Size 320

K.1. Measuring the diameter at breast height 321
K.2. Measuring or estimating the height 324

Appendix L: Planning, Conducting and Analysing Regeneration Studies 328

L.1. Plan the regeneration studies 330
L.2. Conduct the regeneration studies 330
L.3. Analyse regeneration studies 332

Appendix M: Planning, Conducting and Analysing a Productivity Study 333

M.1. Plan a productivity study 334
M.2. Conduct the productivity study 340
M.3. Analyse the productivity study 340
M.4. Apply a productivity study to a range of different products 342

Appendix N: Botanical Specimen Forms ... 352

Figure N.1. Botanical specimen form for trees, climbers, shrubs and herbs ... 353
Figure N.2. Botanical specimen form for palms (including rattans) ... 355
Figure N.3. Botanical specimen form for bamboo ... 357

Appendix O: Compilation and Calculation Forms ... 358

Figure O.1. Compilation Form ... 359
Figure O.2. Calculation Form 1 ... 360
Figure O.3. Calculation Form 2 ... 361

Appendix P: Data Forms ... 363

Figure P.1. A simple tally form ... 364
Figure P.2. A full data form ... 365

Bibliography ... 367

Index ... 368

Introduction

Who this manual is for

This manual is designed for people who wish to facilitate a participatory inventory. It can be used by people who work with villagers, or by the villagers themselves. The users of the manual must have a good level of literacy and an understanding of basic mathematics.

The aim of this manual

A participatory inventory is, by definition, an inventory done with the participation or active involvement of a village. The villagers make all the crucial decisions, and are involved in all of the steps of the inventory. The role of the people who use this manual is solely that of facilitator.

The aim of this manual is to provide the facilitators with step by step instructions on how to conduct a participatory inventory, which the facilitators in turn must relay to the villagers. For each step of the method, therefore, the manual describes how to explain any new information to the villagers and how to provide them with training in any new skills.

How the participatory inventory method was developed

The authors of this manual developed the participatory inventory method from a number of sources. Initially, we developed a basic method consisting of an assemblage of techniques. These included:

- Participatory Rural Appraisal (PRA) techniques,
- Standard mapping techniques, and
- Standard inventory techniques.

These techniques, and the way in which they have been applied to the participatory inventory method, are described in more detail below.

Participatory Rural Appraisal (PRA) techniques

PRA techniques provide an efficient and flexible way of identifying development issues or problems in a village and developing solutions for them. With PRA, an outsider goes to the village in the role of facilitator. The planning and decision making is taken by the villagers and not the outsider.

PRA techniques are used at several stages in the participatory inventory method. They can be used at the outset to familiarise outsiders with the village situation, enabling them to be more effective facilitators of village meetings. They are also used by the facilitators to help the villagers to discuss and make important decisions in these village meetings about:

- Whether or not the villagers want an inventory,
- The purpose and objectives of the inventory, and
- Plans for follow up to the inventory.

Standard mapping techniques

Mapping is also closely linked with the participatory inventory method. An accurate map is needed in order to plan an inventory, and must be made by ground surveying if it cannot be copied from available maps, aerial photographs or radar images. However, this ‘planning map’ only needs the bare minimum of information essential for planning. During the inventory work, additional information can be gathered which will enable a more complete map to be made, if desired. This final map can be used to display the methods used in the inventory (i.e. where the villagers placed their plots) or the results of the inventory (i.e. where the forest resources were found in highest numbers).

Note: If the villagers want to use maps for purposes other than displaying inventory methods and results (e.g. for displaying village land uses, land tenure or important cultural sites), they may need to separate their mapping activities from their inventory activities. They should consider making this multiple purpose map before beginning a participatory inventory. To do this, they should consult a mapping manual such as Flavelle (1996), or seek training on how to make a multiple purpose map. However, the villagers should still try to ensure that their multiple purpose map contains the information necessary for planning a participatory inventory.

Standard inventory techniques

Standardised inventory methods are used by foresters and other professional people to quantify forest resources, usually commercial timber species, in forests under their management. In participatory inventory, some of these standardised inventory methods have been selected for use by villagers to quantify locally important forest resources, both commercial and non-commercial, timber and non-timber, in forests around the village.

Villagers can quantify forest resources by counting every plant in the forest, a process called 100% enumeration. Under some circumstances this may be a good method to use, but generally 100% enumeration almost always costs too much time, people and other resources to make it worthwhile. Alternatively, villagers can quantify forest resources by sampling. This involves marking out small areas of land called plots in the forest and counting only the plants that are found within these plots, in order to arrive at reasonably reliable estimates of total quantity with considerably less cost. Standard inventory techniques almost always use some form of sampling.

The challenge, in selecting standard inventory techniques to be recommended in this manual from the range of techniques available, was to choose those that are:

- Simple,
- Accurate, and
- Cost efficient.

The importance of all three of these aims is discussed below.

Simplicity

When conducting a participatory inventory, it is very important that all villagers involved understand the basic concepts of participatory inventory (i.e. what it is, what it can be used for, how it is done) so that they can participate in all major decision making. It is less important that all villagers understand the technical aspects of inventory (i.e. how to plan the location of the plots, or how to calculate the quantity of a resource). Nonetheless, at least some of the villagers should understand these technical aspects so that if necessary they can explain their inventory methods and results to the people to whom the results are presented.

Thus the technical aspects of inventory should be comprehensible to at least the more educated and numerate members of the village. This might preclude, for example, using complicated mathematical analyses. Technologies which require a fairly high level of training or which are expensive or difficult to obtain may also not be suitable for participatory inventory. For these reasons, the method described in this manual does not rely on the use of equipment such as remote sensing images, Global Positioning Systems (GPS) or computers, although mention is made of how these technologies can be used if they are available.

Accuracy

The accuracy of an estimate is related to the difference between an estimated value (i.e. the estimated quantity of a resource after sampling has taken place) and the true value (i.e. the actual quantity of a resource in the same area). The lower the difference, the greater the accuracy. For example, if the true number of trees in an area is 15,637 trees, an estimate of 15,600 trees is much more accurate than an estimate of 15,500 trees.

It is important to have estimates which are as accurate as possible. The main reason why villagers should want accurate results is in order to make the right decisions. If the information the villagers have obtained from an inventory is not correct, they may make the wrong decisions and jeopardise their own future use of their forest resources. Another reason why they may want to have accuracy is in order to have credibility with the people to whom they plan to present the results. If necessary, anyone can check inventory results by conducting another inventory. If the estimates from the second inventory are very different from the results of the original inventory then the results of the original inventory, and the people who obtained them, may lose credibility.

Inventory techniques which will help villagers to achieve accurate estimates have been selected for use in the participatory inventory method described in this manual. These include:

- Objective methods for selecting where to place the plots,
- Carefully defined procedures for determining whether a plant is in or out of a plot,
- Carefully defined procedures for measuring the plants,
- Thorough training in the use of these procedures, and
- Frequent checks of the work that has been completed.

Cost efficiency

The precision of an estimate is a measure of the level of confidence that you can have in an estimate, even if you do not know the true value. Precision is a statistical concept that will be defined later in the manual. To use an example of a measure of precision, an estimate of 15,600 ± 100 trees (at 90% probability) implies that in 90 cases out of 100 the true value is likely to be within the confidence limits that have been set around the estimate (i.e. in 90 cases out of 100 the true value is likely to be between 15,500 and 15,700 trees). Thus, an estimate of 15,600 ± 100 trees (at 90% probability) is more precise than an estimate of 15,600 ± 1000 trees (at 90% probability).

The precision is important because if you do not state the precision of an estimate, the villagers, and more importantly any outsiders familiar with inventories, will have no idea of how reliable the results are.

The most important practise in increasing the precision of an estimate, as opposed to increasing the accuracy, is to:

- Establish as many plots as possible in the inventory area.

However, increasing the number of plots increases the cost of the inventory. This cost includes the time, people, and resources required to establish plots and count the plants within them.

A cost efficient inventory is one in which the precision is as high as possible for a given cost. Inventory techniques which improve cost efficiency have been recommended in this manual. These include:

- A cost efficient pattern for placing the plots called 'systematic strip sampling',
- Advice on how to select a cost efficient orientation (or direction) for these plots.

How the participatory inventory method was evaluated and improved

After developing the participatory inventory method, the authors of this manual evaluated it over the course of two trial inventories conducted in villages in East Kalimantan and Jambi provinces in Indonesia, as well as subsequent training workshops conducted with people from villages, government and non-governmental organisations from across Indonesia. Consultation with villagers and other collaborators resulted in a number of improvements to the method and the manual.

This method has been developed for the particular social, economic and ecological context of Indonesia. By developing this method in Indonesia, it is likely that we have taken for granted the existence of certain conditions that may not apply to countries besides Indonesia. These may include, for example, the type of forest in which the inventory will be conducted, the type of forest resources that the inventory will be quantifying, the general education level of the villagers, or the uses to which they are likely to put their inventory results. Nonetheless, this method is likely to have relevance for other countries in Southeast Asia as well as other countries in the tropics, as long as the users of this manual bear in mind that their conditions may differ from those under which this manual was developed.

How To Use This Manual

This manual consists of a series of step by step instructions to guide the facilitator, and for later steps the inventory team, through the process of a participatory inventory. This process consists of four main stages, each of which is discussed in its own section of the manual:

I. *Decision making in the village*: Here, the facilitator helps the village as a whole to make important decisions about the inventory in a series of village meetings. These decisions include whether or not the villagers want to conduct an inventory, and if they do what the purpose and objectives of the inventory will be. The villagers also select a group of villagers to form the inventory team that will conduct the remainder of the inventory.

II. *Planning the inventory work*: In this stage, the inventory team makes all plans and preparations for the inventory work in the forest. This includes assembling the equipment, preparing a planning map, planning where to locate the plots, deciding how to measure the plants and the environment, designing a data form for recording these measurements, and planning how to organise the inventory work in the forest.

III. *Inventory work in the forest*: Here, the inventory team conducts the inventory work in the forest, including the initial training, the work itself, checks of the work, and the collection of botanical specimens of the forest resources included in the inventory.

IV. *Presenting the results of the inventory*: In this final stage, the inventory team returns to the village to sort, prepare and present the results of the inventory. They must prepare the final maps, compile the inventory data and calculate the final results, write the final report and present the contents of the final report to the villagers. They must also help the village as a whole to plan the follow up activities in a final village meeting.

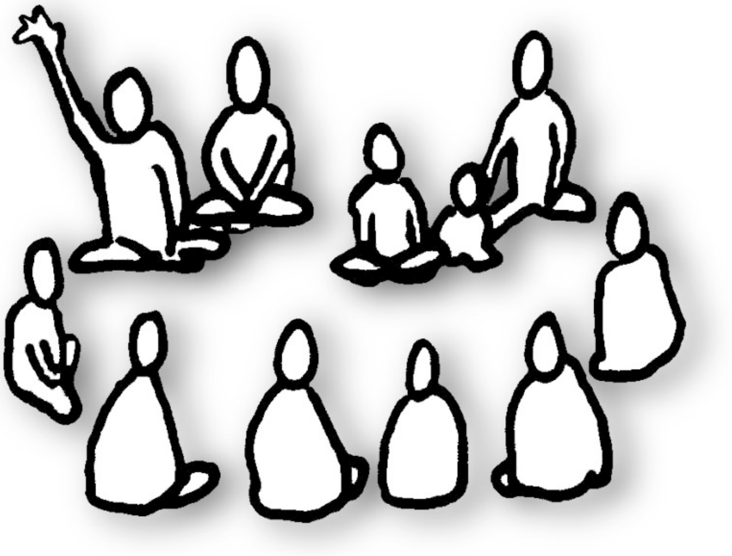
The four stages described above have been broken down into smaller steps, each of which is described in its own chapter in the manual. The step by step, or chapter by chapter, instructions for the participatory inventory method, found in the main body of the manual, have been separated from descriptions of specific skills or useful background information, which are found in appendices at the end of the manual. You will be referred to the relevant appendices at the beginning of each chapter, as well as in footnotes throughout the main body of the manual.

To use this manual, it might help to begin by reading the introductions at the beginning of each chapter in order to obtain an overview of the participatory inventory method. Then, begin at Chapter 1 and work your way through to Chapter 19.

This manual is not meant to be prescriptive. You the reader are encouraged to use your creativity to alter the process outlined in the manual in any way that might make it more appropriate to your particular situation. However, you are advised to improvise on your areas of strength, not your areas of weakness. For example, readers with much experience in working with villagers are very likely to come up with better ways of facilitating decison making in the village. However, if they do not have a background in forestry inventories, they should follow closely the manual's instructions for planning the inventory and conducting the inventory in the forest.

I

Decision Making in the Village

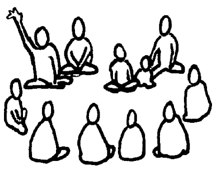


1

Introduce Participatory Inventory to the Villagers

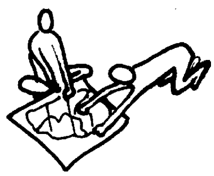
Where you are in the participatory inventory method:

I Decision making in the village



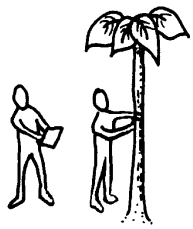
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



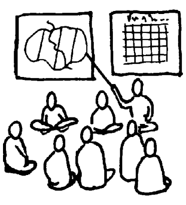
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks

1.1. Prepare to introduce participatory inventory to the villagers,

1.2. Hold a preliminary meeting with the village leaders, and

1.3. Hold an introductory general village meeting.

Skills/information required

The skills or background information that you will require can be found in:

- An overview of the participatory inventory method, obtained by reading the introductions to the chapters in this manual.
- *Appendix A*. Organising and facilitating village meetings.

Materials required

- Large sized paper, broad nib marker pens, drawing pins, other materials for preparing visual displays (optional), lighting, food and drinks.

Introduction

A participatory inventory begins with the villagers making a number of important decisions. The most crucial of these decisions is whether or not the villagers want an inventory for their village. Participatory inventory will be a new idea to most villagers. All villagers should have a basic understanding of participatory inventory before deciding whether or not they want one. This chapter discusses how to explain participatory inventory to the villagers and ask them to decide whether they are interested.

1.1. Prepare to introduce participatory inventory to the villagers

There is no single way to introduce participatory inventory to a village. Each person or group of people introducing a participatory inventory to a village will differ in their reasons for introducing the inventory, their relationship with the villagers and the amount of support they are able to provide to the inventory.

If you are planning to introduce participatory inventory to villagers, you should begin by thinking about:

- The questions the villagers are likely to have about participatory inventory, and
- The best way to present the answers to these questions.

1.1.1. The questions that the villagers are likely to have about participatory inventory

The villagers are likely to have a number of questions for you when you present them with a proposal for participatory inventory. Some of these might be:

- Who are you the facilitator (i.e. where do you come from, what organisation do you represent) and why are you proposing a participatory inventory (i.e. what is your personal motivation)?
- What is participation and why is it important?
- What is an inventory?
- What is participatory inventory?
- What type of outputs will be produced by a participatory inventory?
- What are possible uses of participatory inventory?
- What are possible misuses or risks of participatory inventory?
- How is participatory inventory done?

1.1.2. The best way to present the answers to these questions

After thinking about the questions you might be asked, you should prepare a summary of appropriate answers to these questions. You should then plan how you will present this information at the introductory meetings that you will be holding in the village.[1]

You are likely to give the same answers whatever the type of meeting. However, the way in which you present these answers may vary. For example, at the preliminary meeting with village leaders, where the atmosphere is calmer and the group more focused, you may make a verbal presentation. However, at the general village meeting, where the atmosphere is more lively and attention spans may be shorter, you may choose to make use of a wider range of techniques in order to involve and inform everybody. These techniques can include using examples chosen from the villagers' lives, drawings, diagrams, dramas, demonstrations and plenty of interaction between facilitators and villagers. You can also show photos, slides or videos from a previous participatory inventory done in another village, or bring a villager who was involved in a previous participatory inventory to explain his or her experience with participatory inventory to the villagers.

---

[1] *Appendix A provides advice on how to plan village meetings.*

1.2. Hold a preliminary meeting with the village leaders

Upon arriving in a village the facilitator, or team of facilitators, initiating the inventory should first identify the individuals and institutions which are responsible for governing the village. These may include members of the village council, elders, local government officials, teachers and/or religious leaders. You should organise a meeting with these people in order to introduce the main concepts of participatory inventory to them.

You should also ask the leaders of the village for permission to conduct a general village meeting. You should tell the village leaders that this meeting will introduce participatory inventory to all of the villagers and ask them if they want to conduct a participatory inventory.

1.3. Hold an introductory general village meeting

There is often a protocol for organising village meetings. You should find out who in the village are usually responsible for running these meetings and work with them.[2] This section describes answers to some of the questions that the villagers might ask. It also provides examples of ways in which these answers have been presented in past general village meetings.

1.3.1. Present an introduction to participatory inventory

Who are you the facilitator and why are you proposing a participatory inventory?

Villagers may be suspicious of you if you are an outsider. They will want to know what your personal motive is for either proposing or wanting to be involved in the inventory. Thus is it important that any facilitator who is new to the village:

- Introduce yourself,
- Say what organisation or group you come from, and
- Explain to the villagers why you are there.

What is participation and why is it important?

The meaning of participation (in the context of participatory inventory) is that:

- The villagers are the centre of the activity; they are the ones who make the important decisions, who plan and implement the inventory and who control and use the data and results,
- Everyone in the village is involved on an equal level in any significant decision making; in other words, each important decision is made by consensus, and
- The facilitators are there only to provide information or training. One measure of their success is whether villagers are able to conduct an inventory on their own after the training is completed.

An example of how to explain the meaning of participation is described in *Example 1.1*.

[2] *Appendix A provides advice on how to hold a general village meeting.*

Example 1.1. Explaining the meaning of participation using the example of *gotong royong*

In one village, the facilitators used the Indonesian concept of *gotong royong* to explain the meaning of participation. *Gotong royong* describes activities which villagers work on together, such as planting the rice. This illustrates some aspects of participation, because everyone in the village is involved in planning and working together on a project.

Participation is important (in the context of participatory inventory) because:

- It empowers the villagers,
- It recognises that the villagers know their history, traditions and current problems best, as well as their forest and its resources; therefore their involvement can ensure that an appropriate inventory is planned and conducted,
- It allows different people's skills and knowledge (whether physical strength, formal education or traditional knowledge) to be combined, and
- It makes the villagers better able to explain the methods and results to others, since they have conducted the inventory themselves.

What is an inventory?

An inventory is an activity that allows people to count and record the quantities of something, whether it is merchandise in a shop, people or plants. An interactive way to explain an inventory is described in *Example 1.2*.

Example 1.2. Explaining what an inventory is

In one general village meeting, the facilitators displayed a drawing that they had made of the inside of a shop. Several types of merchandise were drawn on shelves. The facilitators also displayed a blank table for recording the quantities of each item of merchandise. The facilitators asked children from the village to come forward to count the different items in the drawing and record the result in the table.

In a typical forestry inventory, people count and record quantities of a chosen forest resource or resources in a chosen area or areas.

What is participatory inventory?

Putting the above definitions together, participatory inventory is an activity in which the villagers are actively involved in counting and recording quantities of chosen forest resources in chosen forest areas. With participatory inventory the involvement of villagers extends from initial decision making about the inventory to final control over what is done with the inventory results.

Example 1.3 shows one way of clarifying participatory inventory by contrasting it with a typical forestry inventory.

Example 1.3. Comparing a typical forestry inventory with a participatory inventory

Facilitators can clarify what participatory inventory is by comparing it to a typical forestry inventory, as shown in the table in *Figure 1.1*. If some villagers are likely to be familiar with a typical forestry inventory, the facilitators can present a blank table and ask the villagers to help to fill it in.

	TYPICAL FORESTRY INVENTORY	PARTICIPATORY INVENTORY
WHO DOES IT?	LOGGING COMPANIES GOVERNMENT	VILLAGERS (POSSIBLY WITH OUTSIDE HELP)
WHERE IS IT DONE?	TIMBER CONCESSIONS NATIONAL FOREST	FOREST WHICH IS IMPORTANT TO VILLAGERS
WHICH RESOURCES ARE INCLUDED	TIMBER SPECIES	ALL NON-TIMBER OR TIMBER SPECIES IMPORTANT TO VILLAGERS

Figure 1.1. An example of a table that compares a typical forestry inventory with participatory inventory

What type of output will be produced by a participatory inventory?

Participatory inventories often result in the following outputs:

a) Maps,

b) Tables, and

c) Reports.

Maps

About inventory maps:

- Before conducting an inventory, the inventory team must obtain or make a scale map called a planning map in order to calculate the size of the inventory area and plan where to go to count the forest resources.
- After an inventory is completed, the inventory team can add information to the initial planning map. They can use the resulting inventory maps to show the methods used (i.e. the location of the inventory lines) or the results obtained (i.e. the location of forest resources).

You may want to use an example to help the villagers to understand what an inventory map is, as described in *Example 1.4*.

Example 1.4. An example of an inventory map

During an introductory village meeting, the facilitators displayed an example of an inventory results map (see *Figure 1.2*) and explained that this map shows the location of the village, rivers, watershed boundaries and different land uses. They also described how this map shows where important forest resources are found in highest concentrations.

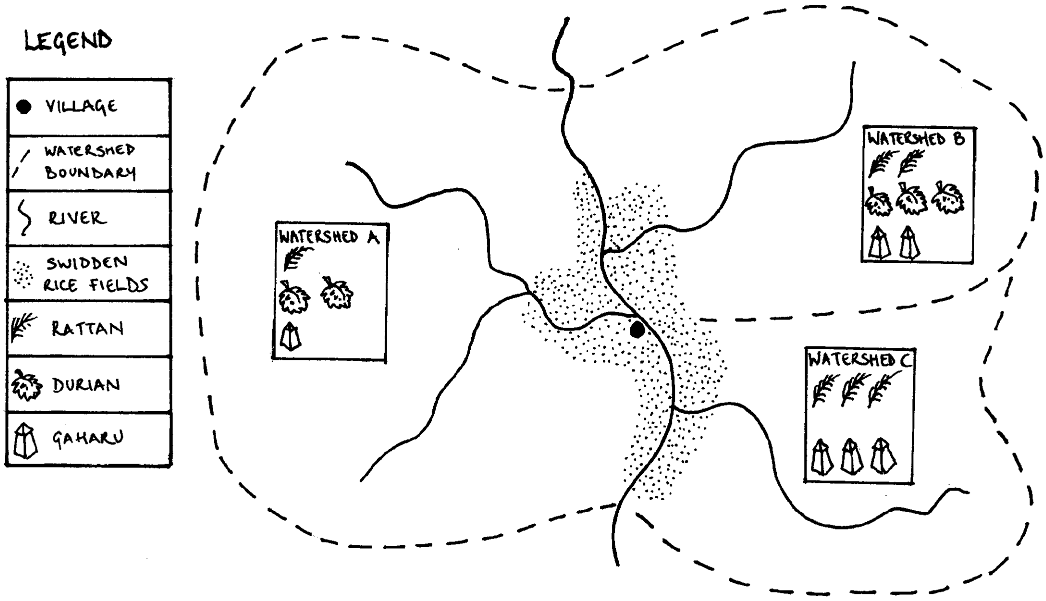


Figure 1.2. An example of an inventory results map showing the relative density of resources in each watershed.

Tables

About inventory tables:

- Tables are arranged into rows and columns so that information in each square relates to its corresponding row and column.
- An inventory table presents information about the quantities of a forest resource or resources estimated for a specific area or areas. Often the columns of a table represent forest resources and the rows represent forest areas.

You may want to use an example to help the villagers to understand what an inventory table is, as described in *Example 1.5*.

Example 1.5. Examples of inventory tables

Examples of inventory tables were shown in the same village meeting described in the previous example (see *Figure 1.3*). Care was taken not to use complex numbers. The areas mentioned in the tables were linked to those watershed areas illustrated in the inventory results map (see *Figure 1.2*). The facilitators explained the following points:

- *What the rows represent:* Each row represents a different area (or watershed) within the overall inventory area, with the bottom row representing the total for the inventory area.
- *What the columns represent:* Each column represents a different forest resource.

The facilitators also explained that in the first table (a), each cell represents the density (i.e. the average number of plants found in one hectare) of a forest resource in an area. In the second table (b), each cell represents the quantity (i.e. the total number of plants) of a forest resource in an area.

a.

AREA	RATTAN	DURIAN	GAHARU
	DENSITY		
WATERSHED A	2	2	10
WATERSHED B	6	7	13
WATERSHED C	7	0	22
AVERAGE	5	3	15

b.

AREA	NUMBER OF HECTARES	RATTAN	DURIAN	GAHARU
		QUANTITY		
WATERSHED A	2 000	4 000	4 000	20 000
WATERSHED B	1 000	6 000	7 000	13000
WATERSHED C	1 000	7 000	0	22000
TOTAL	4 000	17 000	11 000	55 000

Figure 1.3. Examples of inventory tables showing a) the density (the average number of resources per hectare), and b) the quantity (the total number of resources in each area).

Reports

An inventory report provides a written record of the participatory inventory. It may describe, amongst other things, why the inventory was conducted, the objectives, the methods used, the results (i.e. the information displayed in the inventory maps and tables) and the conclusions drawn from these results.

What are possible uses for participatory inventory?

Inventory maps display information about the location of forest resources, and inventory tables display information about the quantities of forest resources in a given area or areas. Villagers can use maps and tables as tools for communicating information about the location and quantity of forest resources to outsiders or people from within the village. Some of the possible uses for participatory inventory are listed in *Box 1.1*.

Box 1.1. Some uses for participatory inventory

1. To negotiate over rights of tenure or access to a forest area by showing which areas have the highest densities or quantities of important forest resources.
2. To negotiate over rights of tenure or access to a forest area by estimating the minimum area of forest necessary to provide a sufficient supply of important forest products to a village.
3. To predict the potential impact of a development project proposed for a forest area.
4. To demonstrate the actual impact of a development project on a forest area.
5. To describe the economic value of resources in a forest area.
6. To plan the location of forest management zones.
7. To plan a sustainable level of harvesting for specific forest resources, and
8. To plan the management of their forest (combining uses 6 and 7, above).

There are no doubt other uses for inventory results, which the villagers may identify when they determine the inventory purpose.

One way for the facilitators to illustrate these uses to the villagers is described in *Example 1.6.*

Example 1.6. Using short dramas to illustrate possible uses of inventory results

In several introductory village meetings, the facilitators used short dramas to provide the villagers with examples of how the inventory results were used in an imaginary village. These dramas proved to be very popular with the villagers, especially when local talent was drafted in! In these dramas the actors portrayed villagers using inventory maps and tables as a means of communication about their forest and its resources, in order to discuss issues such as:

- A plan to create an industrial tree plantation in a forest used by villagers, *or*
- A concern of village elders that certain resources in their forest were not as plentiful as they used to be.

The content can be tailored so that it is relevant to the situation of the village. However, it may be a good idea to show more than one drama to provide a range of ideas on how the inventory results might be used.

What are possible misuses or risks for participatory inventory?

There are potential misuses or risks in doing a participatory inventory, although some of these can be minimised. Some of these risks are listed in *Box 1.2*:

Box 1.2. Some misuses or risks for participatory inventory

1. The villagers often have a more holistic view of the forest than the people with whom they are communicating (for example, a commercial interest). There is a danger that the villagers' view will be lost when they use inventory results to communicate with other people. For example, only a limited number of forest resources can be enumerated in an inventory due to the prohibitive cost of trying to count too many resources. Thus the inventory results may under-represent the value of the forest resources to the villagers. Also, the villagers often value the forest for more than its resources. For example, the forest may have ecological value (such as watershed protection) or cultural value (such as the site of ancestors' graveyards). One solution may be to make sure these other important resources or values are mentioned in the inventory report.
2. An inventory incurs cost, because of the time and labour required. There is a risk that this cost will be wasted if the inventory results cannot be used. For example, the people for whom the results are intended may not believe that the villagers have conducted the inventory in a statistically appropriate manner and have produced credible results. One solution is to discuss the plans for the inventory (i.e. the sampling design) with these people before beginning the inventory, to see if they approve of them. Another is to invite these people to observe or be involved in the planning of the inventory or the collection of the inventory data.
3. There is a risk that some factions within the village may use the inventory results for their own benefit. The village must be sure it is unified in agreement upon how the inventory results will be used.
4. The information on an inventory map or table may also be obtained by people outside the village who will use this information for their own benefit. For example, they may use information on the location of a resource to harvest the resources themselves. If a forest resource with a high commercial value is concentrated in one place, it may be a good idea to exclude information about its location from the inventory results.

Some of these potential misuses or risks may also be highlighted in a short drama, as were the potential uses described in *Example 1.6.*

How is participatory inventory done?

Schedule of activities

During the introductory village meeting the facilitators can show the villagers a proposed schedule of participatory inventory activities. This schedule cannot be very specific about the timing, the number of people needed, etc. as the villagers will not yet have determined the purpose and objectives of the inventory. However, the schedule can contain general information about:

- The major activities of the inventory,
- How much time each activity might take (e.g. one evening, several weeks),
- Who will be involved (e.g. will this activity involve all villagers in a general village meeting or just the members of the inventory team), and
- Where the activity will take place (e.g. in the village, in the forest)

Figure 1.4 provides an example of a schedule of activities.

ACTIVITY	WHO IS INVOLVED (WITH FACILITATORS)	TIME	WHERE
MEETING WITH VILLAGE ELDERS	VILLAGE ELDERS	2 HOURS	VILLAGE
VILLAGE MEETING TO INTRODUCE P.I.	WHOLE VILLAGE	2 HOURS	VILLAGE MEETING PLACE
VILLAGE MEETING TO DETERMINE P.I. PURPOSE	WHOLE VILLAGE	1-2 HOURS	VILLAGE MEETING PLACE
SMALL GROUP MEETINGS TO DETERMINE P.I. OBJECTIVES	WHOLE VILLAGE DIVIDES INTO GROUPS OF MEN, WOMEN & YOUTHS	2-3 HOURS	VILLAGE MEETING PLACES
VILLAGE MEETING TO AGREE ON P.I. OBJECTIVES	WHOLE VILLAGE	1-2 HOURS	VILLAGE MEETING PLACE
WORK IN FOREST	VILLAGE INVENTORY TEAM	2-3 WEEKS	FOREST
CALCULATE INVENTORY DATA	SOME MEMBERS OF VILLAGE INVENTORY TEAM	1-3 DAYS	VILLAGE
FINAL VILLAGE MEETING	WHOLE VILLAGE	1-2 HOURS	VILLAGE MEETING PLACE

Figure 1.4. Example of a schedule of participatory inventory activities.

How to gather and analyse inventory data

Explaining how the inventory information is recorded in the forest and how this information is analysed in order to produce an inventory table can be approached as follows, if you think the villagers will be using sampling in their inventory[3]:

1. Explain first about the concept of sampling, using examples that come from the villagers' own lives. An example is given in *Example 1.7.*

Example 1.7. An example of sampling

The way in which facilitators explained the concept of sampling in one village went as follows:

'If we want to know how many trees there are in the forest, one way of doing this is to count every tree. However, this will take a lot of time and effort. Another option is to use a method called sampling, which involves using a few representative trees to estimate the total number of trees.'

'We all use sampling in our everyday lives. For example, if we go to our rice fields to see if the rice is ready for harvesting, we do not check every plant to see if it is ripe, as this would take too much time. Instead, we walk about the field and examine a few representative plants of the crop, maybe some in the flat area where it is wet and some on the hilltop where it is dryer. If these few representatives are ripe, we assume all the plants are ripe.'

'To sample trees, we take representatives of the trees in the forest by using something called a plot. A plot is a small area of land, for example, an area of land that is 10 metres wide by 50 metres long. We can set up a plot in the forest and count the number of trees within it. If we set up a sufficient number of plots, we can then use the information we gather from them to estimate the total number of trees in the forest.'

2. The second step is to describe how to establish an inventory plot and to count and measure forest resources within the plot. Some ideas for doing so are discussed in *Example 1.8*.

Example 1.8. Ways of explaining how to establish and enumerate a plot

The way in which a plot is established and enumerated can be explained using drawings that show a view of the plots as if seen from above (see *Figure 1.5*). Another way is by using a short demonstration, in which facilitators and helpers act out the way in which the plots are established and enumerated in the forest. Members of the audience can be encouraged to participate in the demonstration.

3 *Chapter 7 describes the conditions under which 100% enumeration may be preferable to sampling.*

Figure 1.5. Example of a drawing that can be used to explain an inventory plot

3. The next step is to explain that the plots will be set up end to end along inventory lines, and that the lines will be placed an equal distance apart, as described in *Example 1.9*, below.

Example 1.9. Ways to show the pattern of inventory lines in the forest area

---

The facilitators can use a map to show the pattern of inventory lines in the forest (see *Figure 1.6*). Another possibility is to overlay a transparent piece of plastic, on which the pattern of inventory lines has been drawn, on the map that was used as an example of inventory results.

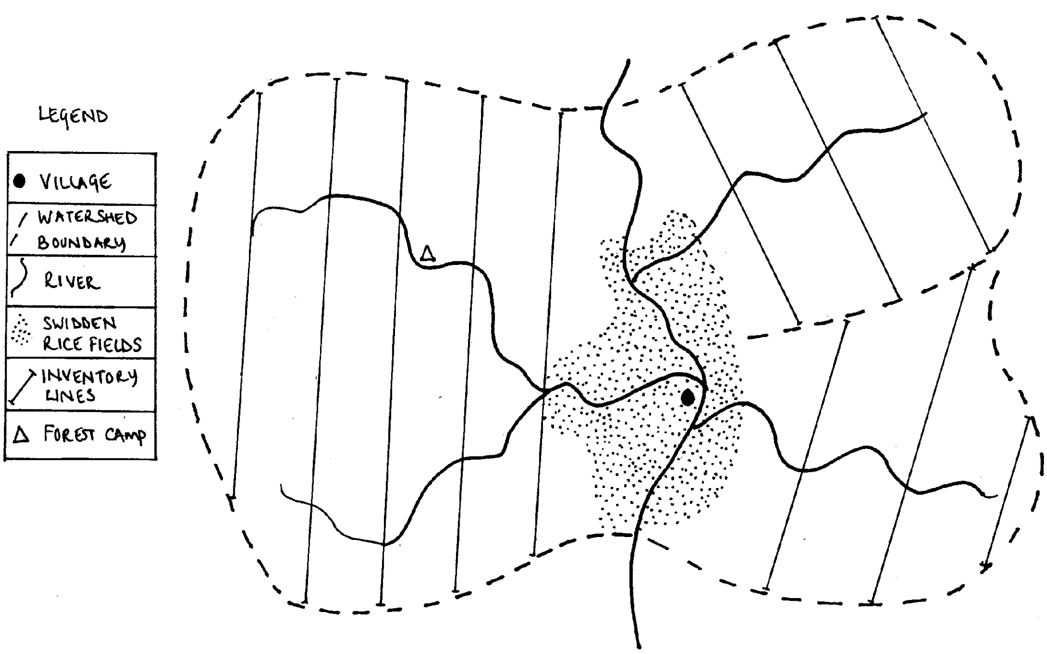


Figure 1.6. Example of the distribution of inventory lines throughout an inventory area.

4. The final step is to show how the inventory information is used to calculate the density and quantity of forest resources in a given area (see *Example 1.10).*

Example 1.10. An example of how forest resource density and quantity are estimated

The facilitators can use a very simple example to explain how the calculations are made:

An inventory team established 200 plots (each 0.05 of a hectare in size), together they added up to an area the size of 10 hectares. They counted the durian trees in all of these plots, which when added together totalled 60 trees. 'If there are 60 durian trees in 10 hectares, how many trees, on average, will there be in 1 hectare?' The answer is an average of 6 trees per hectare (60 trees / 10 hectares = 6 trees/hectare).

This answer is the density of this resource, which the facilitator can point out in a density table like the one shown in *Figure 1.3a.*

The facilitators can also explain that the second column in the quantity table shown in *Figure 1.3* represents the size of each inventory area in hectares. This value is multiplied by the density of the resource for each area in order to obtain the estimate of quantity for each area. Thus 'if there are 6 durian trees on average in one hectare, and if a specific forest is 1000 hectares in size, how many durian trees are there in the forest area?' The answer is 6 000 trees (6 trees per hectare x 1000 hectares = 6000 trees).

This answer is the quantity of the resource, which the facilitators can point out in a quantity table like the one shown in *Figure 1.3b.*

1.3.2. Ask the villagers to decide whether they want an inventory

A participatory inventory is supposed to be done by and for the benefit of the villagers. Thus it is essential that the people who initiate the inventory ask the whole village whether they feel they need an inventory and would like to take part in it. The villagers should have as much time as they want to ask questions and make comments before making a final decision.

Some questions the facilitators could pose that will focus the discussion include:

- What problems or concerns could the villagers solve with the use of an inventory?
- Are there other better ways to solve these problems?
- What are the possible risks of doing an inventory?
- Is the potential benefit of the inventory worth the risks of the inventory?

Where to next

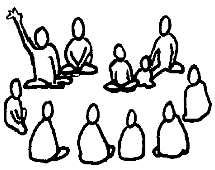
Now that the villagers have decided that they want to conduct a participatory inventory, they will need to determine the purpose of their inventory. This consists of defining why they want to conduct an inventory, what type of results will be produced by the inventory, for whom the inventory results are intended and to what uses the results will be put. This very important step is described in the next chapter.

2

Determine the Inventory Purpose

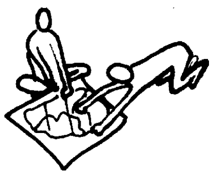
Where you are in the participatory inventory method:

I Decision making in the village



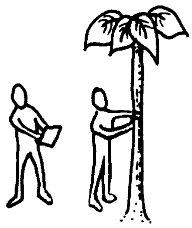
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



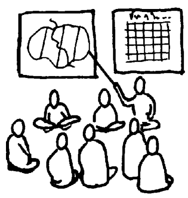
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

2.1. Prepare a general village meeting to determine the inventory purpose, and

2.2. Facilitate the general village meeting.

Skills/information required

The skills or background information that you will require include:

- *Appendix A*. Planning and facilitating village meetings,
- *Appendix B*. Gathering information about the village, and
- *Appendix E*. Information and analyses needed for some inventory purposes.

Materials required

- Large sized paper, broad nib marker pens, drawing pins, lighting, food and drinks.

Introduction

After the villagers have decided that they want a participatory inventory, their next decision is to define the inventory's purpose. Defining the inventory purpose clarifies the following:

- The reason why the inventory is being conducted,
- What type of results will be produced by the inventory,
- For whom these results are intended, and
- The uses to which these results will be put.

Determining the purpose is an important step because it provides the foundation upon which all subsequent inventory plans will be based. The facilitator should ensure that this step is conducted in as participatory a manner as possible in order that all share a unified vision from the outset of the inventory. This chapter describes how to prepare and facilitate village meetings to determine the inventory purpose.

2.1. Prepare a general village meeting to determine the inventory purpose

To prepare the general village meeting, you should:

- Make sure you are aware of the villagers' major concerns regarding the village's forest and forest resources. You can do this is by using the Participatory Rural Appraisal (PRA) methods described in *Appendix B*. You should also think about whether and how an inventory could be used to address these concerns or issues.
- Plan the general structure of the meeting.[1] Suggestions for meeting structure are provided below.
- Prepare visual displays in advance, such as:
  a) A general list of inventory uses, like the one shown in *Box 1.1*. These uses should be general rather than specific to the village situation, as it is important that the facilitator does not influence the villagers too highly in their choice of purpose. For example, one use in the list might be 'to plan a sustainable level of harvesting for certain forest resources'; there is no need to list specific resources.
  b) A blank template of the statement of inventory purpose, like that in *Box 2.1.*

2.2. Facilitate a general village meeting to determine the inventory purpose

This section describes one possible meeting structure for determining the inventory purpose.[2]

2.2.1. Introduction

The facilitator(s) should introduce the meeting by:

- Defining what is an inventory purpose (for ideas, see the introduction to this chapter),
- Explaining why it is important that the community agrees upon the purpose (for ideas, see the introduction to this chapter), and
- Describing how the meeting will be run in order to determine the purpose.

2.2.2. Describe the outputs and uses of an inventory

Sometimes the villagers may not be aware of all the potential outputs or uses of an inventory. You may want to explain the following points to them to increase their understanding.

Outputs:

- Remind the villagers that the results of participatory inventory are explained in outputs such as maps, table and reports. Use examples to explain what maps and tables are, if you wish.

---

[1] *Appendix A has information on how to plan a general village meeting.*

[2] *Appendix A contains general information on how to facilitate a general village meeting.*

Uses:

- Explain to the villagers that inventory maps and tables are used to communicate information about forest resources. Inventory maps explain about location of resources, and inventory tables explain about quantities of resources.
- Display a list of possible uses for information obtained from inventories[3] (see examples in *Box 1.1*). Remind the villagers that there may be other uses than the ones on the list.

2.2.3. Discuss the villagers' issues and concerns and how an inventory could address them

The villagers may or may not be clear about the purpose that they want for their particular inventory. You may want to use the techniques described below to stimulate discussion:

- Guide the villagers through a discussion of the major issues or concerns in the village to do with forest and forest resources. Ask them to think about present as well as possible future issues. People may be reluctant to discuss sensitive issues openly, especially in front of an outsider. You must make sure they are clear about why they are discussing these issues, which is in order to stimulate thought about how an inventory could be used to resolve them. Draw up a list of these issues or concerns, and if necessary, reduce it to the most important ones.[4]
- Ask the villagers to discuss how an inventory might help to resolve some of these major issues or concerns. This should result in a list of possible inventory uses.

2.2.4. Determine the purpose

One way for the villagers to determine the inventory purpose is to write a statement of inventory purpose, as shown in *Box 2.1*. You should explain to the villagers that they do not need to have too narrow or rigid a definition of purpose. For example, they may identify multiple uses for the inventory rather than just one. They may also find that their purpose evolves as the inventory progresses.

Your role as facilitator is to ask them for suggestions for each space in the statement, and try to ensure that everyone agrees with the final result.[5] It is important to try to achieve consensus amongst all villagers on the definition of the purpose. If desired, this statement may be signed by village leaders as proof of their support for the inventory and included in the final report.

---

[3] *Appendix E describes some of the information and analyses needed for each use.*

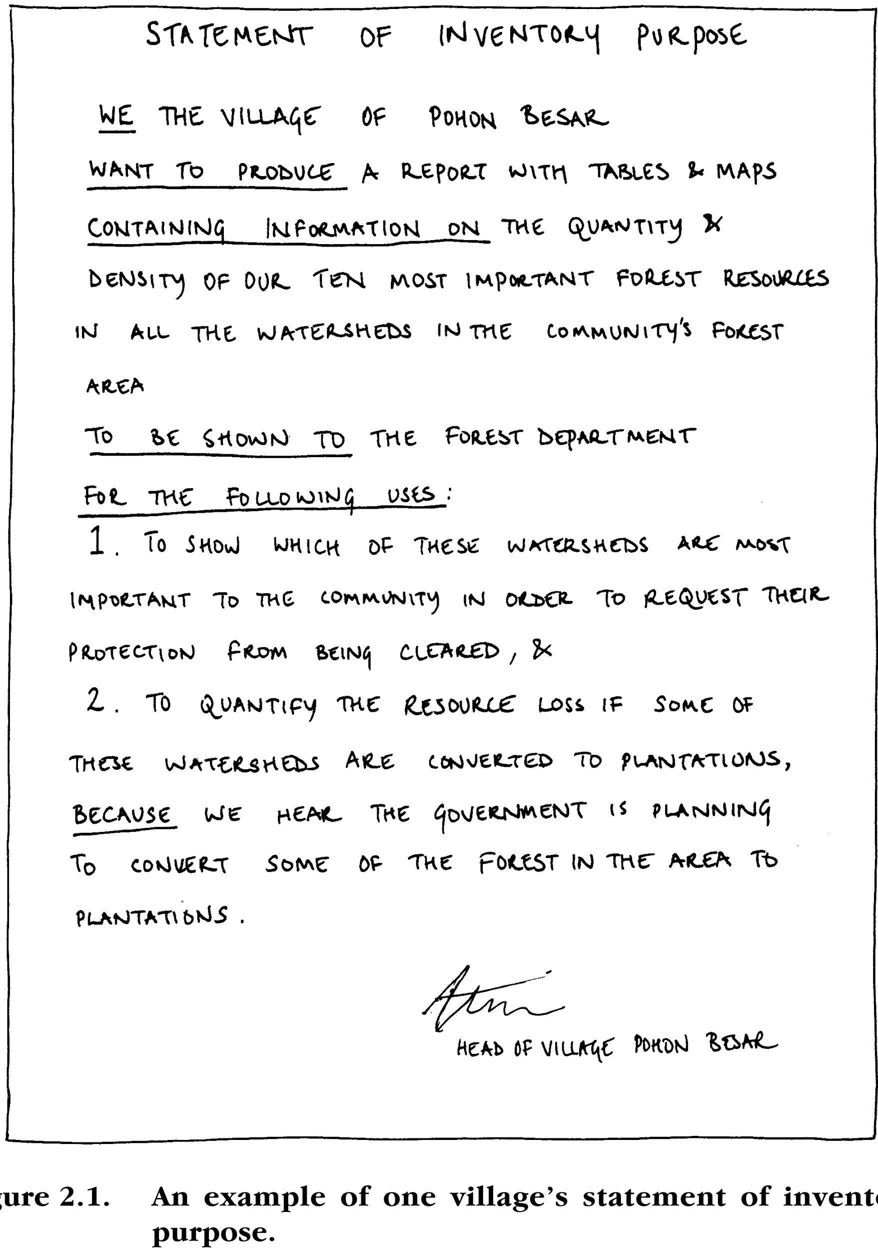
[4] *Appendix B provides advice on how to reduce a list using scoring and ranking.*

[5] *Appendix A describes how to facilitate consensus decision making.*

Box 2.1. Statement of inventory purpose

- *We* ..... (who? usually the name of the village is written here)
- *want to produce* ..... (what outputs: maps? tables? reports?)
- *containing information on* ..... (think about the kind of information these outputs will display)
- *to be shown to* ..... (think about to whom this information is intended)
- *for the following use(s)* ..... (list the uses to which the information can be put)
- *because* ..... (list concerns which may be solved by using the outputs of the inventory).

An example of a statement of purpose is shown in *Figure 2.1*.


STATEMENT OF INVENTORY PURPOSE

WE THE VILLAGE OF POHON BESAR
WANT TO PRODUCE A REPORT WITH TABLES & MAPS
CONTAINING INFORMATION ON THE QUANTITY & DENSITY OF OUR TEN MOST IMPORTANT FOREST RESOURCES IN ALL THE WATERSHEDS IN THE COMMUNITY'S FOREST AREA
TO BE SHOWN TO THE FOREST DEPARTMENT
FOR THE FOLLOWING USES:
1. TO SHOW WHICH OF THESE WATERSHEDS ARE MOST IMPORTANT TO THE COMMUNITY IN ORDER TO REQUEST THEIR PROTECTION FROM BEING CLEARED, &
2. TO QUANTIFY THE RESOURCE LOSS IF SOME OF THESE WATERSHEDS ARE CONVERTED TO PLANTATIONS,
BECAUSE WE HEAR THE GOVERNMENT IS PLANNING TO CONVERT SOME OF THE FOREST IN THE AREA TO PLANTATIONS.

HEAD OF VILLAGE POHON BESAR

Figure 2.1. An example of one village's statement of inventory purpose.

Where to next

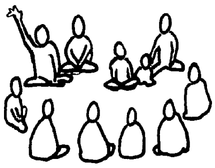
A clear sense of the purpose is very important as it provides a basis for the planning of specific inventory objectives. These objectives include the forest resources to be included in the inventory, the information desired about the forest resources, the area to be included in the inventory, the subdivisions of the inventory area, the information desired about the inventory area, the cost desired, and the precision desired. The next chapter discusses how to determine the inventory objectives.

3

Determine the Inventory Objectives

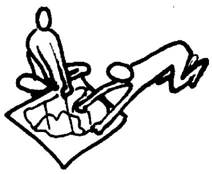
Where you are in the participatory inventory method:

I Decision making in the village



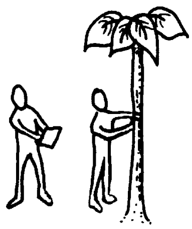
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



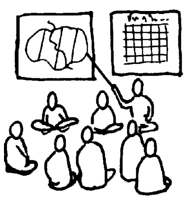
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

3.1. Prepare for small group meetings to discuss the inventory objectives,
3.2. Facilitate the small group meetings,
3.3. Prepare for a general village meeting to decide upon the inventory objectives, and
3.4. Facilitate the general village meeting.

Skills/information required

The skills or background information that you will require include:

- *Appendix A*. Planning and facilitating village meetings,
- *Appendix B*. Gathering information about the village,
- *Appendix C*. Making a sketch map,
- *Appendix D*. Balancing cost and precision,
- *Appendix E*. Further information and analyses needed for some inventory purposes.
- *Appendix L*. Planning, conducting and analysing regeneration studies, and
- *Appendix M*. Planning, conducting and analysing productivity studies,

Materials required

- Large sized paper, broad nib marker pens, drawing pins, lighting, food and drinks.

Introduction

The inventory purpose provides the foundation, and the inventory objectives provide the framework, upon which the inventory plans are based. The decisions that the villagers have made about the inventory purpose will guide them in making decisions about inventory objectives. These objectives include:

- Objective 1. The forest resources to be included in the inventory,
- Objective 2. The information desired about the forest resources,
- Objective 3. The area to be included in the inventory,
- Objective 4. The subdivisions of the inventory area,
- Objective 5. The information desired about the inventory area,
- Objective 6. The desired cost limits, and
- Objective 7. The desired precision.

This chapter describes how to prepare and facilitate small group meetings. The aim of these meetings is to provide everyone in the village with a means for greater involvement in discussing the inventory objectives. All villagers, grouped by gender, age, ethnic background or social status, should be invited to participate in these meetings because each group has a unique perspective on the forest. This chapter also describes how to prepare and facilitate a final general village meeting for making final decisions on the inventory objectives.

3.1. Prepare for the small group meetings to discuss the inventory objectives

To prepare for the small group meetings to discuss the inventory objectives,[1] you should:

- Make sure you are familiar with some background information about the villagers and their interaction with the forest. One way to do this is by using Participatory Rural Appraisal (PRA) techniques.[2]
- Think about whether the villagers will need to conduct more than one inventory in order to fulfill their inventory purpose. *Box 3.1* describes some of the situations under which more than one inventory may be required. If the answer is not apparent to you from the available information, hold the small group meetings to determine the objectives, then reassess the situation.
- Plan the general structure of the meeting. Suggestions for structure are provided below.
- Prepare visual displays in advance, such as:
  a) A completed statement of the inventory purpose (The villagers should have determined the inventory purpose already in *Chapter 2*), and
  b) A map of the village area. This should be used to discuss and record suggestions for Objectives 3 and 4 (the boundaries of the inventory area and its subdivisions). If available, and if the villagers are comfortable with using it, then a scale map should be used. Otherwise you, together with some villagers, will need to prepare a sketch map.[3] Villagers may find scale maps more difficult to understand than sketch maps.

Remember that with all visual displays and maps, one copy will be needed for each separate small group meeting, and one more for the final village meeting.

[1] *Appendix A discusses what small group meetings are and how to plan them.*

[2] *Appendix B describes how to gather information about a village.*

[3] *Appendix C describes how to make a sketch map.*

Box 3.1. How to determine whether the villagers need to conduct more than one inventory

In some situations, the villagers may need to conduct more than one inventory in order to fulfill their inventory purpose. More than one inventory is required whenever:

1. Different levels of precision are required for different estimates of resource density and quantity. Different levels of precision may be desired if there are forest areas or forest resources that differ in importance to the villagers or if the inventory has more than one use planned for it, any of which require a higher precision than the others. The way to increase precision is by placing more plots in a given area.
2. 100% enumeration is preferable to sampling in some parts of the forest area. In this case the 100% enumeration is done in a seperate inventory from the sampling inventory. The conditions under which 100% enumeration is recommended over sampling are described further in *Chapter* 7.

Example 3.1 illustrates some conditions under which more than one inventory is necessary. If the villagers decide they need more than one inventory, they must then define the purpose and specific objectives of each inventory. They will need to think carefully, when determining the cost limit objectives, how best to allocate their cost limits between the different inventories so as to achieve acceptable levels of precision for each of the inventories that involve sampling (for 100% enumeration the cost limit is fixed, and determined by the size of the inventory area, as described in *Chapter* 7). The villagers should allocate their cost limits using the procedure described in *Appendix D* as a guide.

Example 3.1. Determining whether more than one inventory is required

In Pohon Besar Village, the villagers decided to enumerate both the important timber and non-timber forest products in their secondary (logged-over) forest area, some of which had been burnt in a fire. The uses for this inventory were to:

A. Make plans to harvest the timber in the burnt forest area before the wood became rotten, and

B. Show outsiders the value of the unburnt secondary forest area to the village.

Inventory use A required a higher precision than inventory use B. This is because the local government required a 100% enumeration of all timber trees before they would give permission to the villagers to harvest the timber. Thus the villagers realised they would need to do two separate inventories:

- One inventory would be conducted in the burnt forest area, would be of timber species only and would be done by 100% enumeration.
- The second inventory would be conducted in the unburnt forest area, would enumerate both timber and non-timber forest products, and would be done by sampling so as to achieve a precision (sampling error %) of approximately 30%.

3.2. Facilitate the small group meetings to discuss the inventory objectives

Each of the small groups should be involved in discussing all of the inventory objectives.[4] However, you must use your discretion in deciding whether all groups should discuss all objectives in the same amount of detail. For example, groups who know little about the forest may have less to say about where the inventory area should be (Objective 2), or groups which are not usually involved in planning village activities (i.e. the women, the youths) may find it difficult to discuss the desired cost limits for the inventory (Objective 6).

If the discussion of a specific objective is not very productive in the small group you are facilitating, you should defer it to the general village meeting where the final decisions will be made, or the subsequent planning sessions of the inventory team. On the other hand, some small groups may be too productive, and discuss some objectives in excessive detail. Again, you may need to move the group on to the next objective, and defer any decisions about these details to a later time.

The remainder of this section describes a possible meeting structure for discussing the inventory objectives.

3.2.1. Introduction

The facilitator(s) should give a brief introduction to the meeting by:

- Putting up the villagers' statement of inventory purpose and reminding everybody that they should choose the inventory objectives with this purpose in mind,
- Explaining what the inventory objectives are,
- Explaining why it is important that everyone is involved in determining the objectives, and
- Describing how the meeting will be run in order to come up with suggestions for objectives.

3.2.2. Discuss the objectives

After the introduction, you should guide the community through a discussion of each of the seven objectives outlined below.

Objective 1. The forest resources to be included in the inventory

The first objective is to determine which forest resources the group would like to include in the inventory.

The villagers may or may not find it an easy process to select the forest resources to be included in the inventory. Much will depend upon the inventory purpose:

- The villagers may have defined an inventory purpose in which they are quite specific about the forest resources that are to be enumerated in the inventory (e.g. the purpose may be 'to plan a sustainable harvesting level for three commercial species of rattan'). In this case, determining which forest resources should be in the inventory should be relatively easy.
- The villagers may have defined an inventory purpose in which they have decided to enumerate 'important forest resources' (e.g. the purpose may be 'to show location and quantities of forest resources most important to the village in order to negotiate community forest boundaries'). In this case, you will need to guide the group through a discussion of what their most important forest resources are. One way of doing this is described in *Box 3.2.*

---

[4] *Appendix A discusses how to facilitate village meetings*

Box 3.2. How to determine the villagers' most important forest resources

Ask the small group to give you suggestions for a list of the forest resources most important to the village. It is best to have an open discussion initially. However, eventually you may want to stimulate people's memories by asking them to think about the resources in terms of the types of products which come from them. Some types of products include construction materials, weaving materials (e.g. for mats or baskets), medicines, dyes, glues, food, herbs, spices, wrapping materials, resins, fruit and nuts. Mentioning these types of products too early in the discussion might stop people from thinking independently of all possible resources, restricting themselves to the products you have mentioned.

This list of important resources can become very long. It may be necessary to reduce it to a final shortlist of the resources that will be assessed in the inventory.[5] It is recommended that no more than fifteen resources be included in an inventory, as more than fifteen become difficult to enumerate in the field. However, if more than fifteen species are considered absolutely necessary for the purpose of the inventory, the number can be higher.

During the discussion of this objective, you should try to ensure that the villagers reduce each of the forest resources that they name to the species or even the variety (sub-species) level. For example, if villagers say 'rattans' you should ask them which species of rattans they are referring to. There are a number of reasons why it is important to reduce the resource to the most specific level possible:

- Resource management must be planned at the species level,
- The economic value of the resource usually varies with the species or variety, and
- This gives the villagers the greatest flexibility, as information can be combined after an inventory has been completed, but it cannot be separated at a later date.

When the group has finished discussing the forest resources to be included in the inventory, write their suggestions on a large piece of paper pinned up in front of the group.

Objective 2. The information desired about the forest resources

The second objective is to determine what information should be gathered about each of the forest resources that have been chosen for the inventory.

The information that the villagers will need to obtain about a particular resource depends upon the purpose of the inventory. The group should think carefully about the information that they require for their particular situation, as information needs vary with the circumstances of each inventory. *Appendix E* describes the resource information needed for a number of inventory purposes. You should look up the appropriate inventory purpose in the appendix and see what information is recommended for that purpose. You can then explain these recommendations to the small group.

If the villagers have chosen a purpose for their inventory that differs from those listed in the appendix, they will have to think for themselves about what information will be useful for their purpose, using the appendix as a guide.

[5] *Appendix B describes scoring and ranking tools that can assist villagers to reduce a long list to those that are most important.*

As shown in *Appendix E*, the information that is needed about a resource can be divided into the following categories:

- Information that can be obtained from the inventory,
- Information that can be obtained from further studies described in this manual, such as productivity studies or regeneration studies, and
- Information that can be obtained from outside sources or further studies not described in this manual.

Each category is described in more detail below.

Information that can be obtained from the inventory

The villagers will need to decide:

- *The type of information.* What type of information they want to collect about the plants of the resource species (e.g. their diameter at breast height (dbh), their health, etc.), and
- *The range*. Whether they want to include all of the plants of the resource species in the inventory, or only a limited range of the plants (e.g. count all plants or only the living trees with a dbh greater than 20 cm).

Both are described in more detail below.

The type of information that is useful to record will vary with the inventory purpose. For example, the villagers may want to collect:

- No additional information.
- Information relevant to a plant's productivity. This will be important if the villagers will be conducting a productivity study.

The range of plants to include in the inventory will also vary with inventory purpose. For example, the villagers may decide that the range will be:

- Unlimited.
- Limited to productive plants only. This is usual if the villagers are wanting to conduct a productivity study.
- Limited to plants of sizes that are efficient to measure. Any benefit from the extra information obtained by including the younger or smaller plants in the inventory will have to be weighed against the extra cost incurred by having to count them. The younger smaller classes incur more cost because:
  a) They usually occur in much higher densities than the older, larger plants; costing the inventory work teams much more time in counting them, and
  b) It is often difficult to determine what species they are.

  For the purpose of planning a sustainable level of harvesting, it is important to study these younger, smaller plants. However, this is better done in a separate regeneration study.

The specific type of information required about a plant or the specific range of plants to include in an inventory will vary with resource as well as purpose. For example, a durian tree's size may be measured by its diameter at breast height but a medicinal plant's size may be measured by height. Discussing information needs resource by resource will take time. It may be important for the small groups to discuss the information needs for each resource. Or it may be better to try to keep the discussion in the small group meetings short and general, and defer discussion of these resource-specific details to the planning meetings of the inventory team.[6]

[6] *Chapter 8 discusses how the inventory team should plan the measurement of plants.*

Information that can be obtained from further studies described in this manual

For some inventory purposes, the only information that is desired about a particular resource species is information about the plants themselves. For other purposes, information is also desired about the products (such as fruit, resin, timber or leaves) which are produced by these plants. This information is usually gathered after the inventory is finished, in a separate activity called a productivity study.[7] Information from such a study can be used to estimate the amount of forest products produced in an average year in a given area.

For some inventory purposes, a regeneration study of the youngest age classes is needed as well, and the regeneration study should be repeated every one to five years.[8] Information from the regeneration studies can be used to determine whether a resource population is increasing, decreasing or stable.

Information that can be obtained from outside sources or further studies not described in this manual

For some of the inventory purposes described in *Box 1.1* of *Chapter 1*, some of the required information does not come from an inventory, or from other studies described in this manual. For example, an inventory does not provide information on market prices for a forest product, or how much of the forest product is used by a village in an average year. Describing how to acquire this information is beyond the scope of this manual.

After discussion of this objective, write the information that is wanted for each forest resource on a large piece of paper.

Objective 3. The area to be included in the inventory

The third objective is to determine the area of forest that will be covered by the inventory.

Determining this objective will once again depend upon the purpose. For some inventory purposes (e.g. for negotiating tenure or access to a forest) the villagers may want to include the entire area of forest that is important to them. For other purposes (e.g. for predicting the impact of a development project), the villagers may only want to include part of the area.

The boundary to use for the inventory area may or may not be obvious to the villagers. For example:

- There may be a well defined area which is specifically designated for the villagers' use, either by traditional or governmental law. In this case, the villagers may automatically make this area the inventory area.
- There may be different areas of forest which are used by different groups of villagers in different ways, but which are not designated for the villagers' use by any traditional or governmental law. In the latter case each of the small groups may need to discuss what forest areas around the village they use and therefore wish to include in the inventory. It will help the discussion to ask people in each of the small groups to draw on a map the places where they tend to gather the resources that they have chosen for the inventory.

At the end of this discussion, you should ask the villagers to draw the boundary of the inventory area on whatever sketch or scale map has been prepared for the meeting.

---

7 *Appendix E describes how to plan, conduct and analyse a productivity study.*

8 *Appendix L describes how to plan, conduct and analyse regeneration studies.*

Some areas may need to be excluded from the inventory area. These may be:

- *Areas which are not forest*. The small groups may need to define 'forest'. For example, should solitary trees in cleared fields be considered a type of forest or not?
- *Areas of forest which the villagers do not wish to include*. There may be areas of forest that the small groups will not want to include because they are:
  - Inaccessible (e.g. an area of extremely steep terrain),
  - A forest type which the villagers are not interested in for the purpose of the inventory (e.g. early succession rice fields, peat swamp forest), or
  - Under a system of tenure or use which makes them not relevant for the purpose of the inventory (e.g. forest owned by other villages not participating in the inventory, sacred groves, etc.).

You should ask the small group to indicate, on their map of the inventory area, the areas which are not forest or which they do not wish to include. If the villagers do not know the exact location of the boundaries, ask them to draw their approximate location. Information collected while doing the mapping or inventory work can be used to improve the accuracy of the map.

Keep in mind that the inventory area may range from being one continuous forest with 'islands' of cleared areas, to 'islands' of forest within one large cleared area.

Objective 4. The subdivisions of the inventory area

The fourth objective is for the villagers to determine the subdivisions of the inventory area.

The choice of whether and how to subdivide the inventory area will depend upon the inventory purpose.[9] There are two ways in which the forest can be subdivided, by area and by type, as discussed below.

Subdivision by area

One way to subdivide an area is into any smaller, geographically distinct areas for which you want to obtain separate estimates of resource density and quantity. Subdivision by area is recommended if the purpose is:

- **Purpose 1**. To negotiate for tenure or access to a forest by demonstrating which areas are most useful to the village. The villagers will want to subdivide by area in order to obtain separate estimates of resource density or quantity for each area.

Some ways in which villagers can subdivide by area are by:

- Watershed (see *Figure 3.1a*),
- Block, if the area has roads or survey lines cut in some sort of grid pattern (see *Figure 3.1b*),
- A specified distance to either side of a road or a river (see *Figure 3.1c*), and
- Separate islands of forest in the village area.

[9] *Box 1.1 in Chapter 1 lists some possible inventory purposes.*

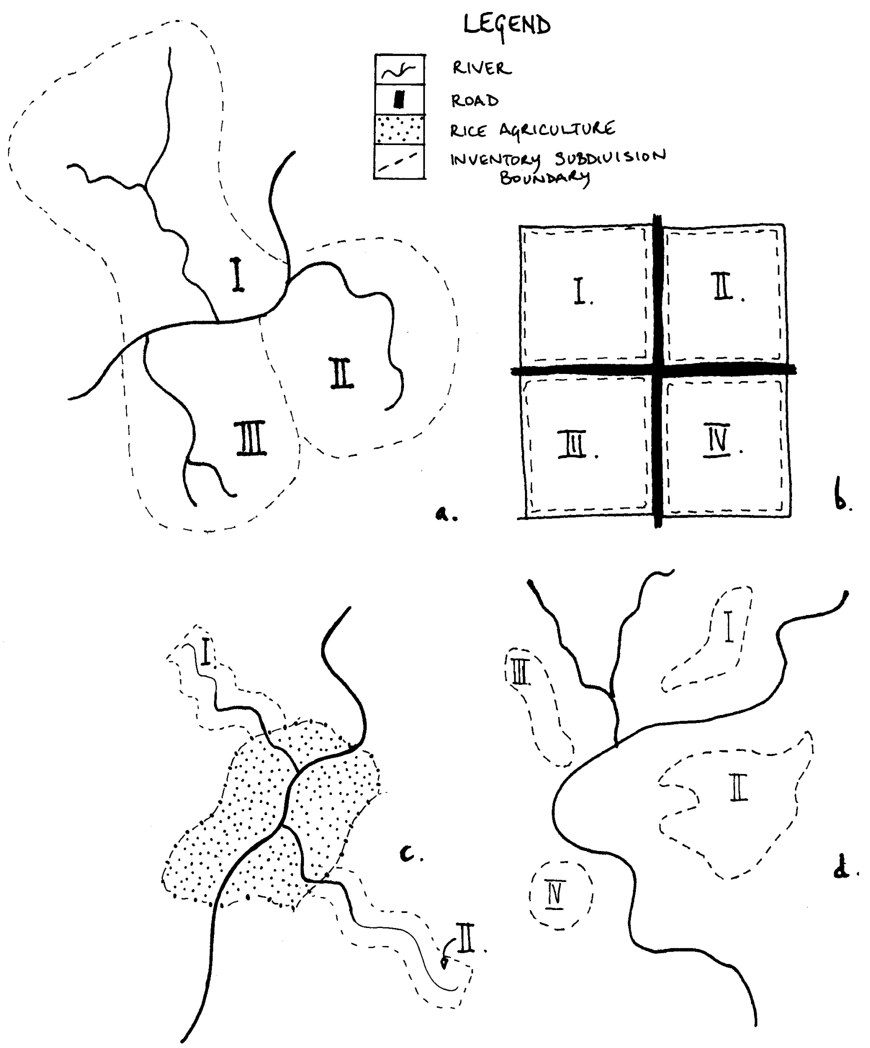


Figure 3.1. Inventory areas subdivided by area, including by: a) watershed, b) block, c) areas encompassed by a specified distance from a river, and d) separate islands of forest.

Subdivision by forest type

Dividing the forest into distinct forest types is recommended for some inventory purposes, such as:

- **Purposes 2, 3 (optional), 4 (optional), 5, 7 and 8**. All purposes for which a productivity study is necessary. Subdivision by all distinct forest types should improve the accuracy of any estimates of product quantity, as forest type often has an influence on the productivity of plants.
- **Purpose 3**. Assessing the impact of a development activity. Subdivision in this case should be into forest affected and unaffected by the development activity.
- **Purpose 4**. Planning the location of forest management zones. The villagers may wish to make distinct management zones of certain forest types. They will need to decide what criteria they want to use for planning zonation. For example, they may decide to zone areas according to their potential for resource productivity, or their sensitivity to disturbance.

If subdivision by forest type is required, the small group should discuss what kind of forests there are within the inventory area. There are many ways in which forests may be divided into types. These include types of:

- Human management (e.g. agroforests, primary forests, secondary forests affected by or at different stages of recovery from swidden agriculture or logging (either by villagers or industries)), and
- Topography, soil type or vegetation (e.g. montane forest, peat swamp forest, lowland dipterocarp forest).

An example is provided in *Figure 3.2*.

These forest types must have distinct boundaries in order that subdivision of the area is clear. This may not be possible in some situations. For example, in very old abandoned fruit tree gardens, the fruit trees may have dispersed and spread far into the forest surrounding the original area, making the location of the boundary difficult to determine.

After deciding whether and how they want to subdivide the inventory area, the villagers should draw the boundaries of the forest areas or types (if any) on the sketch or scale map which you have prepared for the meeting. If the villagers do not know the exact location of the boundaries, ask them to draw their approximate location. Information collected while doing the inventory work can be used to improve the accuracy of the map. You may want to list the subdivisions on a large sheet of paper.

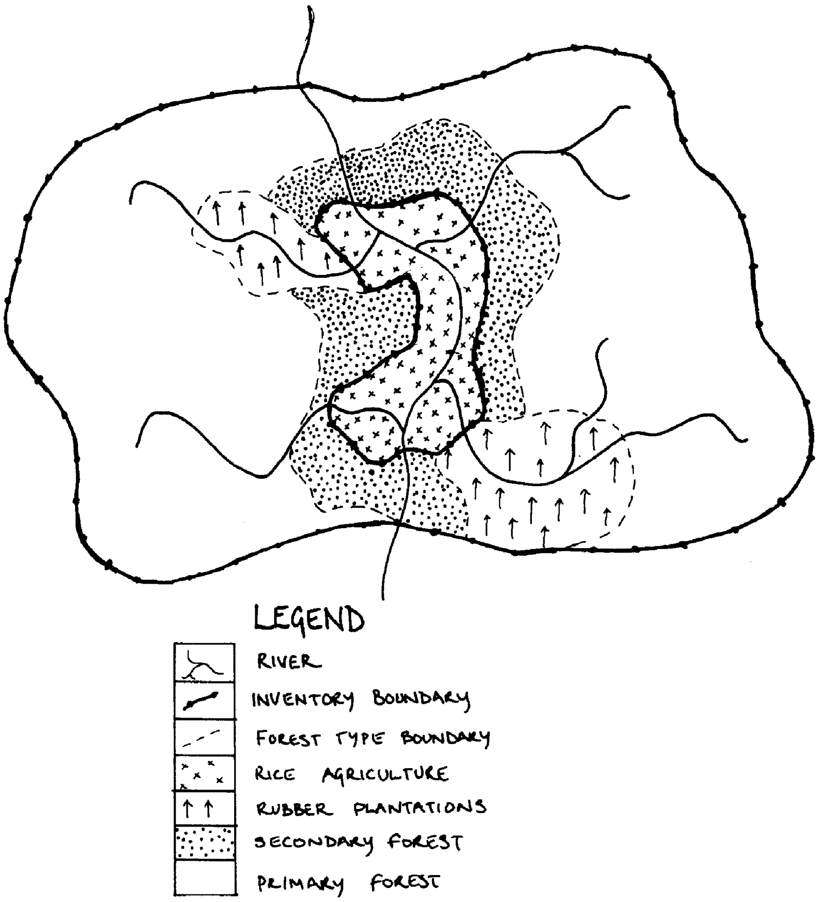


Figure 3.2. An inventory area subdivided by forest type, including primary, secondary and rubber forests.

Objective 5. The information desired about the inventory area

The fifth objective is to determine what environmental information is wanted about the inventory area.

The inventory work teams gather environmental information while they are doing the inventory work. Thus it is usually recorded for each inventory plot, as is the resource information.

The environmental information needed depends upon the inventory purpose, and whether or not the purpose requires the inventory area to be subdivided:

- If the purpose requires subdivision by area, the villagers should think about what subdivision boundaries (such as rivers, ridges, and roads) to look for and record.
- If the purpose requires subdivision by forest type, the villagers should think about what information (such as slope, soil colour, a dominant plant species, canopy height) might act as an indicator of these forest types. However, the villagers may not want to record environmental indicators of forest type, preferring instead to directly name and record the forest type each plot is in.

If the villagers would like a map to be one of the products of the inventory work, they may want to think about what additional information they might desire for this map. For example, they may wish a note to be made of the location of rivers, ridges or roads that are not necessarily boundaries of the inventory area or its subdivisions. Or, they may wish to note the location of other important features (e.g. abandoned villages, graveyards or animal salt licks).

It is not necessary for the villagers to discuss the environmental information that they need in great detail. The inventory team will be able to discuss the finer details of what information is needed and how they want to measure it later in their inventory planning sessions.[10]

You should conclude the discussion of this objective by writing a list of the environmental information that is desired for the inventory area on a large piece of paper.

Objective 6. The cost limit desired

The sixth objective is to set the limits of cost.

Cost may be evaluated in terms of time, labour, money, inventory equipment, or supplies required to conduct the inventory work. In some cases, the village may be paying all of the inventory costs. In other cases, some of the costs of the inventory (e.g. money and inventory equipment) may be funded by outsiders, but the village may contribute the remainder (e.g. time, labour and supplies).

As villagers are usually working with limited resources, it is important that they think about what they can afford to give to the inventory, and plan the inventory accordingly. To get some idea of costs, they villagers should ask themselves:

- How many people from the village can take part in the inventory? The best way to think of labour is in terms of how many inventory work teams of six people can be in the field at one time. The villagers should remember that if the teams are camping, an additional one or two people must stay in camp to look after the camp and cook.
- For how many days can these inventory work teams work in the forest?
- Will other resources, such as money, inventory equipment or fieldwork supplies,[11] limit the number of inventory work teams or days that are possible? For example, if only two compasses can be obtained, this will limit the village to two inventory work teams because each team must have a compass.

---

[10] *Chapter 8 discusses ways of measuring information about the environment.*

[11] *Chapter 5 describes the equipment needed for work in the forest.*

The group should then set the desired cost limit for the inventory. The cost should be written in terms of teams and days. For example, one village might decide that they can put together two teams which can do the actual inventory work for no more than 20 days.

Following this discussion, you should write the desired cost on a large piece of paper.

Objective 7. The precision desired

The seventh objective is to determine the desired precision.

As explained in the introduction, the precision of an estimate of resource quantity is a measure of the level of confidence that one has in the estimate (see *Box 3.3* for a more mathematical explanation). The precision of an estimate improves with the number of plots established in the inventory area. It is usually possible to obtain the precision you want in an inventory, as long as you can afford to establish the number of plots required for that precision. However, there is usually a limit to the cost that can be spent on the inventory, especially in a village-based inventory where resources are often scarce. Thus the cost provides a limit to the number of plots and hence the level of precision that can be achieved. Later in this chapter you will be advised to consult *Appendix D* to determine whether the desired precision is possible for the desired cost limits.

Box 3.3. An explanation of precision for those familiar with statistics

The precision of an estimate can be expressed in several ways:

- One is by the confidence range. For example, an estimate of 10 durian trees per hectare has a confidence range (at 90% probability) of plus or minus (±) 3 trees per hectare. This implies that in 90 cases out of 100 the true value is probably within the confidence limits that have been set around the estimate (i.e. 90 times out of 100 the true value is likely to be between 7 to 13 trees per hectare (10 − 3 = 7, 10 ± 3 = 13)). Thus, an estimate of 10 ± 3 trees per hectare (at 90% probability) is more precise than an estimate of 10 ± 6 trees per hectare (at 90% probability).
- Another is by the sampling error, which is the confidence range expressed as a percentage of the estimate. Using the above example, the estimate of 10 durian trees per hectare with a confidence range of ± 3 trees per hectare (at 90% probability) has a sampling error of 30% (at 90% probability) (divide 3 by 10 and multiply by 100).

The sampling error is a useful expression of the precision as it allows the comparison of different estimates, even estimates using different units, whereas the confidence range does not. For example, an estimate of 10 ± 1 trees per hectare may superficially appear to be more precise than an estimate of 1000 ± 100 trees because one has a confidence range of ±1 and the other a confidence range of ±100. However their sampling errors are both 10% which means the estimates are equally precise.

As illustrated above, you must always state the probability level of the precision, no matter what way you have chosen to express the precision. It is standard to use a probability level of 0.1 (90%), although 0.05 (95%) is also popular. *Appendix J* describes the probability level in more detail.

Nonetheless, the village may want to try to achieve a certain precision in order that they, and any outsiders receiving their inventory results, have confidence in their estimates. The precision that is desired will depend upon the inventory purpose. The precision (expressed as the sampling error) of the estimates of all but the most rare resources should be:

- 15-25% (at 90% probability) if you want a reasonably reliable estimate of resource quantity (e.g. for Purposes 2, 3, 4, 5, 7 and 8 in *Box 1.1* of *Chapter 1*), and
- 25-35% (at 90% probability) if you are comparing relative resource quantities between areas (e.g. for Purposes 1 and 6 in *Box 1.1* of *Chapter 1*).

There may be cases when the precision must be even higher.[12]

Following discussion of this objective with the villagers, you should write the desired precision on a large sheet of paper.

3.2.3. Selection of small group representative

A final activity of each small group meeting will be to select someone from each of the small groups to present the group's suggestions at the community meeting.

3.3. Prepare for a general village meeting to decide upon the inventory objectives

To prepare for the general village meeting you should:[13]

- Reassess whether the villagers will need to conduct more than one inventory, using *Box 3.1* as a guide.
- Meet with the representatives of the small groups in order to discuss plans for their presentations to this village meeting. You should plan who will talk and in what order, and what will be talked about. Some representatives will be confident and fully prepared to speak at the community meeting. Others (for example, the women or youths' representatives) may need a bit of briefing in advance if they are unused to public speaking. Visual displays of the suggestions made by the small groups should already have been prepared during the small group meetings. If not, they should be prepared by the representatives during this meeting.
- Prepare your own visual displays to help with the decision making, such as:
    - **For Objective 1:** If the number of forest resources chosen by the small groups need to be reduced to a shortlist of 15, prepare a master list of all the resources on the shortlists of each of the small groups, with scores indicating how many of the small groups have suggested each of the resources.
    - **For Objectives 2 to 5:** Prepare displays of the points of agreement and disagreement between the small groups.
    - **For Objectives 6 and 7:** Calculate whether the limits set for cost and precision by each of the small groups are or are not compatible with one another, using *Appendix D* as a guide. If the cost and precision objectives are not compatible, you should prepare a display explaining the options available to the villagers.

---

[12] *See Chapter 7 for a discussion of cases in which a precision (sampling error %) of 0% (from a 100% enumeration) may be recommended.*

[13] *Appendix A contains general information on how to plan a general village meeting.*

3.4. Facilitate a general village meeting

Small group meetings are designed to promote fairness in decision making by bringing out the opinions of the less dominant groups within the village. There is a danger in this final general village meeting that one group or even individual may dominate the discussion and the final decision will tend to most represent their views. The facilitator can help to prevent this by giving preference to the suggestions offered from the small groups over the suggestions offered by a few individuals in the general village meeting.[14]

The remainder of this section provides a possible structure for a general village meeting to decide upon the inventory objectives.

3.4.1. Introduction

You should introduce this meeting by:

- Putting up the villagers' statement of inventory purpose and reminding everybody that they should choose the inventory objectives with this purpose in mind,
- Explaining the purpose of the meeting, which is to reach an agreement on the objectives of the inventory, and
- Describing how the meeting will be run in order to decide upon the objectives.

3.4.2. Presentations by the small group representatives

Each small group representative should explain the suggestions from each of the small group meetings.

3.4.3. Deciding upon the objectives

Below are some suggestions on how to facilitate decision making on some of the specific inventory objectives:

- **For Objective 1:** If reducing a list of forest resources to a shortlist of 15, try to give preference to those resources that have been chosen by more than one small group.
- **For Objectives 2 to 5:** Highlight the similarities and differences between the different suggestions, so that you can set the similarities aside and guide the discussion to a mutually acceptable resolution of the differences.
- **For Objectives 6 and 7:** Explain whether the cost and precision objectives are compatible and if not, what the options are for balancing them.

Where to next

Once the villagers have determined the inventory purpose and objectives, their final decision is to choose representatives from the village who will carry out all subsequent work on the inventory. They will also determine the dates when the work will take place. These final decisions of the villagers are described in the next chapter.

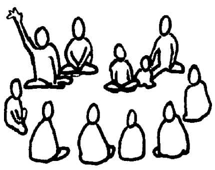
[14] *Appendix A gives advice on how to facilitate decision making in community meetings.*

4

Select the Inventory Team and Work Dates

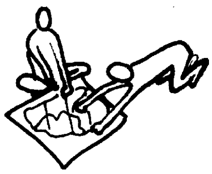
Where you are in the participatory inventory method:

I Decision making in the village



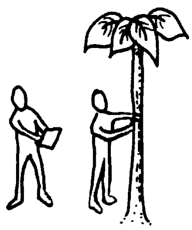
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



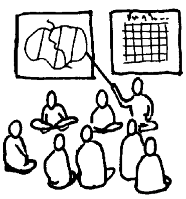
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

4.1. Ask the villagers to select representatives who will form the village's inventory team, and

4.2. Ask the villagers to determine the dates when the inventory work will take place.

Skills/information required

The skills or background information that you will require can be found in:

- *Appendix L*. Planning, conducting and analysing regeneration studies.
- *Appendix M*. Planning, conducting and analysing productivity studies, and

Materials required

- None

Introduction

After the villagers decide whether they want an inventory, and if so, what its purpose and objectives will be, they will need to determine who will carry out the inventory work and when this work will be done. This chapter describes how to help the villagers to select people for the village's inventory team as well as establish a timetable for the work.

4.1. Ask the villagers to select representatives who will form the village's inventory team

There are a number of ways in which you can ask the villagers to select the inventory team. You can ask either just the village leaders or all the villagers to suggest who should be on the inventory team. The general village meetings for determining the purpose and objectives provide good opportunities for discussing this issue with the villagers. It is good if everybody in the village approves of this list of names.

Some considerations that the villagers should keep in mind when choosing the inventory team are:

- Do they want the inventory team to plan, conduct and analyse the inventory work or should they conduct the inventory work only, with the planning and analysis open to other members of the village, and
- What the composition of the inventory team should be.

4.1.1. Do the villagers want the inventory team to plan, conduct and analyse the inventory work?

The work that remains to be done includes planning the inventory in the village, conducting the inventory work in the forest, and compiling, calculating and presenting the inventory results in the village. The villagers have the choice of asking the inventory team to do all of this work. Alternatively the inventory team can to do the work in the forest, and members of the inventory team, together with other members of the village, can do the planning and analysis in the village.

4.1.2. The composition of the inventory team

The most successful inventory teams are those with representatives from all groups in the village. These include people of a mixture of genders, ages, ethnic origin or social status. Picking inventory teams to represent all groups within a village should help to maximise the available knowledge and skills. For example:

- **Gender**. Men and women tend to have their own knowledge and skills related to their specific tasks in the village. For example, in an inventory women may be better at identifying and finding herbs used for cooking, whereas men may do better with the timber species which they use for building houses and boats.
- **Age**. Older people tend to know more about the forest and its resources, whereas the young often know more about mathematics and writing from school.
- **Ethnic origin**. Different ethnic groups often have different knowledge and skills to contribute to the inventory.
- **Social status**. If possible, both leaders and ordinary villagers should be members of the inventory team. The village leaders are often called to explain the results of the inventory, and should be involved in the entire process in order to understand it fully. However, ordinary villagers often provide knowledge and skills that differ from those of the leaders.

4.2. Ask the villagers to determine the dates when the inventory work will take place

You should also ask the villagers to determine the best dates for doing the inventory work. The best time of year for the inventory work in the forest may be when:

- The villagers are least busy with agricultural work or other activities, or
- It is the flowering or fruiting season for the forest resources. This is because it is easier to identify the resources accurately at this time.

You should also discuss good times for doing the productivity study or regeneration study, if either are planned.[1]

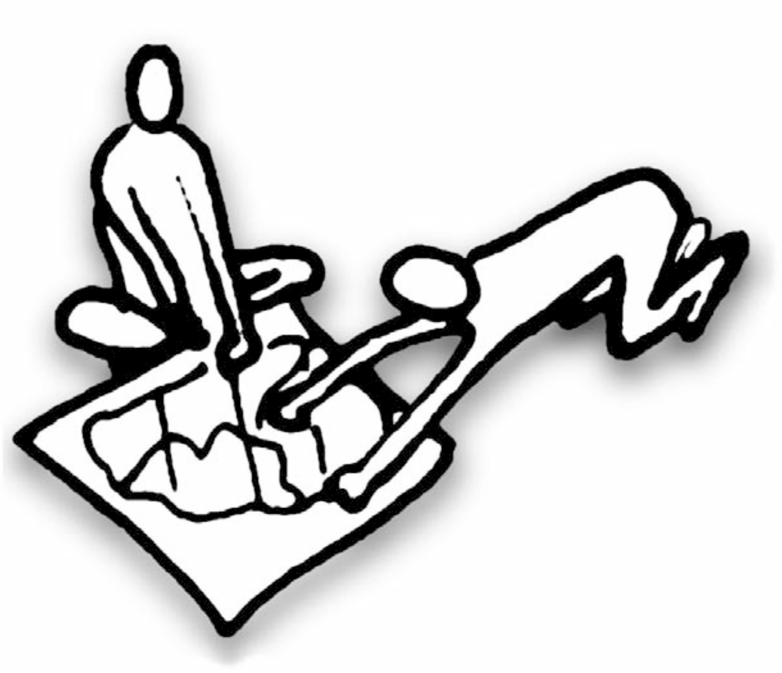
Where to next

These decisions about who will be on the inventory team and when they will do their work are the final decisions to be made by the village as a whole at the outset of the inventory. Now the inventory team can be left to plan the inventory in accordance with the purpose and objectives determined by the village. The inventory team should begin planning the inventory by assembling the equipment necessary for the inventory work. This process is described in the next chapter.

[1] *Appendices L and M discuss the best times for conducting productivity or regeneration studies.*

II

Planning the Inventory Work

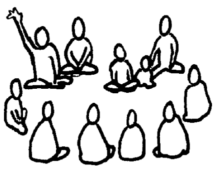


5

Assemble Equipment Unavailable in the Village

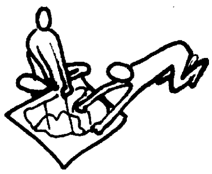
Where you are in the participatory inventory method:

I Decision making in the village



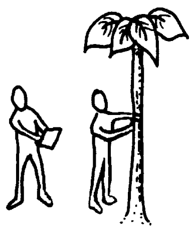
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



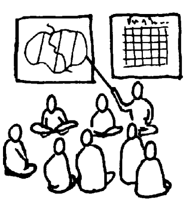
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

5.1. Assemble equipment that might be difficult to find in a village.

Skills/information required

The skills or background information that you will require include:

- An overview of the participatory inventory method, obtained by reading the introductions to the chapters in this manual,
- *Appendix H*. Surveying techniques,
- *Appendix K*. Measuring plant size,
- *Appendix N*. Botanical specimen forms, and
- *Appendix O*. Compilation and calculation forms.

Materials required

See *Box 5.1* for a list of equipment that will need to be assembled for a participatory inventory.

Introduction

After the villagers have made all the major decisions relating to the inventory, you and other members of the inventory team are now able to begin to plan the inventory. One important aspect of planning is to assemble the equipment that you will need in order to complete a participatory inventory. This chapter assists you in assembling the equipment that is unavailable in the village.

Box 5.1. Equipment that might be difficult to find in a village

Necessary equipment:	*Quantity:*
✔ Compasses	1 compass per inventory work team
✔ Nylon rope (0.5 cm diameter)	75 metres of rope per inventory work team
✔ Metre tape (10-50 metres in length)	At least 1 tape
✔ Ribbon (1.5 to 2.0 cm width)	12.5 metres of ribbon per inventory work team per work day, or 12.5 metres per 25 plots[1]
✔ Brightly coloured electrical (sticky) tape (1.5 to 2.0 cm width)	1 roll
✔ Diameter tapes	2 tapes per inventory work team
✔ Fine nib permanent ink pens	At least 5 pens per inventory work team
✔ Pencils	At least 5 pencils per inventory work team
✔ Pencil sharpeners	At least 2 sharpeners per inventory work team
✔ Erasers	At least 2 erasers per inventory work team
✔ Squared exercise books (option 1)	Depends upon the number of plots[1]
✔ Photocopies of data forms (option 2)	Depends upon the number of plots[1]
✔ Clipboards (option 2)	1 clipboard per inventory work team
✔ Folders (option 2)	1 folder for each inventory work team, 4 additional folders
✔ Lined notebooks	1 book for each inventory work team, 10 additional books
✔ Ball point pens	15 to 20 pens
✔ Large sized (A0) paper	At least 30 sheets
✔ Broad nib marker pens of different colours	At least 16 pens
✔ Drawing pins	1 pack
✔ Simple grid graph paper (0.5 cm x 0.5 cm) photocopied onto transparent A4 sheets	At least 2 sheets
✔ Methylated spirits	1 litre
✔ Protractor (360 degree plastic)	At least 1 protractor
✔ Long ruler	At least 1 ruler
✔ Large sheet of transparent tracing paper or radar image	Enough to trace a map, aerial photograph
✔ Large sized sheet of graph paper	Enough to make a map approximately 1 m x 1.5 m in size
✔ Wide sized sticky tape	1-2 rolls
✔ Glue	1 stick
✔ Scissors	1 pair
✔ Correction fluid	At least one bottle
✔ Good quality, very fine nib, permanent ink pens of different colours	1 set

✔ Map rolls	1-2 rolls
✔ Photocopies of compilation form	Depends upon the number of forest resources and plots[2]
✔ Photocopies of calculation forms	Depends upon the number of forest resources, smaller areas and/or forest types, and the calculations desired[2]
✔ Electronic calculator	At least 1 calculator
Equipment for collecting botanical specimens:	*Quantity:*
✔ Photocopies of botanical collection forms	1 per sample or approximately 15 pages of each type of form
✔ Labels	5 per sample or approximately 100 labels
✔ Rafia string	One roll of rafia string
✔ Newspaper	5 per sample or approximately 100 pages
✔ Cardboard	1 per sample or approximately 15 pieces of cardboard
✔ Field press	1 or 2 field presses
✔ Methylated spirit	0.5 litre per bulky sample collected (i.e. Palms, bamboos)
✔ Strong plastic bags (1 m x 0.5 m)	1 bag per 2 bulky samples collected (i.e. Palms, bamboos)
Optional equipment:	*Quantity:*
✔ Clinometers	1 clinometer per inventory work team
✔ Geographic positioning system (GPS)	1 GPS is useful; 1 per inventory work team is even better
✔ Computer	1 computer

5.1. Assemble equipment that might be difficult to find in a village

A checklist of the equipment that might be difficult to find in a village can be found in *Box 5.1*. This list has been broken down into three categories:

- Equipment that is necessary for participatory inventory,
- Equipment that is necessary if you choose to collect botanical specimens, and
- Equipment that is useful for participatory inventory but optional due to high expense.

The remainder of this chapter explains what each item of equipment is used for. For some equipment, this chapter also discusses what types are best and how to make your own if you cannot afford or obtain it easily.

1 *The quantity of each item required will depend upon the desired cost limits determined by the villagers; see Chapter 3.*

2 *The quantity of compilation and calculation forms will depend upon the desired forest resources, subdivisions of the inventory area, and cost limits; see Chapter 3.*

5.1.1. Necessary equipment

Compasses

Compasses are used by the inventory work teams to establish inventory lines of the desired orientation.[3] They also may be used to make scale maps.

There are many different types of compass available. The most simple type of compass, consisting of a needle rotating over a card and with only the main directions (i.e. north, south, east, west) labelled, will not be accurate enough to use in either the inventory or mapping work.

At the very minimum, it is important to have a compass which:

- Has a needle (a small thin strip of metal) that revolves smoothly within an oil-filled capsule, which in turn is mounted on a base plate which can be rotated by the user,[4]
- Is clearly marked with numbers and ticks every 2 or 5 degrees, and
- Is strong and unlikely to break in the forest.

Compasses with sighting mirrors are more accurate and easier to use than other compasses, but they are more expensive.

When buying a compass it is important to make sure that the compass has been designed for tropical work. Compasses that are designed to be used in northern latitudes have needles that are weighted. When these compasses are used close to the equator the needle tends to dip into the card and stick instead of rotating freely. To check this, hold the compass in your hand parallel to the ground and rotate it from left to right. If the needle moves smoothly then the compass is fine. If the needle becomes stuck, or does not rotate smoothly, then the compass may not suitable for use in the tropics.

Nylon rope

It is more efficient to measure distances in the forest with nylon rope than with a metre tape. Nylon rope is more durable than a metre tape and is not as easily snagged on undergrowth. Nylon rope is also cheaper and easier to buy than a metre tape.

The most suitable nylon rope is brightly coloured. Its diameter should be large enough to be durable and resistant to stretching but at the same time not too heavy to carry (approximately 0.5 cm diameter).

Each inventory work team will need to measure and mark the following lengths of nylon rope: one 50 metre rope, one 10 metre rope and two 5 metre ropes. To measure and mark a nylon rope you will need:

- Approximately 75 metres of nylon rope,
- A metre tape, and
- Brightly coloured electrical (sticky) tape (optional).

The first step in marking each rope is to measure the appropriate length of rope using the metre tape and mark the beginning and end points of this length with a piece of brightly coloured sticky tape or a knot. There should be a small amount of rope (at least 50 cm) extending beyond these marked points at either end. If you cut the rope make sure to melt the ends so they do not fray.

---

[3] *Chapters 6 and 11 explain when to use a compass in participatory inventory.*

[4] *Appendix H explains more about what a compass is and how to use it.*

Metre tape

You will need at least one metre tape, of any size from 10 to 50 metres in order to measure nylon rope lengths. However, you may need one metre tape per inventory work team if you are planning to use it to measure the lengths of plants (e.g. lengths of rattan or bamboo stems). If the measurements do not need to be too accurate, you could mark out every 0.5 metres on the 5 metre nylon rope and use this to measure plants instead of a metre tape.

Ribbon

Brightly coloured and durable ribbon, flagging tape, strips of cloth or strips of plastic sheeting are needed to mark plot marker sticks. Any strip of material is suitable as long as you are able to:

- Tie it around a marker stick or place it in a notch in the stick,
- Write the plot number on it with a permanent pen, and
- See it from a distance in the forest.

Brightly coloured electrician's (sticky) tape

Brightly coloured electrician's (sticky) tape is used to mark distances on the nylon rope and to make the compass sighting stick or the height measuring pole used in the fieldwork more visible. There may be other ways to mark the rope, stick or pole in a visible way, using knots for the rope and brightly coloured paint, ribbon, strips of cloth, etc. for the sighting stick or height measuring pole.

Diameter tapes

Diameter tapes are used to measure the diameter of trees.[5] A diameter tape is a special tape that measures the diameter of a cylindrical object such as a tree by taking a measurement around the circumference. As only professional foresters generally use diameter tapes, the tapes may be difficult to buy, even in a large town. If diameter tapes cannot be bought it is also possible to make them.

The equipment required to make a diameter tape includes:

- A ruler with millimetres marked on it,
- A dark coloured pen with permanent ink, and
- A piece of light coloured, wide (approximately 2 centimetres), 2 metres long cloth tape or ribbon that is strong enough not to stretch.

Line up the tape or ribbon against the ruler. With the ink pen make a mark every 3.14 centimetres on the tape or ribbon, and number these marks '0', '1', '2' and so on. The distance marked with a '1' will represent 1 centimetre in diameter when the tape or ribbon is wrapped around the circumference of a tree.

Fine nib permanent ink pens

These pens are used to write the plot number on the ribbon that is attached to the plot marker stick. They are also used to calculate the size of an area on a map.[6]

---

[5] *Appendix K explains how to use a diameter tape.*

[6] *Chapter 7 explains how to calculate the size of an area on a map.*

Pencils, erasers, pencil sharpeners

Pencils are used to record information in the field, as unlike ink, pencil lead does not run when the page is wet. Erasers and pencil sharpeners help to ensure that the data is recorded clearly. Pencils, erasers and pencil sharpeners are also used in map making.

Squared exercise books

Squared exercise books are one option for recording information in the field.[7] These books have a grid of squares marked on their pages instead of lines. They are usually available in any shop that sells school supplies. It is good to get the most durable books available. Sometimes plastic book covers can be bought to protect the cover.

Photocopied data form, clipboards, folders

Photocopied data forms are another option for recording information in the field. You may decide to use the data form provided in this manual, or to design your own. Each inventory work team will need a clipboard for writing on the data forms in the field, and a folder for storing the blank data forms. A master folder will also be needed for the data forms that have been filled in. Other folders may be useful for storing the botanical specimen forms, the compilation forms and the calculation forms.

Lined notebook and ballpoint pens

Leaders of inventory work teams or people playing a major role in planning the inventory will need lined notebooks and ballpoint pens. These are required for keeping daily records of the inventory work in the forest, or for recording other useful information in the village or in the forest.

Large sized (A0) paper, broad nib marker pens of different colours and drawing pins

The facilitators will need large sheets of paper, broad nib marker pens and drawing pins for preparing displays of information or writing down suggestions in general village meetings. Large sheets of paper and drawing pins are also needed for making sketch maps.[8]

Simple grid graph paper photocopied onto transparent sheets, methylated spirits

The inventory team will need to use simple grid graph paper, which has been photocopied onto transparent sheets, for calculating the size of areas on the planning map.[9] They will draw on these sheets with fine nib permanent ink pens. Methylated spirits will be needed to erase the permanent ink so that the sheets can be used again.

---

[7] *Chapter 9 explains how to prepare and use data recording sheets.*

[8] *Chapter 3 and Appendix C describe when and how to make a sketch map.*

[9] *Chapter 7 explains how to calculate the size of an area on a map using transparent squared paper.*

Protractor, ruler, tracing paper, graph paper, tape, glue, scissors, correction fluid and set of coloured fine nib pens

This set of equipment is needed for making or improving maps.[10] The protractor must be in the same units as the compass (i.e. if the compass is in degrees the protractor must be in degrees, if the compass is in grades the protractor must be in grades). The transparent tracing paper is only necessary if the maps are to be copied by tracing rather than by photocopying them.

Map rolls

Map rolls are useful for carrying maps in the forest and for storing them safely in the village. A less expensive substitute for map rolls are cardboard tubes that have been used to carry large sized paper. Both of these are usually available in stationary and photocopy shops.

Compilation form, calculation forms and electronic calculator

Compilation and calculation forms will be used together with an electronic calculator for making the final calculations of the inventory results.[11] The forms, available in *Appendix O*, should be photocopied as many times as necessary. An electronic calculator capable of simple arithmetic (i.e. adding, dividing, subtracting and multiplying, squaring and finding the square root) is required to make the calculations.

5.1.2. Equipment for collecting botanical specimens

Botanical specimen forms, labels and rafia string

The botanical specimen forms, labels and rafia are needed for collecting botanical specimens in the field.[12] The botanical specimen forms are available in *Appendix N*. The labels can be made by cutting small rectangles of card (although thick paper will do) and piercing a hole through one corner in order to pass the rafia string through.

Newspaper, cardboard and field press

The newspaper, cardboard and field press are for pressing the botanical specimens.[12] The cardboard should be cut into rectangles that are slightly larger than the newspaper page folded in half. A field press can be made from two rectangles of plywood which have been cut to approximately the same size as the cardboard, and two strong pieces of string or straps. The cardboard and newspaper are layered between these two outer boards, and the entire pile is tied together tightly with the two pieces of string, rope or straps, as shown in *Figure 5.1*.

---

[10] *Chapter 6 describes how to make a map and Chapter 16 describes how to improve a map.*

[11] *Chapter 17 describes how to compile data and make calculations.*

[12] *Chapter 15 explains how to collect, press and preserve botanical specimens.*

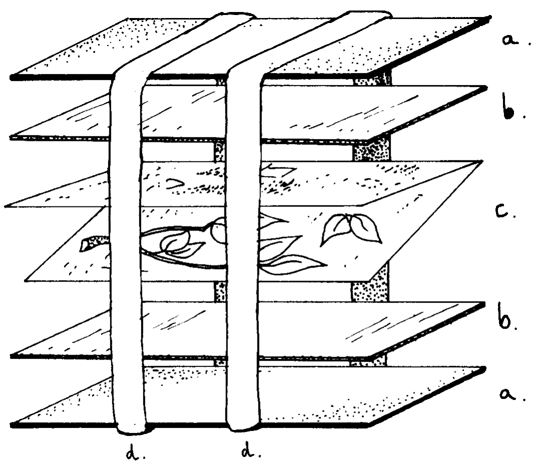


Figure 5.1. A field press is comprised of: a) two plywood ends, b) alternate layers of dry cardboard, and c) full pieces of newspaper in which the botanical specimen is placed, and d) straps which are used to tie these layers together tightly. A field press can take up to seven or eight specimens.

Methylated spirits and plastic bags

The methylated spirits and plastic bags are for preserving the samples in alcohol. Methylated spirits are commonly available as rubbing alcohol (*spiritus* in Indonesian), which is commonly sold in local shops for medicinal purposes. The plastic bags should be big enough (approximately 1 x 0.7 metres) that a thick bundle (the length and width of a newspaper page folded in half) can be placed inside the bag and the open end taped shut. You should try to find the thickest and most durable plastic available.

5.1.3. Optional equipment

Clinometers

Clinometers measure the angle of a slope. They are useful for mapping and for inventory work as they ensure that the desired horizontal distance is measured accurately along a slope. They are also useful for estimating the height of trees or other plants which are too tall to measure directly.[13] Clinometers may or may not be available in a local large town. Local professional mapping experts or foresters should be able to advise you on the best way to order one. This manual describes simpler alternatives for measuring horizontal distance or plant height that do not require the use of a clinometer.

Geographic positioning system

Geographical positioning systems, also known as GPS, are used to determine your position on the globe. They can be accurate to 100 metres, although some are less accurate. They are very useful in participatory inventory for map making. Inventory work teams can also use them to find their way to the inventory lines in the forest. However, they are expensive and difficult to obtain; for this reason this manual provides you with alternatives to using GPS.

[13] *Appendix H and Appendix K explain how to use a clinometer.*

Computer

A computer stores inventory data and makes calculations of the final inventory results much more efficiently than if the calculations are done by hand. A computer also makes it much easier to write the final report. Thus computers are recommended if they are available. However, computers are expensive and you will need training to be able to use one, so this manual does not assume that you have access to one.

Where to next

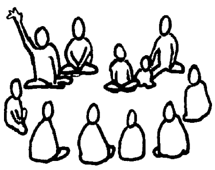
After assembling the equipment, you must prepare a planning map. This step is described in the next chapter.

6

Prepare the Planning Map

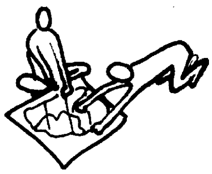
Where you are in the participatory inventory method:

I Decision making in the village



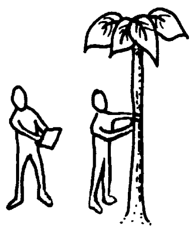
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



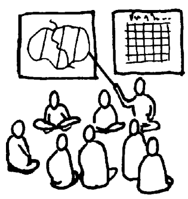
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

6.1. Decide whether you need to make a planning map, and if so, which option to use to make it,

6.2. Option 1. Make a planning map by copying, modifying and building upon an existing map, aerial photograph or radar image, or

6.3. Option 2. Make a planning map by ground surveying.

Skills/information required

The skills or information that you will require include:

- *Appendix C*. Making a sketch map,
- *Appendix F*. Five features of maps,
- *Appendix G*. Scale maps, aerial photographs and radar images, and
- *Appendix H*. Surveying techniques.

Materials required

For Option 1:

- If copying a scale map by photocopying: A scale map of the inventory area, pencils, a pencil sharpener, an eraser, black pens, and correction fluid (Tippex).
- If copying a scale map, aerial photograph or radar image by tracing: A scale map(s), aerial photograph(s) or radar image(s) of the inventory area, large sheets of tracing paper, pencils, a pencil sharpener, an eraser, permanent ink pens, a ruler, and drawing pins or tape.

For Option 2:

- A compass, a metre tape, brightly coloured electrical tape, GPS equipment (optional), a clinometer (optional), a notebook, pencils, a pencil sharpener, an eraser, graph paper, a ruler, and a protractor.

Introduction

At the time that you and the inventory team assemble equipment for the inventory, you will also need to obtain or make a map of the inventory area. A map is essential for planning and conducting the inventory, and is also important for calculating the inventory results. This chapter helps you to assess whether maps that are available to you are suitable for use as a planning map. If the maps are not suitable, two options for making a planning map are described. These options are to prepare a planning map by:

- Copying, modifying and building upon an existing scale map, aerial photograph or radar image, or
- Ground surveying.

6.1. Decide whether you need to make a planning map, and if so, how you will make it

6.1.1. Information required on a planning map

The inventory team will use the planning map to:[1]

- Plan where to put the inventory lines, and
- Find the starting points of these inventory lines when they go to the forest.

The inventory team also has the option of using the planning map to:[2]

- Calculate the size of the inventory area (it is important to know the size if calculating resource quantity), and
- Provide a basic structure to which other mapping or inventory information can be added, in order to produce a final map or maps.

In order to be useful, a planning map must contain the following information:

- *Scale*.[3] This is important for determining the length of the inventory lines, the distance between them, and for finding the starting points of the inventory lines in the forest. It is also needed to calculate the size of the inventory area.
- *Orientation*.[3] This is needed for determining the orientation (or direction) of the inventory lines and for finding the starting points of the inventory lines in the forest.
- *The location of the main access routes in the inventory area*. This is needed to plan the orientation of the inventory lines and to plan how to find the inventory lines in the forest. Access to the inventory area will usually be by river systems or by roads.
- *The location of 'reference points' along the main access routes to the inventory area.* 'Reference points' are used by the inventory work teams to find the starting points of the inventory lines in the forest. A 'reference point' is a point on a map that corresponds to a place in the forest that is easy for the inventory work teams to locate. Good reference points include the points where minor rivers flow into a major river, or where a main road branches into other roads. As only points are needed, it is not necessary to map fully all the smaller streams or roads.
- *The location of the inventory area*. The entire inventory area must be contained in the map. At the same time, the inventory area should not comprise too small a proportion of the map. It is good if the inventory area covers at least half of the map. Information on the exact location of the inventory area boundary is not essential for planning the inventory, although it is when making the final calculations. The approximate location of the inventory area boundary can be drawn on the planning map by the villagers, and the map improved later using information gathered while doing the inventory.

The accuracy required for the planning map will depend upon what the map is to be used for. If it will just be used to plan where to put the inventory lines and how to find them in the forest, the accuracy is not so important. However, if it is to be used to calculate the size of the inventory area

---

1 *Chapters 7 and 12 discuss these uses for a planning map in more detail.*

2 *Chapters 16 and 17 discuss how to calculate the size of the inventory area and some of the types of final maps that can be produced.*

3 *Appendix F explains terms such as scale and orientation.*

4 *Appendix E indicates which inventory purposes require the estimation of resource quantity.*

(which in turn will be used to estimate resource quantity), it must be very accurate, as otherwise the estimates of resource quantity cannot possibly be reliable.

The size of the map is also important. The larger the map, the more easy it will be to see the details drawn on it. At the same time, the map should be small enough to be easily transported to and used in a forest camp. A good map size is approximately 1 metre by 1.5 metres. If desired, a map that is to be used in the field can be divided into more easily handled sheets.

6.1.2. *Deciding whether and how you will need to make a planning map*

Figure 6.1 illustrates the decision making process described in this section.

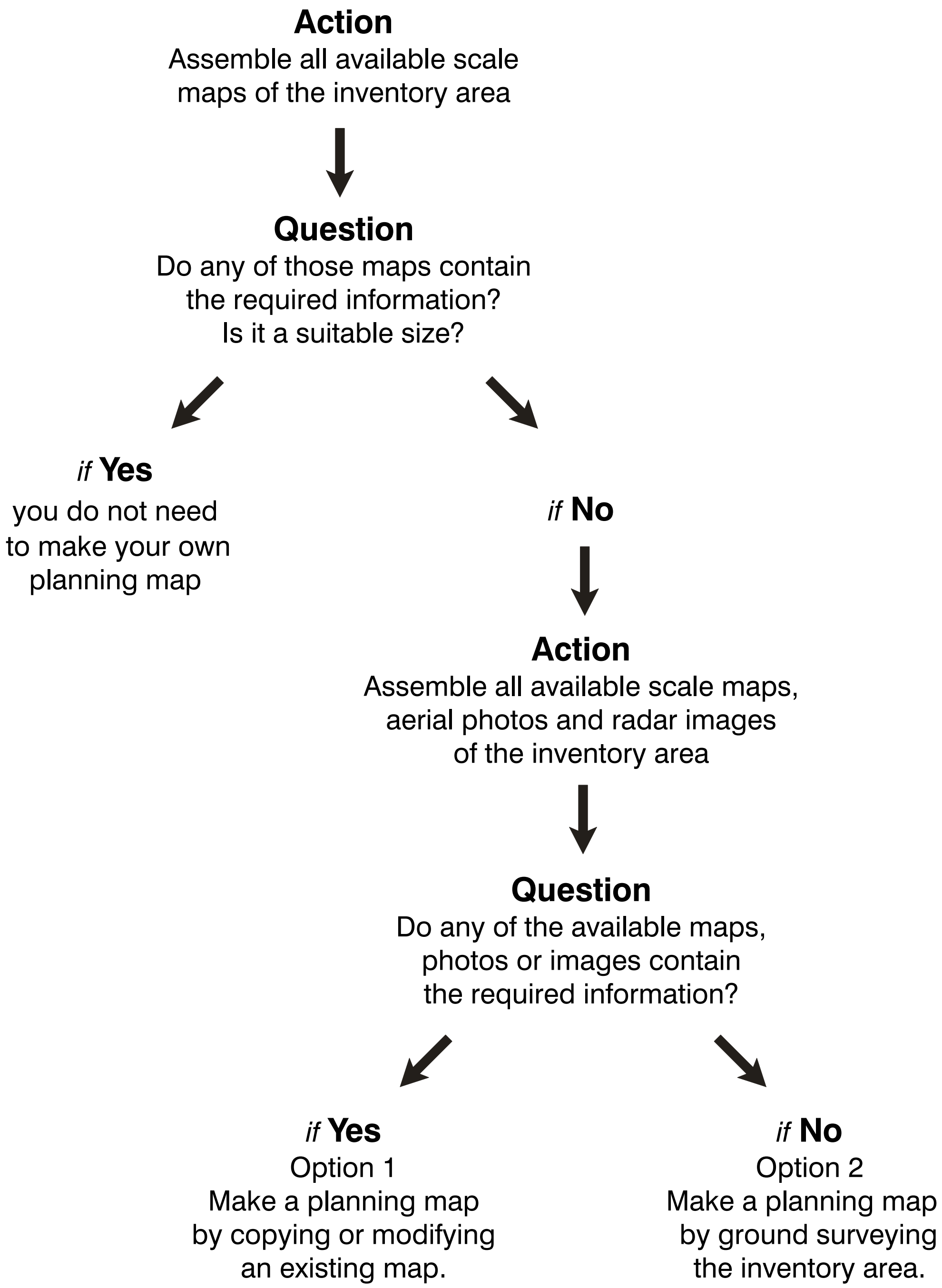


Figure 6.1. The decision making process for deciding whether you need a planning map and how to make it.

Do you need to make a planning map?

Deciding whether you need to make your own planning map begins with finding out what scale maps are available of the inventory area.[5] The village may already have made a scale map of their own. If not, sources outside the village may have scale maps of the area.

Once you have assembled all the maps available, you should evaluate them. For each map, you should ask:

- Does this map have the information we require (using the criteria outlined in the previous section)?
- Is this map of a suitable size?

If the answer to both questions is yes, then the map is suitable for use as a planning map, and you will not need to make your own map. However, if the answer to either question is no, or if no maps of the inventory area are available, then you will need to make your own planning map. Two options for making a planning map are described below.

How will you make your planning map?

You should begin by finding out if aerial photographs and radar images of the inventory area, or part of the area, are available.[6]

These, together with the maps that you have already assembled, should be evaluated. For each map, photograph or image, you should ask:

- Does the map, photograph or image contain the information we require?

Note: The size of the map, photograph or image is not a consideration, nor does it matter if it contains information about only part of the inventory area.

If the answer to this question is yes, then you can make a planning map by following Option 1: making a planning map by copying, modifying and building upon a scale map, aerial photograph or radar image. However, if the answer to this question is no, then you must make a planning map by following Option 2: making a planning map by ground surveying.

6.2. *Option 1*. Making a planning map by copying, modifying and building on a map, aerial photograph or radar image

Copying, modifying and building upon other maps, photographs or images is an easy and inexpensive way to make a planning map. This method of making a planning map involves three distinct stages:

1. Make a copy of the map, photograph or image,
2. If necessary modify the scale of this copy, and
3. Build upon this basic copy by adding information to it.

[5] *Appendix G discusses types of scale maps and some ways of obtaining them.*

[6] *Appendix G explains what aerial photographs and radar images are and discusses some ways of obtaining them.*

6.2.1. Copy the map, aerial photograph or radar image

There are two ways to copy maps, one using a photocopying machine and the other using tracing paper. Photocopying maps is usually more efficient. However, copying maps onto tracing paper may be preferable if you want to copy only some selected information from a complex map. This is because it may take less time to trace the original map than it would to delete excess photocopied information using correction fluid (Tippex). Aerial photographs and radar images, unlike maps, can only be copied using tracing paper.

How to copy a map using a photocopy machine

A map can be copied by photocopying the original map. Once a single copy has been made, irrelevant information and blotches caused by the photocopy machine can be deleted using correction fluid (Tippex). Photocopy this adapted map one more time to get a good quality copy.

How to copy a map using tracing paper

A scale map can also be copied onto tracing paper. Lay a sheet of transparent tracing paper over the map (see *Figure 6.2*), and draw four registration marks (it is best to draw these as '+' symbols) in the corners of the map and tracing paper overlay, so that the two pieces of paper can be lined up again if separated. Use tape or drawing pins in the corners of both sheets of paper to hold them in place.

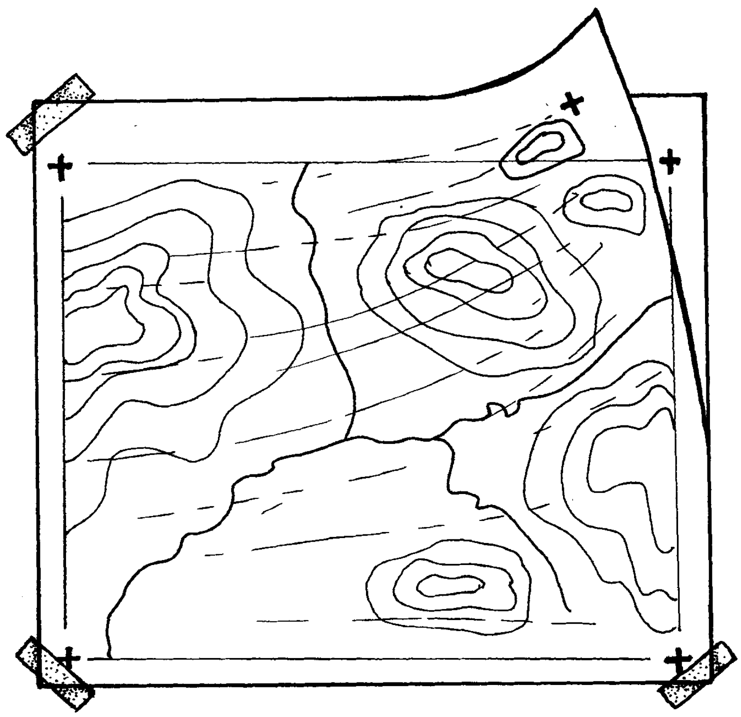


Figure 6.2. How to copy selected information from a scale map onto tracing paper

Once the sheets of paper are taped or pinned together and placed on a smooth, flat surface, draw the relevant information from the map onto the tracing paper using a pencil.[7] The pencilled information can be darkened later using permanent ink pens. Remember to trace the scale,

[7] *Appendix G discusses information that can be obtained from different types of maps.*

latitude and longitude grid, north symbol and legend, if appropriate. In addition to tracing the required information on the location of the main access routes and the reference points along them, you may want to trace the following information:

- The location of other rivers, roads and ridges,
- The location of villages,
- If the villagers have decided to subdivide the inventory area by area, the location of the areas, and
- If the villagers have decided to subdivide the inventory area by forest type[8], the location of the forest types.

Tracing paper is awkward to use in the forest. It cannot be folded and will distort when it gets wet. If a photocopy machine is available you should photocopy the tracing paper onto plain paper.

How to copy an aerial photograph using tracing paper

Copying from an aerial photograph is often referred to as 'interpreting', because some of the information on the photograph is not immediately obvious and must be guessed at from visual clues found in the photograph.[9] People making the planning map from a photograph will either require some skill in interpreting aerial photographs or have a good knowledge of the area contained in the photograph. It is best if people of both skills can interpret the aerial photograph together.

To begin with, the interpreters should familiarise themselves with the photograph. Some natural features should be immediately noticeable, including ridges, river valleys and sometimes the rivers themselves, if they are large enough not to be covered by trees and other vegetation. Human made features will also be noticeable, including agricultural areas, roads and perhaps villages. A magnifying glass can help the interpreters to examine certain parts of the map more carefully.

It is often possible to differentiate between different land use or forest types (for instance the difference between secondary and primary forest) on an aerial photograph by looking at the tone (or colour) differences. This is because different tree species can be coloured differently. Also important is the 'texture' of the forest in the photograph, which can appear to be rough or smooth. If the forest appears to have a uniform and smooth texture the interpreter can assume the forest is comprised of young trees, whereas a coarse texture will imply larger trees.

Once the interpreters have familiarised themselves with the photograph they are ready to begin copying it. Lay a sheet of transparent tracing paper over the aerial photograph (in the same way described earlier for copying a map using tracing paper), and copy the information required from the photograph on to the paper. It is often easiest to start with river or road systems as these are a good framework to which other information can be added. Although a river itself might not be visible, because trees or cloud obscures it, the river valley will usually be noticeable because of the valley slope and shadows on the photograph. A river will nearly always follow the base of the river valley so it should be possible to quite accurately approximate the course of the river.

Other information, such as that listed for copying a map, should then be copied, if desired. It is important to add or trace the information about the scale, latitude and longitude grid and the north symbol on to the tracing paper as well.

---

8 *In Chapter 3 (Objective 4) the villagers will have decided whether they are subdividing the inventory area by area or forest type.*

9 *Appendix G discusses information that can be obtained from aerial photographs in more detail.*

How to copy a radar image using tracing paper

Copying a radar image is done in the same way as copying an aerial photograph, described above.[10] Radar images have areas of darkness which look like shadows that can sometimes cover large parts of the image. These shadowed parts are areas that have been missed at the angle at which the radar equipment has been set to take the image. It is not possible to determine features inside these shadow areas and the interpreters should be cautious about building a planning map by guesswork. Where there are areas of uncertainty it is best to draw in features using a dashed line and then check these features on the ground.

6.2.2. Modify the scale of the copy

The next stage is to select the scale that is desired for the planning map,[11] and if necessary enlarge or reduce the scale of the copied map, photograph or image to the desired level. The main consideration in choosing the scale is to end up with a planning map of a suitable size. As mentioned earlier, the map should not be much larger than 1 metre by 1.5 metres in size.

As a general rule, the following inventory area sizes are best depicted by maps of the following scales:

- Less than 2 500 hectares — 1:5 000
- 2 500 - 7 500 hectares — 1:10 000
- 7 500 - 25 000 hectares — 1:25 000
- More than 25 000 hectares — 1:50 000

However, if these areas are long and thin in shape they will require a smaller scale (i.e. a larger number to the right of the colon) than if they are round or square in shape.

If your planning map is not of the desired scale, it will be necessary to enlarge or reduce it to the scale that is required. In most cases the map will have to be enlarged rather than reduced. The easiest way to enlarge a map is by using a photocopy machine. This machine will enlarge by percentages. To enlarge a map by 200% means that its dimensions have been doubled and its scale has been halved, for example from 1:50 000 to 1:25 000.

If a 1:50 000 map needs to be made into a 1:10 000 map the map must be enlarged by 5 times or 500%. Most photocopiers cannot enlarge by 500% in one turn. They will usually have a maximum enlargement capacity of up to 150% or 200%, therefore the map will need to be enlarged in stages to make it 500% larger. This is done in three steps, as illustrated in *Table 6.1*.

Table 6.1. Enlarging a map in three steps

Step	*Enlargement*	*Original scale*	*Divide by*	*Enlarged scale*
1	200%	50 000	2	25 000
2	200%	25 000	2	12 500
3	125%	12 500	1.25	10 000

[10] *Appendix G discusses information that can be obtained from a radar image.*

[11] *Appendix F describes what the scale of a map is an how to use it.*

Sometimes a photocopier will not have sufficiently large paper to fit the entire map on a single piece of paper. If this is the case the map should be divided up into segments and each piece enlarged the same amount. It is best if there is some overlap between the pieces of map because it will make it easier to stick the finished pieces together using glue and tape.

To check if the enlargement is accurate, use a ruler to measure the distance between the same two points on the original map and the enlarged map. If, for instance, there is a 5 cm distance between two points on the original 1:50 000 scale map, the distance between the same two points on the new 1:10 000 map should be 25 cm. On some older machines enlargement might not be uniform and the machine might stretch the copy and enlarge one part of the map more than other parts. For instance, it might enlarge the middle by 205% and the outside by only 195%. It is therefore a good idea to check the map in several different places. Every time an enlargement is made from a copy the distortion will get worse. It is better therefore to use the minimum number of steps necessary to reach the desired scale map. If the distortion is perceptible on a particular machine try to find another.

There might be cases when only a small portion of a scale map covers your inventory area. If so, you will need to enlarge or reduce that part of the map alone, as shown in *Figure 6.3*.

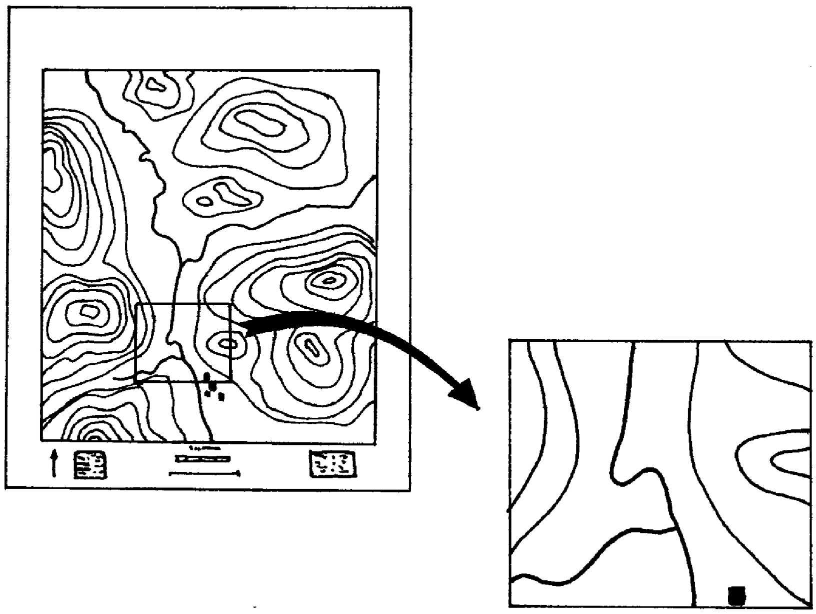


Figure 6.3. It is possible to enlarge or reduce only a part of a scale map that covers your inventory area.

Often when enlarging maps the copy will have blotches and marks, and its lines might be broken and smudged. If this is the case the map will need to be touched up using correction fluid (Tippex) to white out the unwanted marks and a fine black pen to fill in lines and features that are broken. If the copy is really bad it might be simpler to trace the information needed onto a piece of tracing paper and then photocopy this.

Once a map has been successfully enlarged, you should check that the scale is written correctly. The scale will have to be rewritten if expressed as a fraction scale, but not if expressed as a graph scale.[12]

[12] *Appendix F explains what fraction and graph scales are.*

6.2.3. Build upon the copy

Additional information can now be added to the copy to make it a completed planning map. This additional information may come from three possible sources, each of which are discussed in more detail below:

- Other maps, aerial photographs or radar images,
- Ground surveys (and possibly from GPS), or
- The villagers or their sketch maps.

Adding information from other maps, aerial photographs or radar images

The base map should be made from the best map, photograph or image available. You may add information from other maps, photographs or images by several methods:

- Photocopy the other map, photograph or image, cut out the part which you need, tape it to the basic copy, and photocopy them together, or
- Trace a line from the other map, photograph or image onto tracing paper with a pencil and transfer it to the basic copy using the method described in *Box 6.1*.

Remember that the scale of maps, photographs or images must be the same. If they are not, one of them will need to be enlarged or reduced first.

Box 6.1. Transferring information from one map to another using a pencil and tracing paper

The steps to follow in transferring information from a second map, photograph or image to a base map using a pencil and tracing paper are as follows:

1. Find a reference point on the second map, photograph or radar image that can also be found on the basic copy (e.g. a river branch, a bridge),
2. Place some tracing paper on the second map, photograph or image and trace the desired information, and the reference point, using a pencil,
3. Take the tracing paper off the map, photograph or image and turn it to its other side. With the pencil, gently shade in an area on the back of the tracing paper, behind the traced information.
4. Turn the tracing paper around to the traced side, place it on the basic map so that the reference points are lined up, and trace over the desired information again with the pencil. This will cause the lead on the other side of the paper to be transferred to the map. Darken this pencilled line with a black pen.

[13] *Appendix F explains these features of maps in more detail.*

Adding information from ground surveys (and possibly from GPS)

Ground surveying involves gathering mapping information in the field and then plotting it on a map. This may be necessary if information is missing or incorrect in sections of your planning map. For example, the maps, photographs or images you have copied may have covered only part of the inventory area. Or, areas within the original photographs or images may have been obscured by shadows and not interpreted accurately. The next section describes how to do ground surveying.

If your planning map has a grid reference[14] (such as latitude and longitude or UTM), you can use GPS in conjunction with or instead of ground surveying. GPS provides a quicker way of gathering information than ground surveys, as you can gather information in an open boat or truck without having to walk. GPS equipment records waypoints (i.e. the coordinates on a grid reference) of features in the field that you can then plot on a map. You can use GPS to record the location of potential reference points along the course of a river or road, at all major bends and all bridges, branches or junctions with other rivers and roads.

Adding information from villagers or their sketch maps

Information from the villagers that needs to be added to the map include:

- *The approximate location of the boundary of the inventory area*. Information about the exact location of the inventory area boundary is not essential for planning the inventory. However, it is needed to determine the size of the inventory area, which must be known in order to make the final calculations.[15] If the location of the inventory area boundary is not known before beginning the inventory work, it should be approximated. Later, information gathered while doing the inventory work can be used to improve the accuracy of the map.

Optional information to add include:

- *Local names for rivers, streams, ridges, mountains and villages*. The names for these features on some maps might be different from the names used by villagers. This is often the case if the maps have been made by people outside the village. For the planning map it is less confusing for the villagers if the local names are used.
- *More up to date information on man-made features than that copied from the map, image or photo*. It is not uncommon for maps, photos or images to be out of date which means that man made features, such as the location of villages and roads or the pattern of land use, are no longer accurate.

Villagers who know the area can add this information directly to the planning map. Or, you may add information yourself using the villagers' sketch maps as a guide.[16] Later, information gathered during the inventory work can be used to improve the accuracy of the map.

6.2.4. Adding the basic features of maps

Once the map has been completed, it should be checked to see whether the scale, north symbol, grid reference, date and legend are in place.[17]

---

[14] *Appendix F describes grid references in more detail.*

[15] *The villagers may have drawn the inventory area boundary on a sketch or scale map when they determined Objective 3 in Chapter 3.*

[16] *Appendix C describes how to make sketch maps if one has not been made already.*

[17] *Appendix F explains these features of maps in more detail.*

You might want to make at least two copies of this map. One can be used for planning where to locate the inventory lines, as described in *Chapter 7*, and the other for making the final maps, as described in *Chapter 16*.

6.3. Option 2. Make a planning map by ground surveying

A village that has no access to any accurate scale maps, photographs or images will need to make a land survey map. A land survey map is a scale map that can be made using only limited tools.

The most common method used in surveying is called a traverse. During a traverse a survey team measures the lengths and bearings of a series of straight lines walked on the ground. Each time the survey team changes direction they must begin a new line. All information about bearings and distances is recorded in a notebook. Later this information is plotted on a land survey map.

6.3.1. Traverse types

During participatory inventory it is likely that only two types of traverse will be used (see *Figure 6.4*), notably,

- A linear, or open, traverse, and
- A boundary, or closed, traverse.

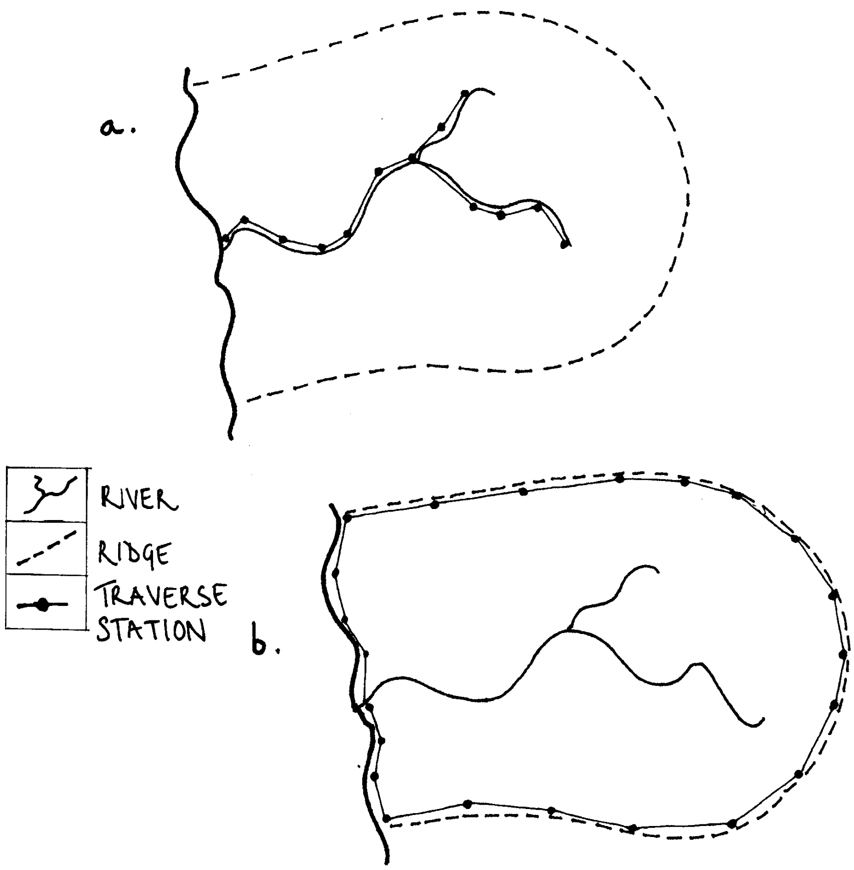


Figure 6.4. Two types of traverse, a) a linear traverse along a river, and b) a boundary traverse.

A linear traverse follows a line, such as a river or road. Information from a linear traverse can be used to create a simple map that is sufficiently detailed to plan the inventory.

A boundary traverse can be used to delimit the boundary of an inventory area or smaller areas within it. Survey work for a boundary traverse usually starts and finishes at the same point. This type of traverse can provide information about the size of an area in hectares, which is important in making the final calculations. However, putting evenly spaced inventory lines across the area will also enable you to draw the location of the boundary and estimate the area's size without having to do a boundary traverse.

6.3.2. Making a traverse

Two people, a leader and a compass person, usually make a traverse. They make the traverse by repeating a sequence of steps:

1. The traverse should begin at a visible landmark, for instance a large tree close to the meeting point of two rivers, so that it can be found again. Preferably, the landmark should be visible on a map or an aerial photograph. This start point is called the 'Point of Commencement', or POC.
2. Once the POC is located the first person (or leader) takes the end of the tape measure that is marked with a zero, and a straight stick two metres in length that is marked with brightly coloured tape, and walks in the direction that the traverse is taking. He or she must make sure the tape is kept straight between the two points and not caught around trees or undergrowth.
3. Once the leader has found a spot where the coloured stick is still visible from the POC, and where the distance from the POC is some multiple of 2 metres (i.e. a distance of 10, 12, 14, …, to 50 metres), he or she stops and holds the coloured stick vertically. This point is called a station, or traverse point. If it is the first station after the POC it will be called station 1.
4. The second person (or compass person) remains at the POC and holds the roll end of the tape measure as the leader pulls it out. When the leader arrives at the station he or she holds the tape end tightly. The compass person then pulls the tape tight, reads the distance and records this number in a notebook. This is the slope distance. The compass person must also measure the angle of the slope.[18]
5. The compass person then takes a compass bearing from the POC to the coloured stick that the leader is holding at station 1.[19] This bearing is also recorded in the notebook.
6. The compass bearer should also make notes about natural and man made features that were crossed or passed between the POC and station 1.

The leader marks the exact location of station 1 by putting a stick or other marker in the ground. The leader then walks on to station 2. At station 2 the leader holds the tape tight and waits until the compass person has reached the mark left at station 1. When the compass bearer reaches this point he or she records the slope distance, angle of the slope and bearing from station 1 to station 2. The compass bearer can also take a bearing from station 1 back to the POC. This is called a back bearing and should also be recorded in the notebook. Information from the back bearing can be used to check the accuracy of the original bearing. To do this, the compass bearer first calculates the opposite direction of the back bearing.[20] If the original bearing and the opposite

[18] *Appendix H describes how to estimate horizontal distance using these measurements of slope distance and angle of the slope.*

[19] *Appendix H explains how to take a compass bearing.*

[20] *Appendix H describes how to calculate the opposite direction of a bearing.*

direction of the back bearing differ by more than 2 degrees, the survey team should try to determine why the error occurred , and take the measurement again, very carefully. During this time the leader marks the exact location of station 2. And so the process continues.

A semi-permanent mark should be made at each station so that it will be easy to find at a later time. The survey team may want to return to a station in order to start a new traverse from a known point on the map. When making a survey map the traverse tends to follow rivers. Once one river has been followed to its source it is easier to return to a station that has been marked in an earlier traverse and use this as a new POC. This means that the surveying team will not have to backtrack on the earlier traverse. *Figure 6.5* shows a surveying team following a major river from the river mouth (POCa) to one of its sources. Once they have completed this they return to station 5 and survey a new line along a tributary of the river using station 5 as the POCb.

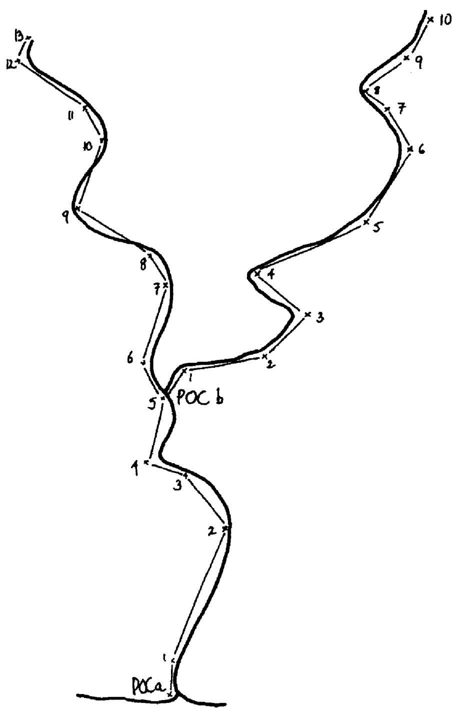


Figure 6.5. How a survey team might follow a major river from the mouth to its source

If the survey team is following a river it is important that the team stays as close to the river as possible. If for some reason it is not possible to follow the river closely the team should measure their distance from the river as accurately as possible and include this information in their notes. If the team passes by features that they would like to include in the map, they should make a 'cross-tie' to these features. They should also make cross-ties to any features that are likely to be visible in maps or remote sensing imagery (e.g. bridges, buildings, mountain tops, river branches), because this information can be used later to verify the accuracy of each leg of their traverse. Cross-ties are made by measuring bearings (and whenever possible, distances) from a station on a traverse to the feature. This information should be recorded in the notebook.

6.3.3. Recording the traverse

When taking any notes in the field it is important to include as much relevant information as possible because it might help to clear up a misunderstanding later. If notes are clear and easy to understand it will also mean that somebody who was not involved with the actual traverse can find and check parts of the traverse just from the notes.

Notes are best written in a bound notebook with a sharp pencil. On the first page you should write:

- The date of the traverse,
- Who did the traverse,
- Where the traverse took place, and,
- A detailed description of the POC so the exact starting point can be found again.

The left-hand pages of the notebook are used to record the measurements from the traverse. The corresponding right hand pages can be used to draw in sketches of the traverse. The traverse notes and sketches should always be written from the bottom of the page and then upwards because this is the view the survey team will have as they look ahead of themselves.

Each left-hand page should be divided into seven columns (see *Figure 6.6*) Information from the traverse should be filled in the columns as follows:

- In the left-hand column called 'station number' the recorder should begin by writing number 0, this represents the POC. This column (station number) can also be used to include a running total of the horizontal distance covered during the traverse
- In the second column called 'front bearing' the compass bearing from the POC to station number 1 should be recorded.
- In the third column called 'back bearing' the compass bearing from station number 1 back to the POC should be recorded.
- In the next three columns, only the columns named 'slope distance' and 'angle of the slope' should be filled. These readings are always recorded from the POC to station number 1 and not the other way around. The column 'horizontal distance' can be filled in at leisure once the slope distance and angle of the slope are known.[21]
- The final column named 'other notes' can include as much or as little information as is required. This information should correspond to features (such as rivers, roads or forest types) passed in the segment of the traverse which falls between the POC and station 1.

Once this is complete the recorder will write number 1 in the 'station number' column on the line above the number 0. This row will be used to record information from station number 1 to station number 2.

The right hand page of the note book can be used to draw a sketch of the traverse (see *Figure 6.6*). The POC should be drawn at the bottom of the page. A line representing the traverse can then be drawn up the page to station number 1 and then on to other stations after that. Information about things seen on the way can be included. The sketch can be very rough and does not need to be to scale or have the correct orientation. It is only important that it gives a rough idea of what was seen on the traverse. Every station should be marked on the map so that the features can be seen in relation to the stations.

---

[21] *Appendix H explains how to determine the horizontal distance from the slope distance and the angle of the slope.*

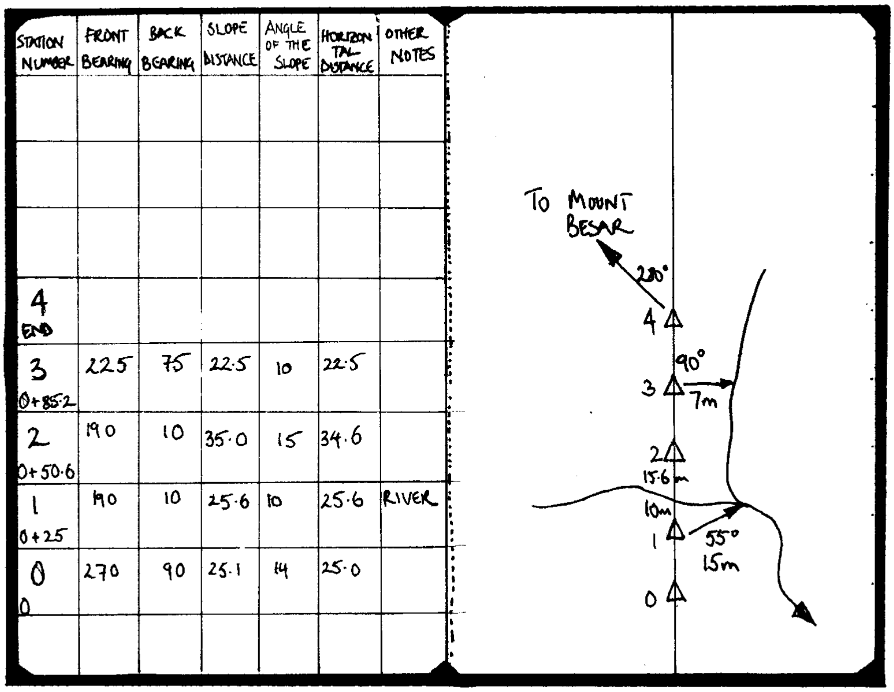


Figure 6.6. Example of how information from a traverse is recorded in a field notebook.

Once the field notes are complete they describe a traverse line. With this information it will be possible to make a survey map.

6.3.4. Making a map from traverse information

The traverse information recorded in the notebook can be used to create a survey map. To do this an appropriate scale must be chosen and then the individual stations and the bearings and distance between them should be plotted onto a piece of graph paper. It is easier to plot the information onto a large piece of graph paper. The final map will also be easier to read and more attractive than if it is drawn onto a small piece of graph paper. Other information gathered from the survey work can be added to this 'skeleton' later.

Choosing a scale

It is important to choose a scale which will enable all the information gathered from the survey work to fit onto a piece of graph paper of a desired size.[22] (1 metre by 1.5 metres is a good map size).

For a simple linear, or open, traverse, this is done by adding up all the horizontal distances recorded between stations. This will give an approximate length of the whole traverse and it will be this length that will have to be mapped onto the longest side of the graph paper. The longest side of the paper, as illustrated in *Example 6.1* must therefore divide this distance.

The information gathered from the survey work may cover a number of different line traverses over a large area. This is particularly likely in participatory inventory, where river systems which

[22] *Appendix F explains what a fraction scale is and how to use it.*

are often surveyed. In this case it might be best draw a quick, but still to scale, map on a smaller piece of graph paper before attempting to plot it on a large piece. Once this is done measure the North-South and East-West dimensions to determine a scale which will enable the information to fit well onto the larger piece of graph paper.

Example 6.1. Estimating a suitable scale for a land survey map

If the traverse is a bit less than 200 metres long and the graph paper is 40 cm long, then the scale that is wanted is one in which 40 cm on the paper is the same as 200 metres on the ground. This is the same as 40 cm = 20 000 cm, or 1 cm = 500 cm. In mapping terminology this is written as 1:500.

However, if the graph paper is 90 cm long, the scale should be 90 cm = 20,000 cm, or 1 cm = 222.22 cm, which is not very convenient to work with. Instead the closest convenient scale that will fit should be used. In this case the appropriate scale is 1:250. A scale of 1:200 is not suitable because if the traverse is straight it will be too long to fit onto the piece of paper.

It can be difficult to choose an appropriate scale for a closed traverse. In some circumstances the traverse might be roughly rectangular. In this case the longest length should be treated as the linear traverse described above. Once a tentative scale has been worked out the total length between the stations of the longest adjacent side should then be calculated. This number should be multiplied by the same scale to see if this will fit the width of the paper. If this does not work a new scale should be chosen, based on the width instead of the length.

Plotting the traverse from the notebook onto the map

The bearings of the traverse are plotted with a protractor and the distance between stations measured using a ruler. The easiest protractor to use is completely round, a full 360°, and transparent. The ruler should have millimetres marked on it and also be transparent.

It is sometimes difficult to know where to start on the piece of graph paper in order that the plotted traverse does not run off the page. If a test map has been made on a small piece of paper, as is described above, this will give a good idea of the overall shape of the map and choosing a starting point will not be too difficult. If there is no test map, then the people doing the plotting should look at the field notes and compare the bearings of the first few stations with the protractor. This will give an idea of which way the traverse is going keeping in mind that the top of the paper is north. For instance if the bearings begin between 90° and 120°, and then they switch to a range between 180° and 230° it can be assumed that the traverse is moving roughly in an anti-clockwise direction. Therefore, if the whole traverse is to fit on a piece of graph paper the start point would probably have to be around the centre of the top of the piece of paper. Once the start point has been determined it should be marked with a small cross. This point will represent the POC from the field notes.

The graph paper should be orientated so that north is pointing to the top of the page. It does not matter if the graph paper is placed on either its side or bottom, this will depend on the shape of the traverse. Place the protractor on the paper so that the centre point is aligned with the exact point of the POC. Align the line between 0° (or 360°) and the centre point on the protractor with the vertical (North-South) lines on the graph paper. Read the bearing from the POC to station 1 from the notebook. If the original bearing and back-bearing differ slightly, use the average of the two bearings. Find the bearing, or angle, on the protractor and make a small mark on the graph paper with a pencil. Move the protractor away and use the ruler to measure the horizontal distance from the POC to station number 1. Make sure to convert the horizontal distance between stations in the field to the appropriate distance on the map.[23] Draw this line along a bearing that is directed at the mark that has been made on the edge of the protractor.

For example, 50 metres is recorded between the POC and station number 1 and the scale being used is 1:1000. This 50 metres is converted to 5000 cm and divided by the scale (i.e. 1000), giving a result of 5. Therefore the distance between the POC and station number 1 on the map is 5 cm.

Once the location of station number 1 has been marked on the map the bearing and distance from station number 1 to station number 2, or from any station to a feature recorded during a cross-tie, is worked out using the same procedure.

Checking your traverse

In a boundary traverse, the end point should meet the starting point when you plot the traverse on a map. Often the points do not meet. This is not a problem if the error is small. To determine whether the error is small enough to ignore, calculate the percent error by following the steps described below:

1. Measure the gap between the POC and the end of the line (in cm).
2. Add up all the distances in your notebook to get the total length of the traverse or the perimeter length.
3. Convert the perimeter length to cm using the scale of the map.
4. Calculate the percent error by dividing the gap by the perimeter length and multiplying this by 100.

If the percent error is below 3%, you have a good traverse. If it is larger than 3%, you should look for the sources of error and try to correct them. For example, have you misread a number or made a calculation incorrectly? If you have an accurate scale map that shows the locations of the features to which you made your cross-ties, you can use your cross-tie data to determine the true locations of some of your stations and isolate where the error has occurred.

In a linear traverse, it is not possible to determine the percent error as you could for the boundary traverse. However, if your traverse is between two known points on an accurate scale map, (or if its two ends are cross-tied to two known points on a map), your map is accurate if, after drawing the traverse, the final point ends neatly at the second point on the map (or at the correct cross-tie distance and bearing from the second point on the map). Again, as with the boundary traverse, if you have an accurate scale map you can use your cross-tie data for some of the stations in between these end points to isolate where the error has occurred.

There are standard procedures for making adjustments for known (and sufficiently small) errors in boundary and linear traverses so that the adjustments are distributed around the mapped traverse in a rational manner. Unfortunately there is not enough space in this manual to describe these procedures. This information should be available in a mapping or surveying manual. However, if your error is large, and if you cannot determine the source of your error, you will have to return to the field to redo your traverse. If you have managed to isolate the location of the error by the use of cross-tie data, you can redo the surveying in that location alone, and will not have to redo the entire traverse.

---

[23] *Appendix F explains how to convert distance on the ground to distance on a map using the map's scale.*

Adding information from the villagers or their sketch maps

Once the basic river or road structure has been plotted, other information may be added to this map.

Information from the villagers that must be added to the map include:[24]

- *The approximate location of the boundary of the inventory area*. Information on the exact location of the inventory area boundary is not essential for planning the inventory. However, it is needed to determine the size of the inventory area, which must be known in order to make the final calculations. If the location of the inventory area boundary is not known before beginning the inventory work, it should be approximated. Later, information gathered while doing the inventory work can be used to improve the accuracy of the map.

Optional information to add include:

- *Local names for rivers, streams, ridges, mountains and villages*. The names for these features on some maps might be different from the names used by villagers. This is often the case if the maps have been made by people outside the village. For the planning map it is less confusing for the villagers if the local names are used.
- *Other information*. Other information that is considered relevant to planning the inventory may be sketched on to the map, such as the location of the village and the boundaries of the major land uses. Later, information gathered during the inventory work can be used to improve the accuracy of the map.

Some information can be added directly by villagers who know the area, or transferred from the villagers' sketch maps.[25]

Adding the basic features of maps

Once the map has been completed it should be checked to see whether the scale, north symbol, grid reference (this feature is often not possible to add if the map has been made by ground surveying alone), date and legend are correct and in place.[26]

You might want to make two copies of this map. One can be used for planning where to locate the inventory lines, as described in *Chapter 7*, and the other for making the final maps, as described in *Chapter 16*.

Where to next

Once the planning map has been prepared, you can use it to plan the inventory work. This step is described in the next chapter.

[24] *In Chapter 3, the villagers should have drawn the inventory area boundary on a sketch map when they determined Objective 3.*

[25] *Appendix C describes how to make sketch maps if one has not been made already.*

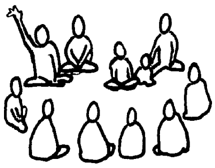
[26] *Appendix F explains these features of maps in more detail.*

7

Use the Planning Map to Plan the Inventory

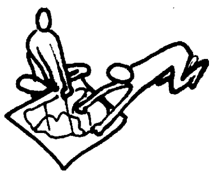
Where you are in the participatory inventory method:

I Decision making in the village



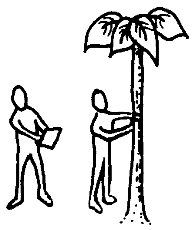
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



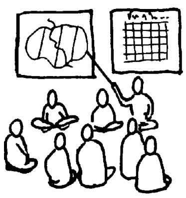
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

7.1. Decide whether you will use 100% enumeration or sampling with inventory lines,
7.2. Option 1. Use the planning map to plan a 100% enumeration, and
7.3. Option 2. Use the planning map to plan the location of the inventory lines.

Skills/information required

The skills or information that you will require include:

- *Appendix I*. Why we have chosen to sample with inventory lines.

Materials required

- A planning map, transparent A4 sheets on which simple grid graph paper has been photocopied, permanent pens, methylated spirits, a ruler, a calculator, a notebook and a pencil.

Introduction

Now that you have a planning map, you are ready to use it to plan your inventory. Your first step will be to decide whether your inventory will be done by 100% enumeration or by sampling. If it will be done by 100% enumeration, you must choose whether to do it in the village or the forest, and follow the instructions for either choice, using the planning map as required. If it will be done by sampling, you must use the planning map to draw the sampling design recommended in this manual. This sampling design is known as 'systematic strip sampling' and consists of inventory lines placed in an even pattern across the inventory area. These inventory lines are divided into plots of 10 metre width and 50 metre length, placed end to end. This chapter describes how to locate the inventory lines on the planning map in a way that ensures that the lines have the appropriate spacing and orientation.

7.1. Decide whether you will use 100% enumeration or sampling with inventory lines

People conduct inventories in order to obtain information about the quantities of given forest resources in a given area. This information can be obtained by counting every individual plant existing in the forest area. This method is called 100% enumeration. Alternatively, this information can be obtained by counting only some of the individual plants, and then estimating the quantities of all individuals in the forest area. This method is called sampling. A more exact estimate of quantity is obtained by using 100% enumeration than by sampling. However, the cost of the inventory, usually measured in terms of time and people, is an important consideration, as 100% enumeration is usually more costly than sampling, and a less exact estimate of resource density or quantity is almost always adequate for most inventory purposes.

A 100% enumeration may still be more affordable or necessary if:

- *All the individual plants of a given resource are known to the villagers.* For example, the honey bee trees in some places in Jambi province are individually known and named by their owners. Here, the 100% enumeration may be done most efficiently in the village by interviewing the villagers, as described below.
- *The inventory area is small enough that one team can enumerate it within a few days.* An area is small enough if it is less than 5 hectares in size. Here, 100% enumeration must be done in the forest, as described below.
- *The inventory area is divided into islands of forest that are small enough that one team can enumerate each of them within a few days.* For example, the rattan and fruit tree gardens found in East Kalimantan province are planted in abandoned rice fields and thus do not tend to ever be more than 2 hectares in size. If there are hundreds of these islands it may be necessary to select a random sample of these islands, rather than visit all of the islands. *Example 7.1.* describes how this was done in one area. Then, on each of the selected islands, 100% enumeration must be done in the forest, as described below.
- *It is required by government.* Under current Indonesian law, if a logging company wants to log an area they must conduct a 100% enumeration of timber trees prior to felling. Villagers may need to do the same in order to obtain permission for logging. Here, 100% enumeration must be done in the forest, as described below.

The way to plan a 100% enumeration, whether in the village or in the forest, is described in Option 1, below.

Example 7.1. Randomly selecting fruit gardens for 100% enumeration

In one village in East Kalimantan, the villagers decided to determine the quantity of important timber and non-timber resources found in their traditional fruit gardens, called *simpukng*. These fruit gardens are small, never more than 2 hectares in size, and numerous, amounting to over 314 gardens. For this reason, the villagers decided to conduct their inventory in the following manner:

1. *Map the location of all of the gardens.* The locations of the gardens were drawn by the villagers on a planning map that had already been prepared. The boundaries of the gardens were not mapped because the gardens were so small and numerous it would have been too difficult and costly to map them.

2. *Randomly select a proportion of the gardens.* The gardens were assigned numbers, and 30 of the 314 were selected using the random selection method described in *Box 7.2*. This was assumed to cover an adequate proportion of the gardens (almost 10%), and was within the cost limits of the villagers.

3. *Map the boundaries of the selected gardens in the field and determine their size.* A mapping team surveyed the selected gardens to determine their size. They also marked the location of the boundaries in the field in order to guide the inventory team later during their 100% enumeration. An alternative to using a mapping team would have been for the inventory team to complete the inventory work first, and then use the information on the quantity and lengths of the inventory lines to draw maps of the gardens and determine their size.

4. *Conduct a 100% enumeration in each selected garden.* The method used for the 100% enumeration is described below.

For the calculations, the average resource density of the selected gardens was assumed to represent the average resource density of all the gardens. The average size of the selected gardens was also assumed to be the same as the average size of all of the gardens. This meant that the remaining unselected gardens were not mapped, nor were their sizes calculated.

Sampling may be preferable to 100% enumeration if:

- The plants are not all known to the villagers,
- The inventory area, or the islands of forest in the inventory area, are large (i.e. greater than 5 hectares), or
- 100% enumeration is not required by government.

The way to plan sampling is described in Option 2, below.

7.2. Option 1. Use the planning map to plan a 100% enumeration

7.2.1. 100% enumeration in the village

As discussed above, sometimes forest resources are sufficiently valuable, and sufficiently few in number, that each individual plant or tree may be owned and its location known by someone in the village, at least in the forest areas near the village. If this is the case for a resource that the village has chosen for inclusion in the inventory, then it may make better sense to count all of the individuals of this resource by consulting the villagers rather than by trying to find them in the forest.

To do so, a list of all resource owners in the village should be drawn up, and each person asked to make their own list of the individual plants that he or she owns. The resource owners may note the locations of these plants on the planning map as well.

7.2.2. 100% enumeration in the forest

With 100% enumeration in the forest, the entire area to be enumerated is covered with inventory lines spaced 10 metres apart (if enumerating timber species only, the lines should be spaced 20 metres apart). This is illustrated in *Figure 7.1.*

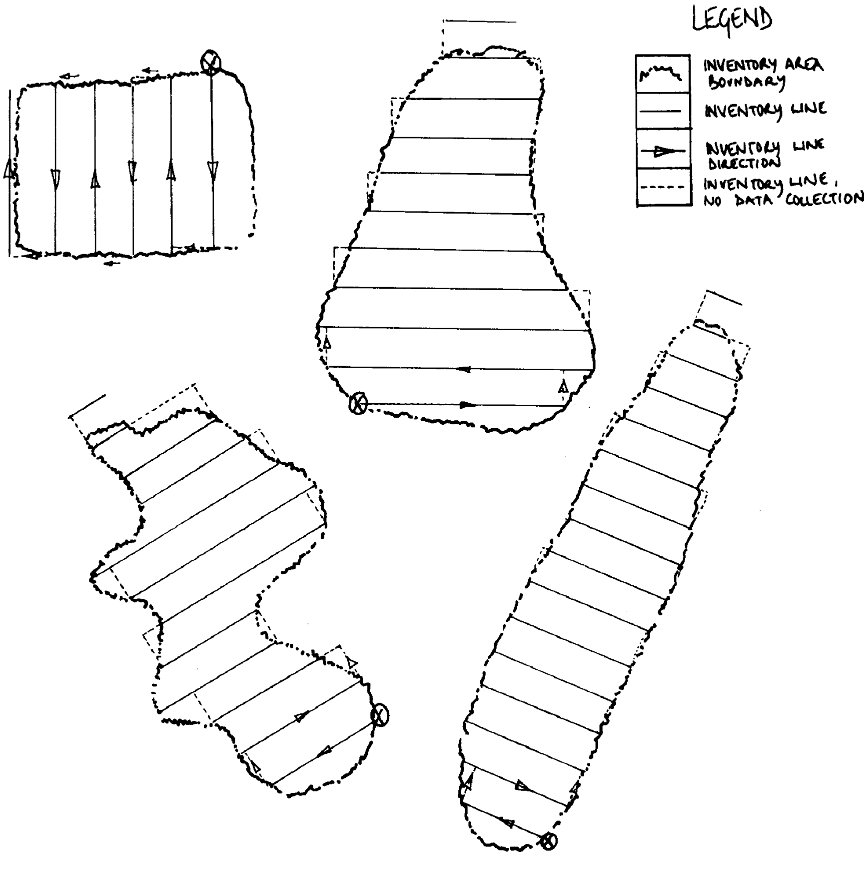


Figure 7.1. Different orientations and starting points of inventory lines for areas under 100% enumeration.

Before the inventory team goes to the forest they should plan the 100% enumeration by using the following steps:

1. Draw the boundary of the area (or areas) on the planning map. Calculate the size of the area (or areas) using the method described in *Section 7.3.3*. If such exact information is not available, ask a villager who knows the area to sketch it and guess its approximate size.
2. Estimate how many days and inventory work teams (of 6 people on each team) and it would take to complete an enumeration of this area (or areas), using as a rough guide the approximation from *Appendix D* that one inventory work team in one day can complete:
   - 1.0 hectare if lines are 10 metres apart (2.0 hectares if lines are 20 metres apart), if the area is hilly, and
   - 1.5 hectares if lines are 10 metres apart (3.0 hectares if lines are 20 metres apart), if the area is flat.
3. Check whether this number of team days is within the cost limits determined by the villagers for this inventory. If it is not, the villagers will have to decide whether they should increase the cost limits for the inventory or reduce the size of the inventory area as a whole.
4. Look at the map of the area (or areas) and determine the orientation for your inventory lines that will be most convenient for the inventory work team. Often it is good to orient the lines so that they are perpendicular to the long axis of the area. *Figure 7.1* illustrates some suitable orientations.
5. Choose a convenient starting point for the inventory work team and mark it on the map. The starting point should be on one end of a line at the edge of the area. *Figure 7.1* also illustrates some suitable starting points.

7.3. Use the planning map to plan the location of the inventory lines

7.3.1. Why and how we sample with inventory lines

If you are sampling your inventory area, you will need to plan where to put your sampling design. The sampling design recommended in this manual is called ‘systematic strip sampling’. This method has been chosen because it is simple, accurate and cost efficient. *Appendix I* explains in more detail why this manual recommends systematic strip sampling as a sampling design. You are recommended to read this appendix. Systematic strip sampling consists of inventory lines with the spacing and orientation described in *Box 7.1*, below. These lines are divided along their length into plots that are 10 metres wide and 50 metres long.

Box 7.1. Spacing and orientation of inventory lines

Inventory lines within one working unit should have the following spacing and orientation:

- Spacing: There should be an equal distance between all of the lines. The actual distance between lines will depend upon how many plots you have decided to put in the working unit.
- Orientation: All lines within the working unit should have the same bearing (i.e. they should be parallel), and oriented so as to:

  a) Cover maximum variation in the vegetation (see *Figure 7.2*), and

  b) Maximise the number of inventory lines that can be placed in the working unit (see *Figure 7.3*).

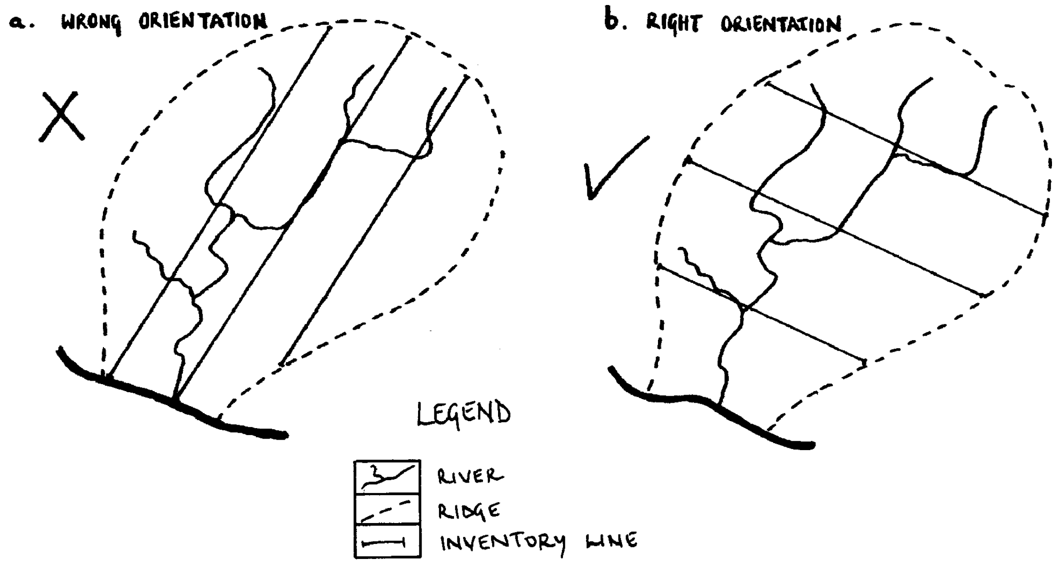


Figure 7.2. **If the topography is considered the main source of variation in vegetation, the inventory lines should go from the main river to the ridge, cutting the river and ridge at right angles.**

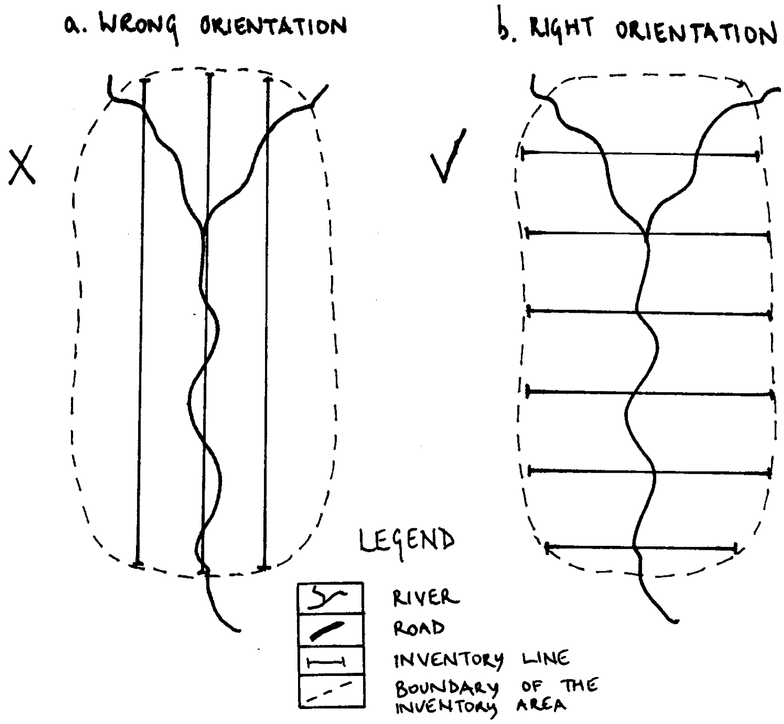


Figure 7.3. **The inventory lines should also be oriented to be perpendicular to the longest axis of the unit, if possible, so that the number of lines is maximised.**

The steps to follow to plan the location of these lines are as follows:

1. Decide whether or not you need to divide the inventory area into working units,
2. Calculate the size of the working units (if there are any),
3. Divide the total number of plots amongst the working units (if there are any), and
4. Draw the inventory lines on the planning map, either in the inventory area as a whole or in each working unit (if there are any).

7.3.2. Decide whether or not to divide the inventory area into working units

It may or may not be necessary for you to divide the inventory area into working units (see *Figure 7.4*). An inventory area should only be divided into working units if:

- A more suitable orientation for the inventory lines within each working unit can be obtained by doing so, or
- It makes it more convenient for the inventory team to conduct the inventory. For example, you should divide an inventory area into working units if this makes it easier to place camps with easy access to all the inventory lines in the working unit.

The boundaries of the working units should be easily distinguishable in the forest. There are a number of possible types of working units:

- *River watersheds* (see *Figure 7.4a*). The ridges that form the boundaries of river watersheds are usually easy to distinguish. Lines oriented so as to cut the general direction of the main river at right angles ensure that maximum variation in topography, and hence the vegetation, is covered. As the river is often parallel to the long axis of the watershed, this line orientation also can maximise the number of inventory lines that could be placed in the watershed. Finally, rivers often provide good access routes to the inventory lines and ensure easy access to the inventory lines as well. Thus one option is to divide the inventory area into its respective watersheds. If desired, neighbouring watersheds that have rivers running in roughly parallel directions can be combined in one working unit.
- *Blocks formed by a grid of logging roads or survey lines* (see *Figure 7.4b*). The logging roads or survey lines may clearly delineate blocks of forest, and also provide good access to these blocks. Usually this sort of situation will only be found in areas that have been, or are about to be, logged.
- *Separate islands of forest* (see *Figure 7.4c*). Islands of forest in the inventory area must each be considered a separate working unit. If large enough, they may need to be divided further into smaller working units.

Remember there is no one correct way to divide an area into working units. Instead, there are usually many suitable solutions. Try to weigh up the different considerations to decide upon working units that are cost efficient and convenient for your situation.

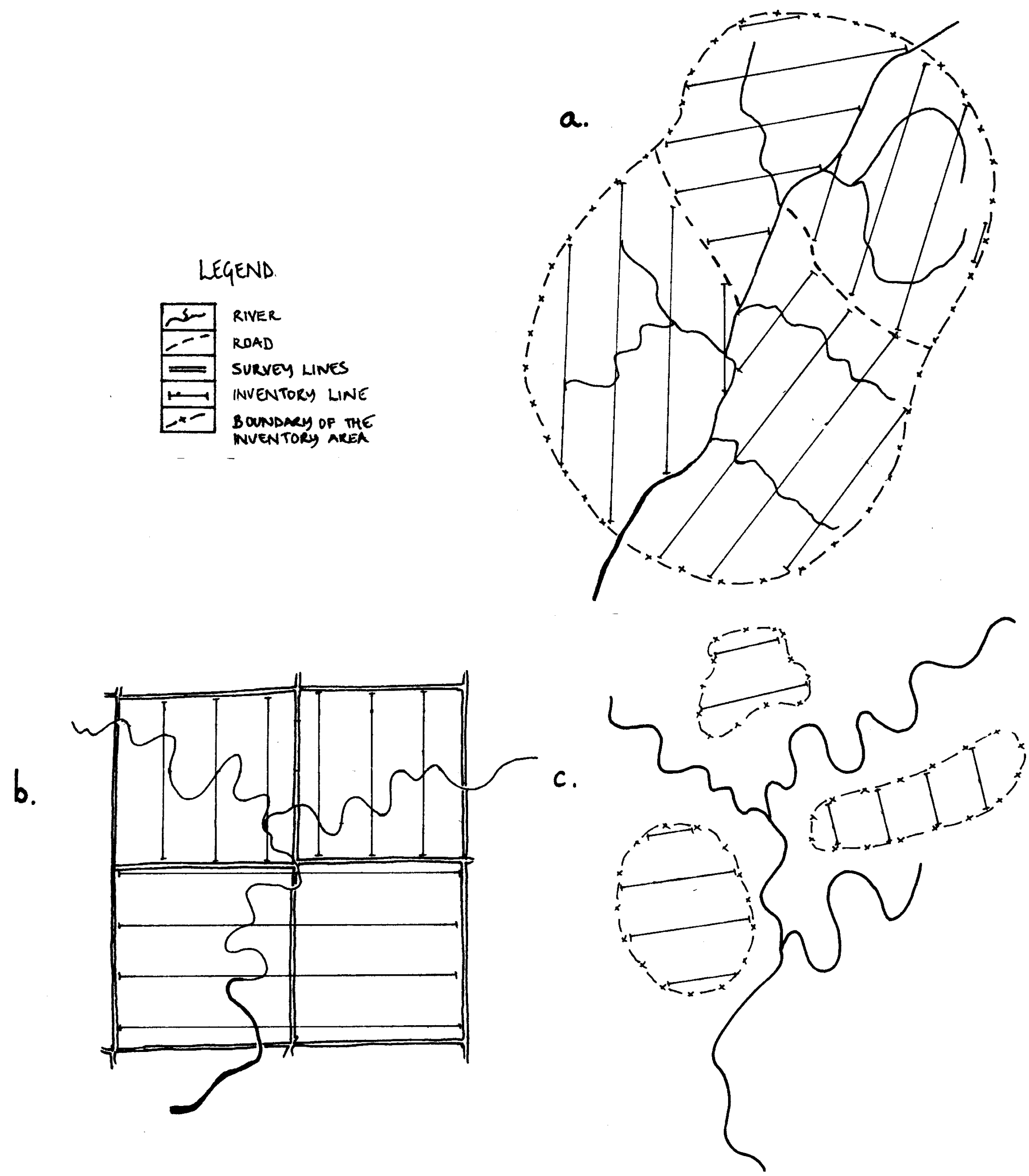


Figure 7.4. Good working units can be made from: a) river watersheds, b) blocks formed by a grid of logging roads or survey lines, and c) islands of forest in the inventory area.

Dividing an inventory area into working units is not the same as subdividing an inventory area, whether by smaller area or forest type.[1] The reasons for making these types of division are not the same. You divide the inventory area into working units in order to plan the most effective and convenient location of inventory lines. In contrast, you divide the inventory area into smaller areas or forest types if you want to make separate calculations for each smaller area or forest type. A working unit may by chance cover the same area as a smaller area or forest type. However, a working unit may encompass several smaller areas or forest types (see *Figure 7.5a*) or it may be only a part of one smaller area or forest type (see *Figure 7.5b*).

---

[1] *Chapter 3 discusses subdivision of an inventory area into smaller areas or forest types.*

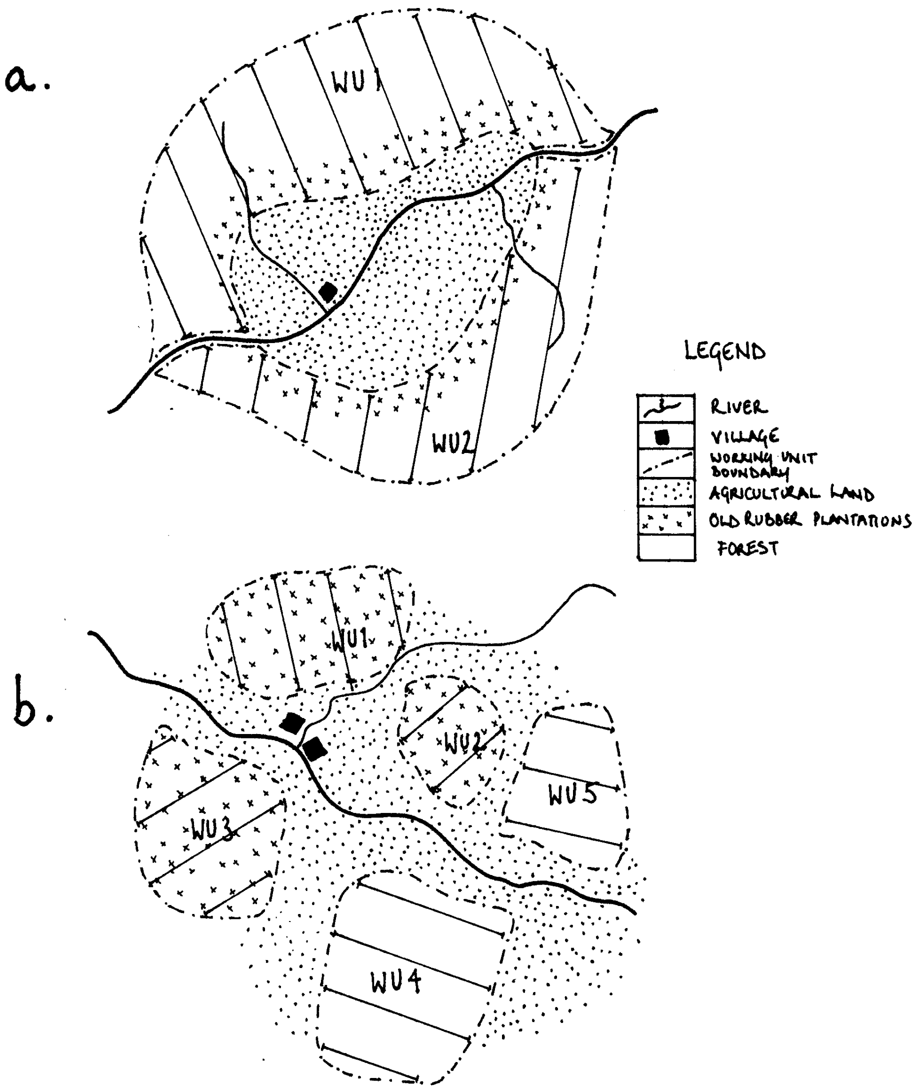


Figure 7.5. A working unit may: a) encompass several forest types (e.g. WU1, which has both old rubber plantations and forest), or b) be only one of several islands of one forest type (e.g. WU3, which is only a part of the village's rubber plantation).

7.3.3. Estimate the size of the working units

If you have divided your inventory area into working units, you will now need to estimate their size. As the boundaries of these working units may not be known exactly, these size estimates may not be accurate. Nonetheless an approximation is still needed for planning the location of the inventory lines. After the inventory work has been completed, a more accurate estimate of the area's size should be possible.

The size of the working units can be estimated in five steps:

1. Draw the boundary of each working unit on the planning map

The boundaries of all working units should be drawn on the planning map. If it is not possible to draw the boundaries accurately (because the planning map does not show the necessary detail), their location should be approximated. Sometimes these boundaries may follow a river, road, or survey line but they will most often follow ridges that separate one watershed from the next. Some maps will show the location of ridges (e.g. topographic maps or aerial photograph- or radar image-derived maps) but local people who know the area should still check these maps. Other maps may not show the location of ridges (e.g. ground survey maps made by surveying the main river system). In such cases the location of the ridges can be approximated by drawing them halfway between a given river and its neighbouring rivers (see *Figure 7.6*).

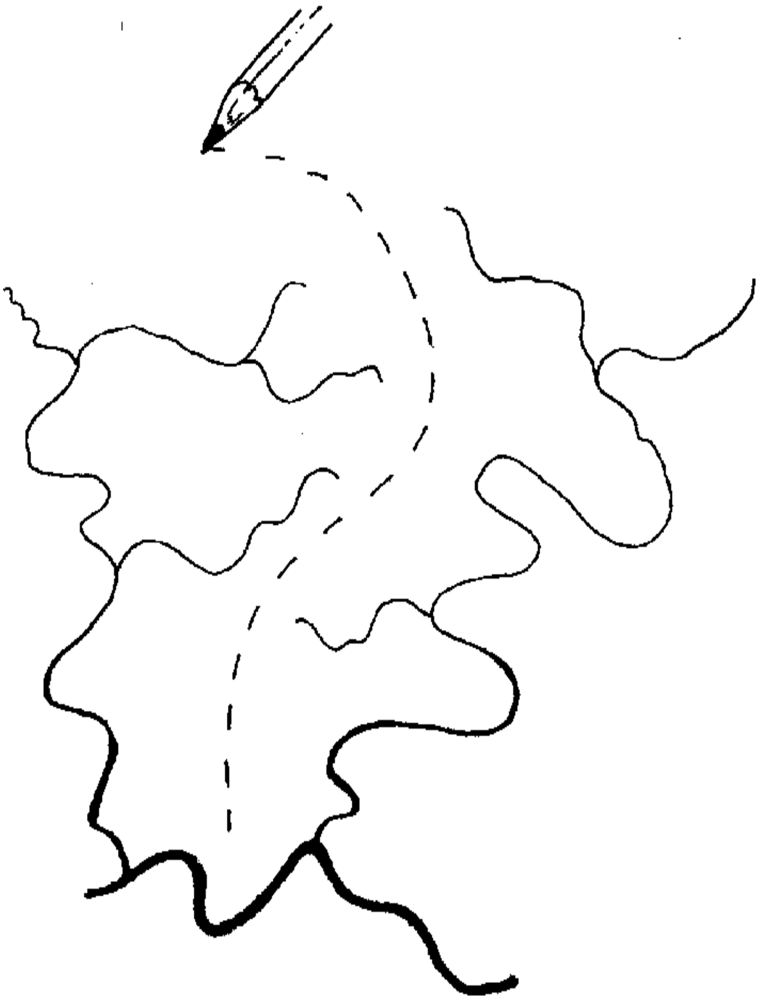


Figure 7.6. The location of the ridges between watersheds can be approximated by drawing them halfway between a given river and its neighbouring rivers.

2. *Trace the boundaries of the units onto a graph paper transparency*

Place a transparent plastic sheet, on which simple grid graph paper has been photocopied, on top of the planning map. Trace the boundaries of each working unit onto the plastic sheet with a permanent ink pen (see *Figure 7.7*). If a working unit is larger than the transparent plastic sheet it should be divided into sections on the map, and each section traced on to different transparent sheets until the whole unit has been covered.

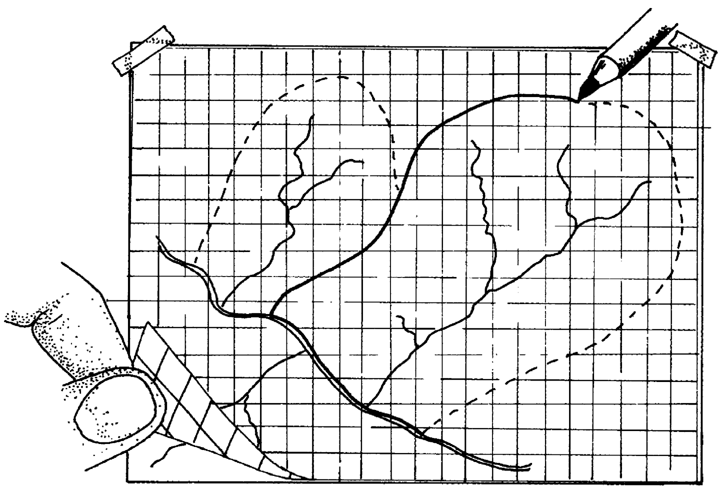


Figure 7.7. How to trace the boundaries of each working unit onto the plastic sheet with a permanent ink pen.

3. Count the number of squares within the boundaries of each unit

Count the total number of squares within the boundary of each working unit. An efficient way to do this is to (see *Figure 7.8*):

- Draw square or rectangular blocks within the boundary and calculate the total number of squares within each block by multiplying its width by its height,
- Count all the remaining whole squares, and then
- Count any partial squares by matching pieces of squares together to make the equivalent area of whole squares.

Using a calculator, add together these subtotals and write the total number of squares for the working unit in a notebook. You can remove the ink from the transparent sheet with methylated spirits in order to use the sheet again.

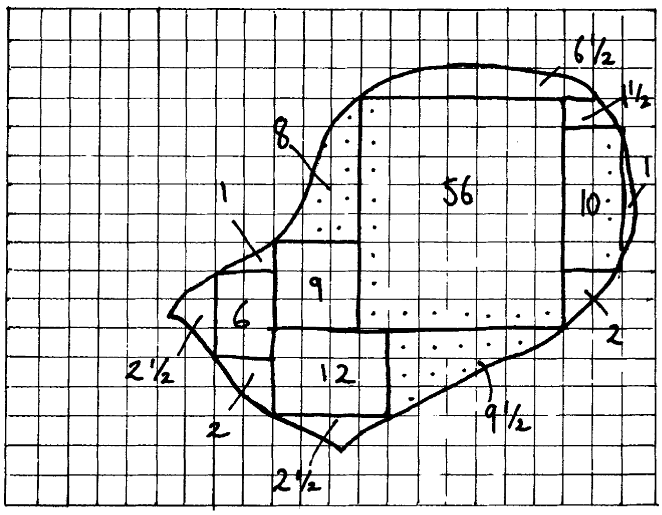


Figure 7.8. Count the total number of squares within the boundary of each working unit by dividing the working unit area up with squares, calculating the sub totals of these squares and then adding all the sub totals together.

4. Calculate the size of one square on the transparent sheet

In order to calculate the size (in hectares) of a working unit you must calculate the size of one square at the scale of your planning map.[2] Measure one side of a square on the transparent sheet. Convert this distance on the map to the corresponding distance on the ground using the scale of the map. This value should then be squared to obtain the size of the square. This value should be expressed in hectares by dividing it by 10 000, as one hectare is equal to 10 000 square metres (*Table 7.1,* below, can be used to express units of area as hectares, square kilometres, square metres or square centimetres). An example of this calculation is provided in *Example 7.2.*

Table 7.1. How to express units of area as hectares, square kilometres, square metres or square centimetres

	ha	*km²*	*m²*	*cm²*
1 hectare or ha=	1	0.01	10 000	1×10^8
1 square kilometre or km²=	100	1	1×10^6	1×10^{10}
1 square metre or m²=	0.001	1×10^{-6}	1	10 000
1 square centimetre or cm²=	1×10^{-8}	1×10^{-10}	0.0001	1

Example 7.2. Calculating the size of one square

In this example, the side of one square on the transparent sheet is 0.5 cm. The scale of the map is 1:25 000, which means 1 centimetre on the map is the same as 25,000 centimetres (which can also be expressed as 250 metres) on the ground. Thus 0.5 cm on the map is the same as 125 metres on the ground (0.5 x 250 = 125).

If each square on the transparent sheet is 0.5 centimetre by 0.5 centimetre then on the ground each square is 125 metres by 125 metres. This is an area of 15,625 square metres on the ground (125 x 125 = 15,625), which can also be expressed as 1.5625 hectares (15 625 ÷ 10 000 = 1.5625) (see *Table 7.1*).

5. Calculate the size of the working units

Once you have counted the total number of squares for a working unit, as well as the size of each square on the transparent sheet, then you can calculate the size of the working unit by multiplying the above two values together. An example is provided in *Example 7.3.*

Example 7.3. Calculating the size of a working unit

A working unit covers 3492 squares, and the size of each square is 1.5625 hectares. The size of the working unit is therefore 3492 squares multiplied by 1.5625 hectares, which gives a result of 5456 hectares.

[2] *Appendix F explains how to convert a distance on the ground to a distance on a map using the map's scale.*

7.3.4. Divide the total number of plots amongst the working units

If you have chosen to divide the inventory area into working units, the next step is to divide the total number of plots that have been planned for the inventory amongst the working units. You should already have calculated the number of plots that best balances the cost and precision objectives of the village.[3] Allocate these plots amongst the working units so that the number of plots in each unit is proportional to the size of each unit. In other words if one working unit is twice the size of another working unit, the larger unit should have twice as many plots as the smaller unit. To do this, work out the ratio of each unit's size relative to the total size of all the units together, and apply this ratio to the total number of plots. An example is provided in *Example 7.4*.

Example 7.4. Dividing the total number of plots amongst the working units

A total number of 900 plots can be established under the cost and precision constraints that the villagers have chosen. The inventory planners want to divide these plots amongst three working units (one of 5456 hectares, one of 5818 hectares and one of 951 hectares) so that the number of plots in each working unit is proportional to the size of each working unit. This is done by making the calculations shown below:

Unit A:	5 456 hectares	5456 ÷ 12 225 = 0.446;	900 plots x 0.446 =402 plots
Unit B:	5 818 hectares	5818 ÷ 12 225 = 0.476;	900 plots x 0.476 =428 plots
Unit C:	951 hectares	951 ÷ 12 225 = 0.078;	900 plots x 0.078 = 70 plots
Total:	12 225 hectares		900 plots

Thus the three working units are allocated 402, 428 and 70 plots, respectively.

7.3.5. Draw the inventory lines on the planning map

This section describes how to draw the inventory lines on the planning map so that they have the appropriate spacing and orientation, as outlined in *Box 7.2.* To do this, follow the seven steps outlined below, repeating all seven steps for each working unit. If you have not divided the inventory area into working units, substitute the words 'inventory area' for the words 'working units' when following these steps.

1. Draw a base line and estimate its length

The base line is the line that the inventory lines will cut at right angles. If the best orientation for the inventory lines is to be perpendicular to a river or road, the base line should be parallel to the river or road. If the river or road is roughly straight, then the decision as to where to place the line will be relatively simple. If it is not, you will have to approximate the general direction of the river or road and place the base line parallel to this direction (see examples in *Figure 7.9*).

[3] *Appendix D describes how to calculate the number of plots that best balances the villagers' cost and precision objectives.*

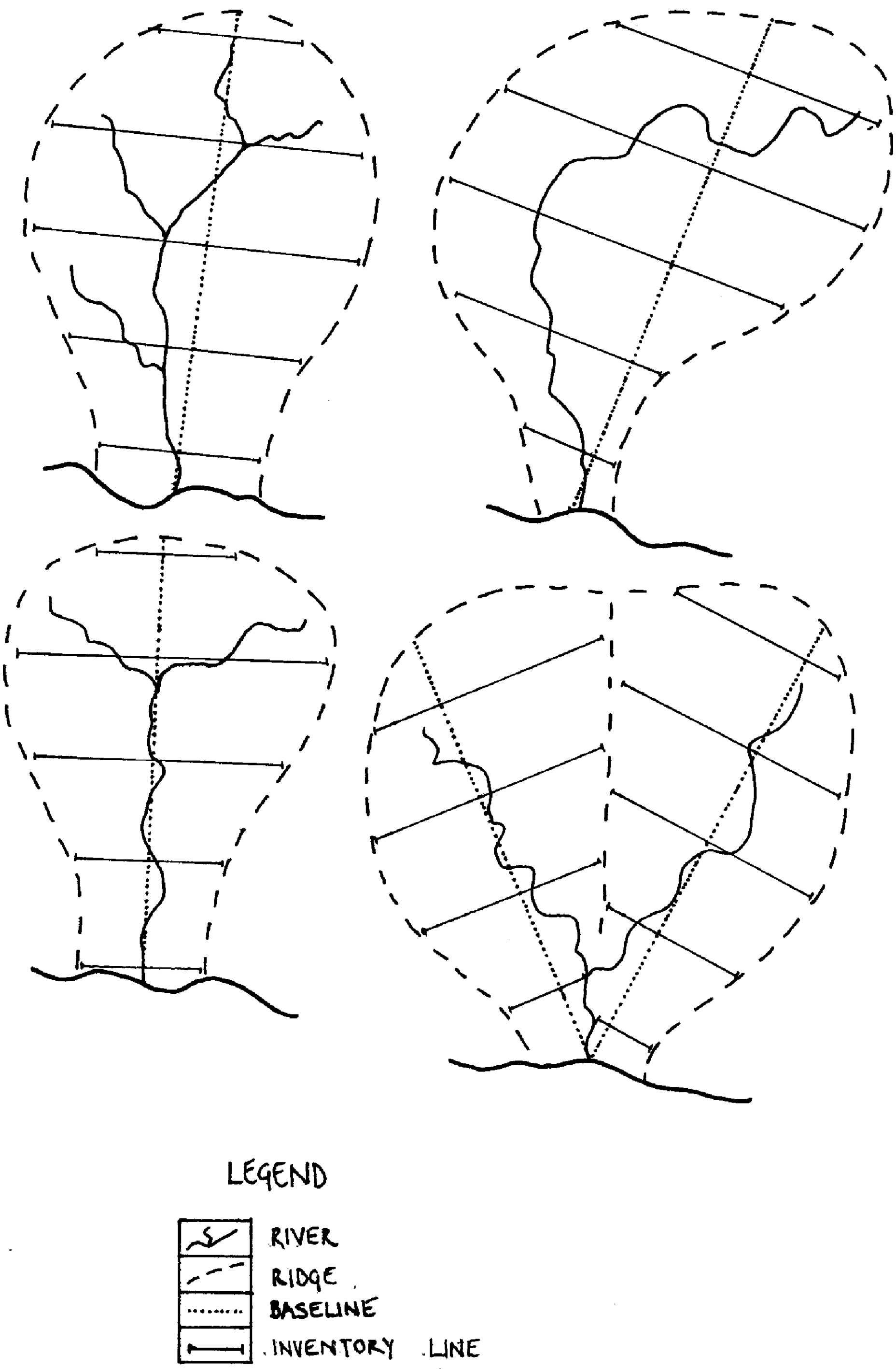


Figure 7.9. How to locate a base line on the planning map if the river or road being used for orientation is not straight.

Draw the base line on the planning map using a pencil and ruler. It should be drawn at the appropriate orientation, in the approximate centre of the working unit. The two ends of the base line should extend as far as the farthest points at which inventory lines could be drawn on the inventory area or unit. This may mean that the base line extends beyond where it meets the boundary of the working unit (see *Figure 7.10* for an example). After drawing the base line, you should measure its length in centimetres with a ruler.

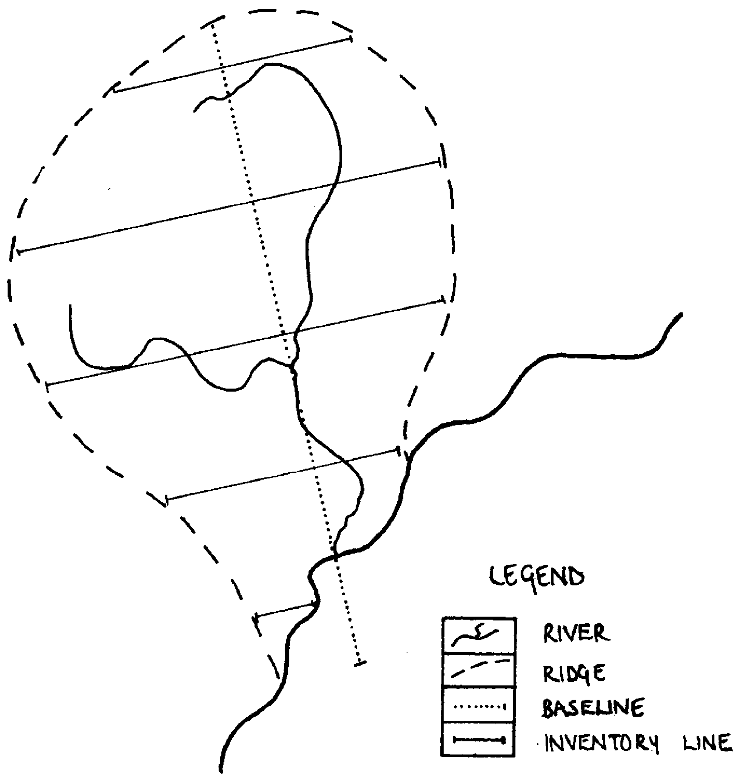


Figure 7.10. The baseline should extend as far as the farthest points at which inventory lines could be drawn on the working unit. Sometimes the base line will extend beyond where it meets the boundary of the working unit.

2. Estimate the average length of the inventory lines

The inventory lines will cut the base line at right angles and extend until both ends meet the boundary of the working unit. They will have different lengths at different points along the base line, depending upon the shape of the working unit that they are in. Measure lengths at several points along the base line and take their average, in order to estimate what the average inventory line length will be (in centimetres). An example is provided in *Example 7.5*.

Example 7.5. Estimating the average length of the inventory lines

To estimate the average length of the inventory lines for the working unit in *Figure 7.11*, the inventory planners drew three lines. The lengths of these lines were 5.5, 5.4 and 2.5 centimetres. These lengths were added together and divided by three to obtain an average line length of 4.6 centimetres ($(5.5 + 5.4 + 2.5) \div 3 = 4.6$).

3. Calculate the total length of the allotted plots

A number of plots will already have been allotted to the working unit. Calculate the total length of these plots, if they were placed end to end, by multiplying the number of plots by their length (in this manual 50 metres is the recommended plot length). This total inventory line length should be then be converted from metres on the ground to centimetres on the map using the scale of the map. An example is provided in *Example 7.6*.

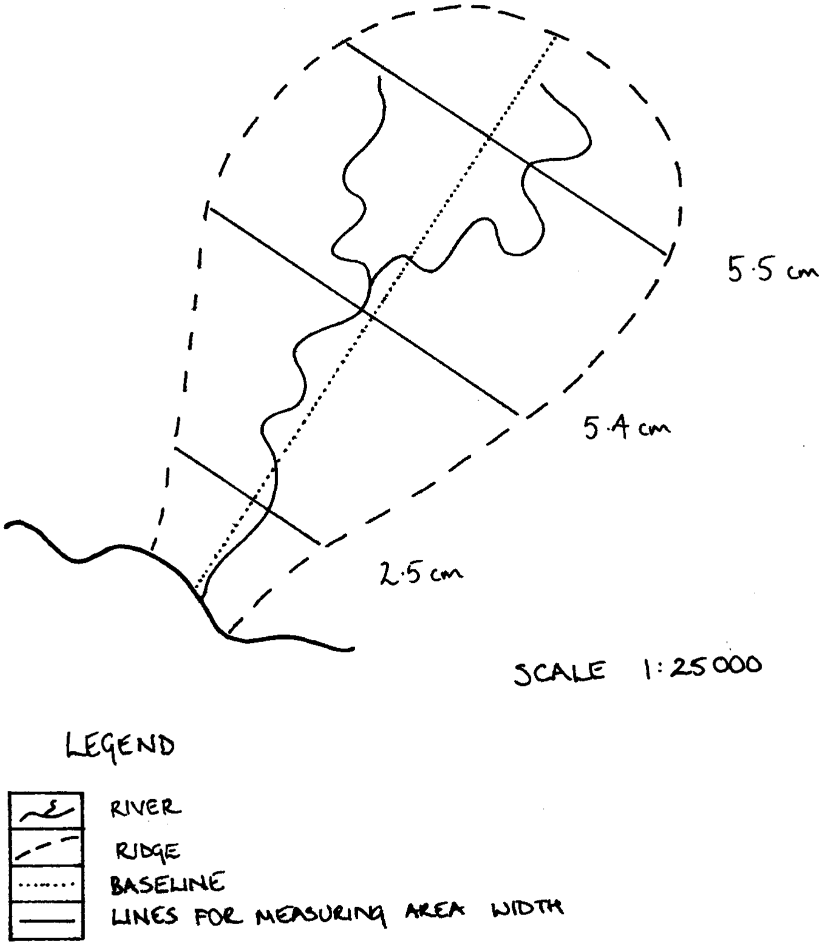


Figure 7.11. Estimating the average length of the inventory lines.

Example 7.6. Calculating the total length of the allotted plots

402 plots have been allocated to the working unit depicted in *Figure 7.11*. This number of plots multiplied by 50 metres (the length of each plot) gives a total length of 20 100 metres (402 x 50 = 20 100).

The map scale is 1:25 000. Therefore, 1 centimetre on the map is the same as 25 000 centimetres (or 250 metres) on the ground. To convert from metres on the ground to centimetres on the map, the total length of the allocated plots (20 100 metres on the ground) should be divided by 250 metres (which is the equivalent of one centimetre on the map), giving a result of 14.0 centimetres on the map.[4] This means that the inventory planners should draw a total length of 14.0 centimetres of inventory lines on the planning map in this particular working unit.

[4] *Appendix F explains how to convert a distance on the ground to a distance on a map using the map's scale.*

4. Calculate the number of inventory lines

To calculate how many inventory lines will be drawn on the map, the total inventory line length (calculated in Step 3) should be divided by the average inventory line length (calculated in Step 2). You must round your answer to a whole number. It is always best to round down rather than round up because rounding up makes it more likely that you will go over the number of plots that you have planned to establish in your working unit. This step is illustrated in *Example 7.7*.

Example 7.7. Calculating the number of inventory lines

On the planning map 14.0 centimetres of inventory line has been allocated to the working unit in *Figure 7.11*. The average length of inventory lines in this unit has been estimated at 4.6 centimetres. 14.0 centimetres divided by 4.6 centimetres gives a result of 3.04, which is rounded down to 3. This result means that 3 inventory lines should be drawn in this working unit.

5. Calculate the distance between inventory lines

To calculate the distance between all inventory lines in this unit, the length of the base line (measured in Step 1) should be divided by the number of inventory lines that need to be drawn in this unit (from Step 4). This is illustrated in *Example 7.8*.

Example 7.8. Calculating the distance between inventory lines

On the working unit depicted in *Figure 7.11*, the length of the baseline is 9.7 centimetres. The inventory planners have calculated that 3 inventory lines will need to be drawn in this unit. 9.7 centimetres divided by 3 inventory lines gives a result of 3.2 centimetres. This is the distance that should be measured between the inventory lines on the map.

6. Select the position of the first line

The position of the first line should be chosen randomly. The way to make a random selection is described in *Box 7.2*. This step is illustrated in *Example 7.9*.

Box 7.2. Selecting a random number

The basic principle involved in selecting a random number is to ensure that every number has an equal chance of being selected. A number of methods can be used:

1. Write all of the numbers on cards of paper, put these cards in a box, and draw one from the box.
2. If there are too many numbers to be able to write each on a card, write the digits ‘0’, ‘1’, ‘2’ through to ‘9’ on cards, and draw them from a hat as many times as there are digits in the largest number (i.e. if the largest number is 99 or less, draw cards twice, if the largest number is 999 or less, draw cards three times). Remember to replace the card you have drawn before drawing a second card. If the number you end up with is larger than your largest number, draw the series of cards again.

Example 7.9. Selecting the position of the first line

As the distance between lines is 3.2 cm, the first line should be placed somewhere between 0.1 and 3.2 centimetres from the beginning of the base line. The inventory planners therefore randomly selected a number between 1 and 32. The number they selected was 23, therefore the point at which the first inventory line will cut the base line will be 2.3 centimetres from the start of the base line.

7. Draw the inventory lines on the planning map

Once the number of lines (from Step 4), the distance between the lines (from Step 5) and the position of the first line (from Step 6) have been established for the working unit, you should draw all the inventory lines on the map in pencil.

Using a ruler, you should then measure the length of these lines and add these lengths together. Compare this total length to the allotted total length for the working unit (from Step 3). If the total length of lines is too high (remember that at a scale of 1:25 000, 4 to 6 centimetres on the map is approximately one team day's worth of work), then the number of inventory lines should be decreased by one. If the total length of lines is too low, then an extra inventory line can be added on. If you drop or add a line, you should return to Step 5 and repeat all subsequent steps until a satisfactory total line length is reached.

Where to next

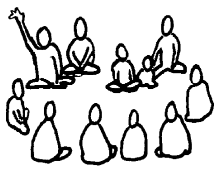
Now that you have planned your inventory on the planning map, the next step is to decide what information about the resources and environment you will be gathering when working along the inventory lines and how you will gather it. This will be discussed in the next chapter.

8

Plan How to Gather Information on Plants and Their Environment

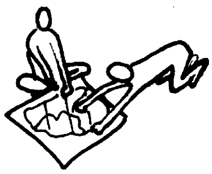
Where you are in the participatory inventory method:

I Decision making in the village



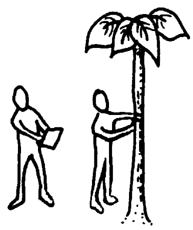
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



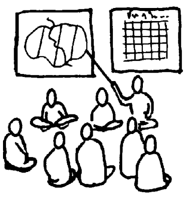
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

8.1. Plan how to gather information on the plants, and

8.2. Plan how to gather information on their environment.

Skills/information required

The skills or information that you will require include:

- *Appendix K*. Measuring plant size.

Materials required

- Notebook, pen, metre tape (optional), diameter tape (optional), ruler (optional) and clinometer (optional).

Introduction

Having planned your inventory using the planning map, the next step for you and the inventory team is to plan what information you will be gathering along the inventory lines and how you will gather it. This information could be about the plants being enumerated in the inventory or about their immediate environment. The general information required (i.e. for all resources generally, not each resource specifically) should already have been decided in *Chapter 3*, when the villagers determined Objectives 2 (resource information) and 5 (environmental information). This chapter explains how to plan the specific information that is wanted about each resource and about the environment. It also explains how to estimate or measure this information.

8.1 Plan how to gather information on the plants

The whole inventory team should discuss plans for gathering information on plants together. The decisions you will have to make include:

- What type of information do you want to collect about the plants of each resource species?
- Do you want to include all the plants of each resource species in the inventory, or only a limited range of the plants?

The next two sections will discuss these decisions in more detail.

8.1.1. Type of information

For each individual plant of a given resource species, information can be recorded about their:

- Age (e.g. whether the plant is a seedling, sapling or tree, etc.),
- Size (e.g. the plant's diameter, height, length, etc.),
- Sex (e.g. whether the plant is male or female (Note: this is only relevant for species where there are separate male and female plants)), or
- Condition (e.g. whether the plant is healthy, sick or dead, etc.).

The villagers will already have made some general decisions about the type of information that is wanted for all of the resources chosen for the inventory.[1] These decisions should relate to the inventory purpose. The inventory team will now need to refine these general decisions by thinking about the specific information required for each resource, still bearing in mind the purpose of the inventory. Each resource should be considered separately because each resource has its own unique growth form. For example:

- Some resources may be clumped and some may not (see *Box 8.1* for discussion of considerations involved when a resource species is clumped), and
- Resources may also be trees, palms (stemmed, non-climbing), rattan palms (stemmed, climbing), bamboo, climbers, shrubs or herbs.

Different growth forms require different ways of assessing or measuring their age, size, sex or condition. For example, trees grow by increments of diameter and their size should be measured by diameter at breast height, whereas rattan stems grow by increments of length and their size should be measured by length.

[1] *Chapter 3 (Objective 2) describes how the villagers determined the information that is wanted about the plants.*

Box 8.1. For clumped species, should you gather information on the clump or the stem?

Some resource species may be solitary (such as durian trees) and some may be clumped (such as bamboo). If a particular resource is clumped, the inventory team will have to decide whether to gather information about the clump or about the individual stems within the clump. There are several considerations affecting this decision:

- One consideration is to think about what is more important for the purpose of the inventory, the clump or the stem. If the purpose is to compare the relative densities of the same resource in different areas, it may be sufficient to count the clumps. However, if the purpose is to determine the total economic value of a resource in an area, it will be necessary to count all stems within each clump.
- A second consideration is how easy it is to determine where one clump ends and another begins. It can be difficult to tell which groups of shoots belong to which clump when a clump is spreading rather than tightly clustered. In this case, it may be wiser to count only the stems, as determining clumps will become very subjective and is likely to vary from person to person.

Table 8.1, and the remainder of this section provide a summary of the way in which different types of information (e.g. information on age, size, sex and condition) is usually gathered for different growth forms. It also discusses how to assess or measure this information. Sometimes standardised methods for measuring plants, particularly trees, are recommended; instructions for these methods can be found in *Appendix K*.

Use the remainder of this section to look up suggestions for the growth form for your particular resource species. These are general guidelines only, and you should remember to keep your particular inventory purpose and resource species in mind when making your decisions.

Table 8.1. Ways of measuring different growth forms of plant

Growth Form	*Age Class*	*Size*
Tree	Seedlings Saplings Poles Trees	Diameter at breast height, Height
Palms (stemmed, non-climbing)	Seedlings Juveniles Stems	Height
Rattans (stemmed, climbing)	*If counting stems:* Buds Stems *If counting clumps:* Seedlings Juveniles Stemmed clumps	Length

Table 8.1. continued

Growth Form	*Age Class*	*Size*
Bamboo	*If counting stems:* Shoots Immature stems Mature stems Over-mature stems *If counting clumps:* Seedlings Clumps	
Climbers	Seedlings Saplings Stems	Diameter at breast height Length
Shrubs	Seedlings Shrubs	Height
Herbs	Age classes (if relevant)	Height, % Cover of subplot area

Age

The age of a plant is an important measurement for some inventories. If the purpose is to determine a sustainable harvesting rotation, information needs to be gathered on the plants' age in order to assess how the resource population is reacting to the harvesting regime.

The age of most plants is difficult to determine directly. Sometimes the age of trees can be determined by looking at the tree rings in a core of wood that is extracted from the trunk. The age of stemmed palms can be estimated by counting the number of internodes on the stem and multiplying this by the average length of time taken to grow one internode (i.e. the time taken from the full emergence of one leaf to the full emergence of the next). However, these are complicated procedures that often require special tools. These procedures are not covered in this manual.

Often the age of a plant can be roughly estimated from its size. However the correlation is usually not exact. Depending upon the nature of an individual plant or its local environment, some plants within one species may grow very slowly and their size will be small for their age, whereas others may grow quickly and their size will be large for their age. That is why researchers monitor plants of commercial species in marked areas, called permanent plots. They monitor these plants over a sufficient period of time to calculate how long, on average, it takes a particular species to grow to a certain size under certain environmental conditions. You might want to do this for your resource species. However, this manual does not describe the procedure for doing this. The manual by Alder and Synott (1992) describes how to monitor plants in permanent plots in order to understand how they increase in size over time.

Below is a system of age classes for the major growth forms that you are likely to encounter in tropical forest. These age classes are based on both the plant's appearance (for the youngest age class) and size (for the older age classes). If your purpose is to plan the harvesting rotation of a resource, you will need to monitor the younger age classes of these plants, in order to understand the impact of harvesting on the resource.[2]

[2] *Appendix L discusses how to conduct regeneration studies in order to monitor the impact of harvesting.*

Tree age

Trees could have the following age classes (*Figure 8.1*):

- *Seedlings*: 0-150 cm high,
- *Saplings*: from 150 cm high to 5 cm diameter,
- *Poles*: 5-20 cm diameter, and
- *Trees*: greater than 20 cm diameter. Trees above 20 cm diameter at breast height (dbh) can be placed in diameter classes such as 20-29 cm dbh, 30 -39 cm dbh, etc.

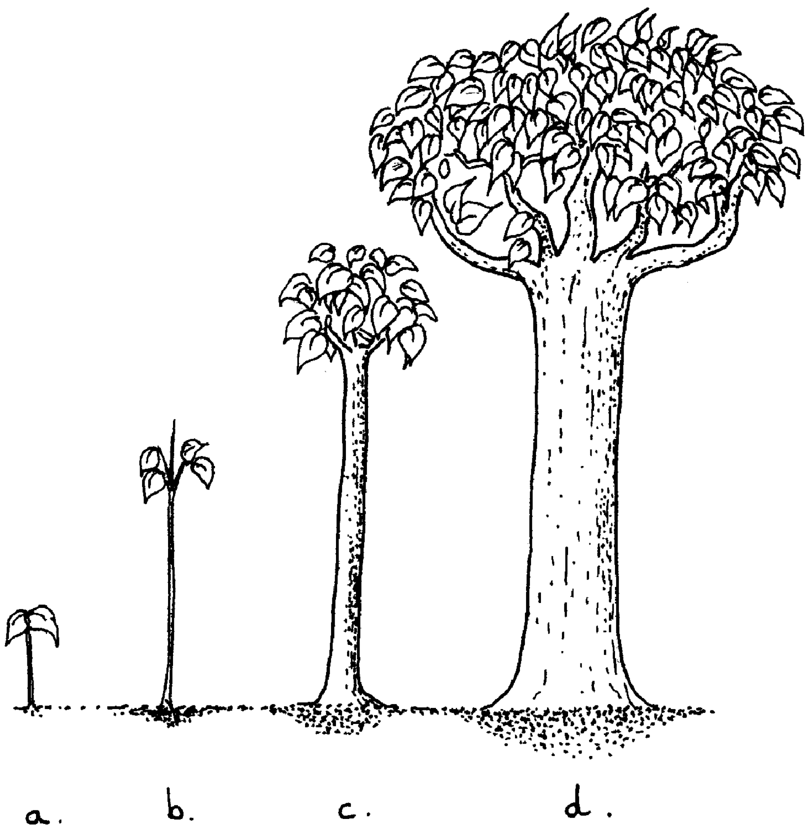


Figure 8.1. Four age classes of a tree: a) seedling, b) sapling, c) pole, and d) mature tree.

Palm age

Stemmed, non-climbing palms could have the following age classes (see *Figure 8.2*):

- *Seedlings*: Palms which have seedling leaves (these are different in appearance from those which are produced later),
- *Juveniles*: Palms which are still stemless, but have begun to develop leaves which are the same in appearance as those of the stemmed palm, and
- *Stems*: Palms that have begun to develop a stem. Stems can be further divided into height classes, such as 1-100 cm, 101-200 cm, etc.

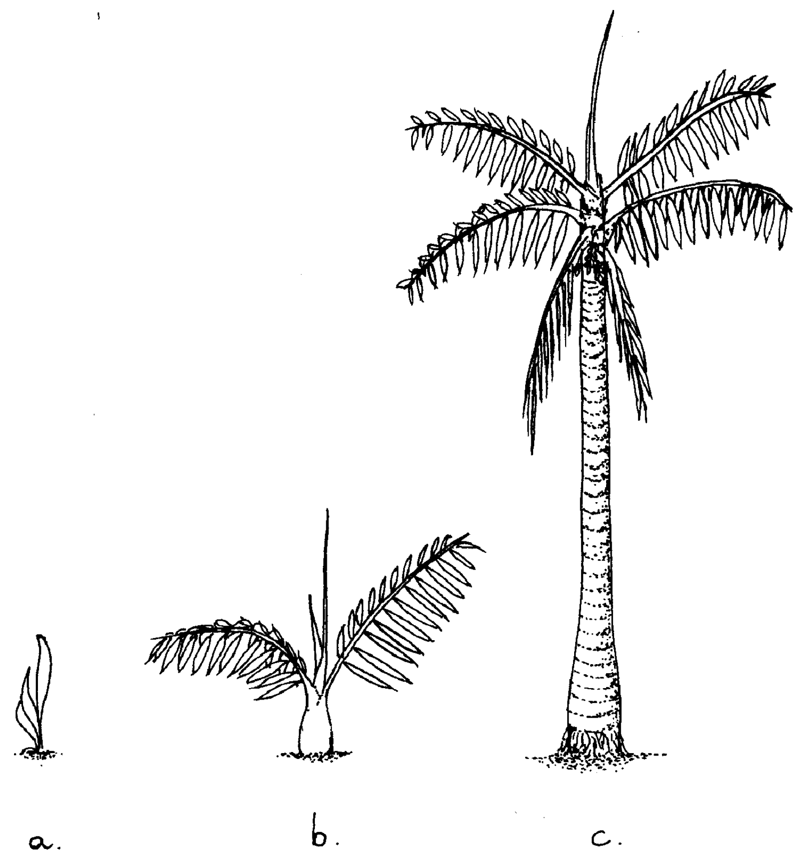


Figure 8.2. Three age classes of a stemmed, non-climbing palm: a) seedling, b) juvenile and c) mature palm.

Rattan age

Some rattan species form clumps of stems rather than just one solitary stem. *Box 8.1* discusses the considerations involved in deciding whether it is better to count clumps or stems in clumped species.

Rattan clumps can be assigned to roughly the same age classes as those of other palms:

- *Seedlings*: Rattans which have distinctive seedling leaves (these are different in appearance from those which are produced later),
- *Juveniles*: Rattans which are still stemless, but have begun to develop leaves which are the same in appearance as those of the stemmed rattan, and
- *Stemmed clumps*: Rattan clumps which have begun to develop at least one stem. Stemmed clumps, however, are difficult to age. The longest stem in the clump will indicate the minimum age of the clump but it will not indicate the actual age of the clump if other, longer stems in the clump have previously been harvested.

Rattan stems can be divided into the following age classes (see *Figure 8.3*):

- *Buds*: Instead of beginning growth as seedlings, stems in a clump will begin as stemless 'buds' which sprout from the base of the clump, and
- *Stems*: Rattan buds that have begun to develop a stem. Stems could be further divided into length classes, such as 1-400 cm, 401-800 cm, etc. Rattan stems change in status from 'immature' to 'mature' or 'harvestable' when they are long enough that a sufficient length of the stem (from the base upwards) is bare and dry, having dropped its outer leaf sheaths. The total stem length at which this happens varies with the species and the environment.

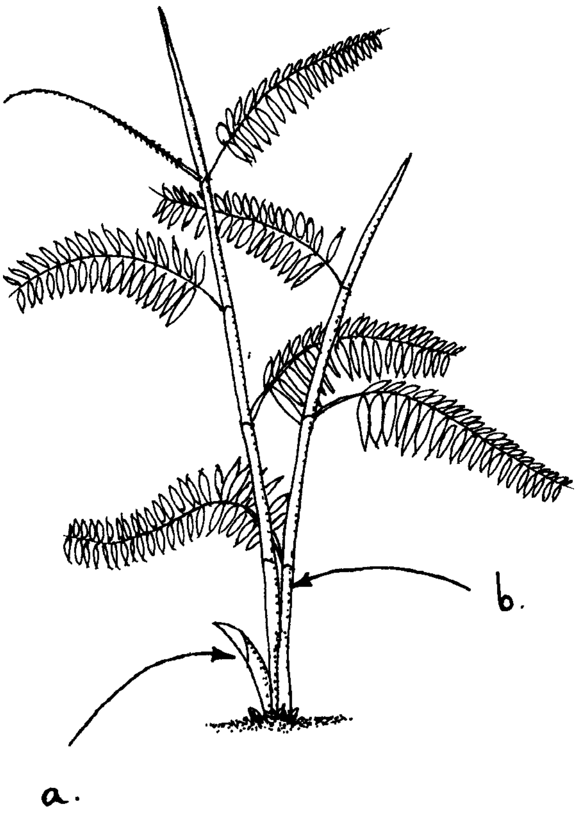


Figure 8.3. Two age classes of a rattan stem: a) bud, and b) stem.

Bamboo age

Bamboos usually form clumps of stems (called culms). Sometimes it is easy to determine what clump a culm is from, sometimes it is not, depending upon how far the culms spread from the original clump. Consult *Box 8.1* to decide whether you will assess bamboo by the culm or by the clump.

Bamboo clumps could have the following age classes:

- *Seedlings*: young bamboo which have not yet begun to develop a culm or produce other shoots, and
- *Clumps*: any clump with a culm.

Bamboo culms could have the following age classes:

- *Shoots*: stems that are still young enough to be eaten,
- *Immature stems*: stems which are too old to be eaten but too young to be harvested,
- *Mature stems*: stems which are ready to be harvested, and
- *Over-mature stems*: stems that are too old and inflexible to be harvested.

Climber age

The age classes for climbers can be defined as follows:

- *Seedlings*: 0-150 cm high,
- *Saplings*: from 150 cm high to 5 cm diameter, and
- *Stems*: 5 cm diameter and greater. These stems should be placed in diameter classes such as 5-9 cm dbh, 10-14 cm dbh, etc.

Shrub age

The age classes for shrubs could be defined as follows:

- *Seedlings*: plants with the first few leaves; branches not yet formed.
- *Shrubs*: plants that have already formed branches. These shrubs could be placed in height classes such as 1-20 cm, 21-40 cm, 41-60 cm, etc.

Herb age

Many herbs are short lived. It may be difficult to assign them to an age class, as can be done with longer lived plants like trees or palms. Other herbs may live long enough to be assigned to age classes based upon their height, as done for shrubs.

If your herb species is clumped, you should consult *Box 8.1* to decide whether you will assess the herb by the individual stem or by the clump.

Size

The size of a plant is an important measurement for a number of inventory purposes. For inventories conducted in order to plan a sustainable harvesting rotation, size can be used to approximate the age of the plant, as discussed earlier. For inventories in which the resource's productivity is being quantified, size is important because it often has a strong link with the productivity of the plant.

The best way to measure the size of a plant depends upon its particular growth form, as is discussed below.

Tree size

Initially trees grow in height as well as diameter. However, once they reach maturity they stop growing in height, and grow mainly in diameter. Thus height is a good measurement of growth in young trees (i.e. saplings) but not older ones. The diameter is an important parameter for older trees, as a tree's diameter is often closely related to its growth and productivity (whether producing timber or non-timber products such as leaves, fruit, resin, etc.). However, in timber trees, the height of the older trees will need to be measured in addition to the diameter in order to calculate their productivity (i.e. timber volume).[3]

The diameter of a tree is the distance from one side of a tree trunk to the other, across the centre point of the trunk (*Figure 8.4*). The diameter is commonly measured 1.3 metres from the ground, a distance called 'breast height'. The way to measure the diameter at breast height (dbh) has been standardised.[4]

---

[3] *Appendix M discusses how to estimate a tree's timber volume.*

[4] *Appendix K has instructions on how to measure tree diameter at breast height.*

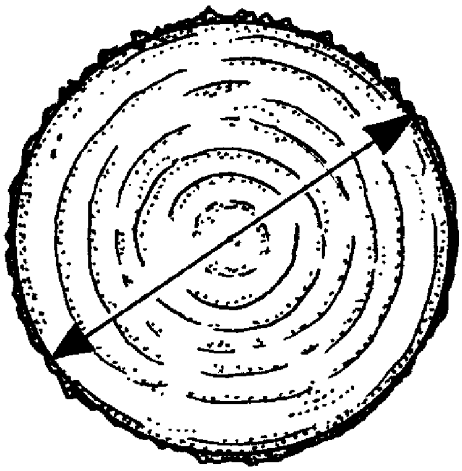


Figure 8.4. The diameter of the tree is the distance across the centre of the trunk.

The height of the tree is usually measured from its base at ground level to a number of different points on the tree (see *Figure 8.5*). These different measurements of height include the:

- *Height to the top of the buttresses*. This is the distance from the base of the tree to the point on the trunk where the buttresses are no longer visible. This is useful to know in order to have a record of where the diameter was measured (since on buttressed trees it is measured 20 centimetres above the buttresses).
- *Timber or merchantable height*. This is the height of the timber in the tree that can be potentially sold (called merchantable volume). This is measured from the base to the point at which the first living branches can be seen.
- *Total height*. This is the vertical distance from the base to the uppermost point of a tree.

There are a number of standardised ways to measure or estimate tree height.[5]

[5] *Appendix K has instructions on how to measure or estimate tree height.*

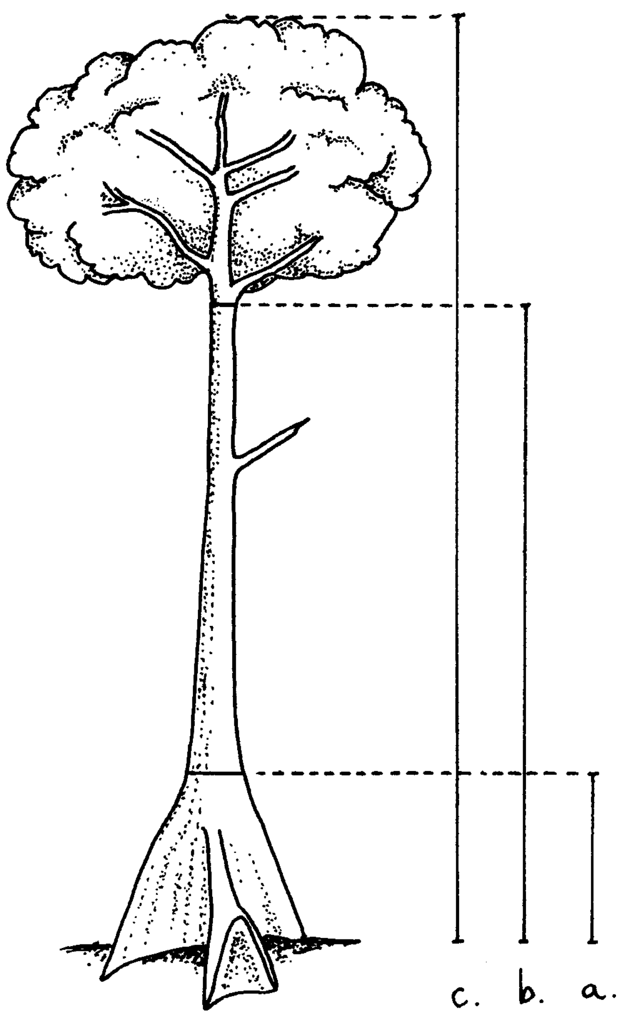


Figure 8.5. The height of a tree can be measured as: a) buttress height: from the ground to the top of the buttresses, b) timber height: from the ground to the point where the first living branches can be seen, and c) total height: from the ground to the uppermost point on the tree.

Palm size

The main difference between stemmed, non-climbing palms and trees is that their trunks do not grow outwards in diameter in the same way that trees do. A palm grows upwards as it ages. At the top of the palm, new leaves are produced one at a time. With the production of each leaf, the stem grows in height by one segment of stem called the internode. As new leaves are produced at the top of the stem, the older leaves further down the stem begin to dry and eventually drop off. This accounts for the appearance of palms, whose trunks consist of a series of leaf scars or nodes with stem segments or internodes in between.

Thus the most significant measurement of stemmed palms is their height, although some palms also increase in diameter as they age. The height of palms may be measured using standard tree height estimation methods.[6] Several measurements of height are possible (see *Figure 8.6*):

[6] *Appendix K gives instructions on how to measure or estimate the height of a tree.*

- *Total height*: from the ground to the base of the uppermost, unexpanded leaf (this is sometimes called the shoot) (see *Box 8.1*), or
- *Height of mature stem*: from the ground to the beginning of the lowermost green leaf.

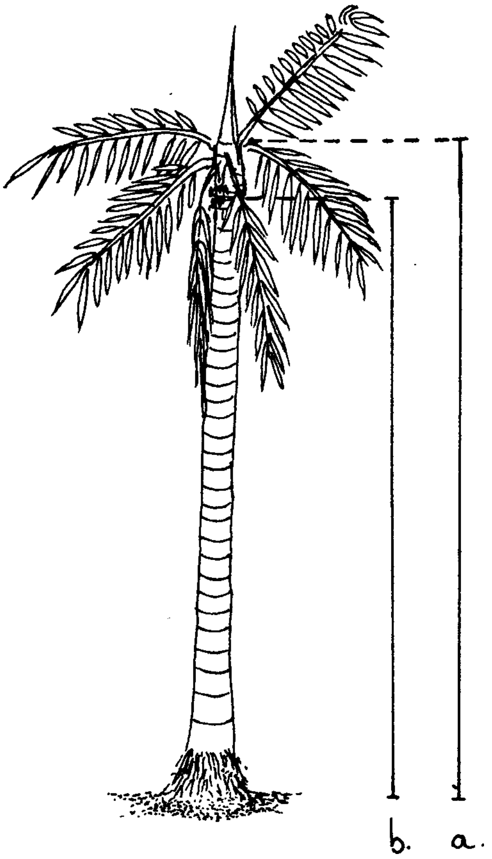


Figure 8.6. Stemmed palms can be measured for their: a) Total height: from the base of the stem to the base of the uppermost unexpanded leaf, or b) Height of mature stem: from the base of the stem to the beginning of the lowermost green leaf.

Rattan size

Rattans are stemmed, climbing palms. As with many other palms, their growth is confined to the top of the stem and their diameter does not increase. Unlike stemmed, non-climbing palms, rattans do not grow straight vertical stems. Instead their stems may coil, loop, and climb. Thus it is more important to measure the length of a rattan stem (i.e. length along the stem) than its height (i.e. vertical height from the ground to the top of the stem).

Estimating rattan length can be difficult, especially when the stems are looped in the upper canopy. However, a typical rattan in a primary forest will be anchored in the canopy, with the remainder of the stem dangling down and coiled on the forest floor (see *Figure 8.7*). To measure it, tug the stem gently so that its length from the canopy to the forest floor is more or less vertical. This 'above-ground' length is then estimated using standard tree height estimation methods.[7] The 'ground' length of the stem (i.e. the part coiled on the forest floor) can be directly measured with a metre tape.

[7] *Appendix K gives instructions on how to measure or estimate the height of a tree.*

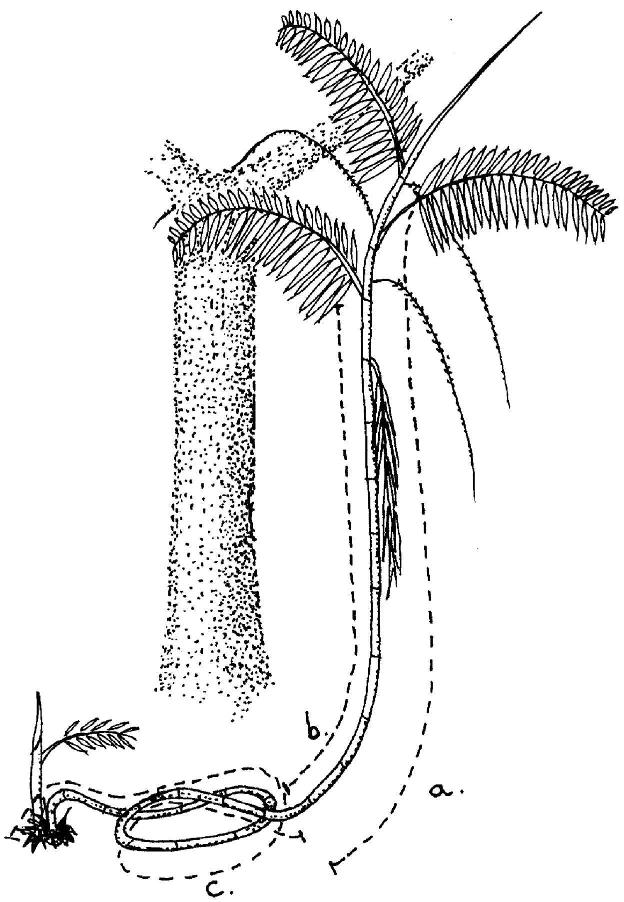


Figure 8.7. The 'above-ground length' of a rattan is usually measured from the point where the stem rises from the ground to: a) the base of the uppermost unexpanded leaf, or b) to the beginning of the lowermost green leaf. The ground length can be directly measured with a measuring tape, from c) the base of the stem to the point where it rises from the ground.

A quicker but less accurate method than the one described above is to visually estimate the length class of the rattan stem (i.e. whether it falls into the 1-400 cm, 401-800 cm, or 801-1200 cm classes).

Bamboo size

The stems of bamboo (culms) grow to a certain height within a period of several years, after which they stop growing. Thus the height of a bamboo culm is different from the diameter of trees, the height of palms or the length of rattans, all of which continue to grow as long as the plant lives. The diameter of the culm similarly does not increase. Thus a bamboo's height and diameter is not related to its growth, survival or productivity, and neither measurement will normally be necessary in a bamboo inventory.

Climber size

Climbers are similar to trees in that they grow in height (i.e. length) and diameter over time. They are also similar to rattans in that their stems may coil, loop, and climb, making a measurement of their length more significant than their vertical height.

Climber diameter should be measured at breast height using the method described for measuring tree diameter at breast height.[8] Climber length can be estimated using the methods described for rattan length. However, climbers tend to have stems which are more coiled than rattan stems and the estimation of their length is likely to be much less accurate.

Shrub size

Shrubs rarely grow significantly in diameter. Therefore, the best way to measure the size of shrubs is by their height. This can usually be measured directly using a height pole, as done for smaller trees.[9]

Herb size

Some herbs take the form of solitary plants. For solitary herbs, height may be a good indicator of size. This may be measured directly by a tape measure or ruler. As these plants do not develop woody stems, diameter is not likely to be a significant measurement.

Other herbs form a cluster that spreads across the ground. With herbs which are spreading clusters, it may be difficult to distinguish where one plant ends and another begins. For spreading clusters of herbs, the size can be estimated by estimating its percent cover of the subplot area (i.e. whether the cluster covers 5%, 50% or 95% of the entire subplot area).

Sex

A plant's sex (if the plant species has separate male and female plants) is directly related to its productivity if the products are flowers, fruits, seeds or nuts. However, often it is difficult to determine the sex of the plant if it is not fruiting. Information on a plant's sex, if this is desired, should be recorded as a code.

Condition

A plant's condition can have a direct relationship to its productivity, growth and survival. Condition does not have to refer to the plant's state of health. For example, if a tree is a species that is likely to support honey hives (i.e. a canopy emergent), it may be relevant to record whether honey bee hives can be seen on its branches or not.

If recorded as informal notes, information about a plant's condition is rarely useful, as it cannot be formally analysed. It is best to develop a system of codes for the conditions that are of interest. This system of codes should have the following characteristics:

- *Flexibility*. The inventory teams should be able to develop new codes for new conditions as they appear in the field. The list of codes should therefore be open ended.
- *Careful definition*. Each code should be carefully and clearly defined in a field reference sheet (such as *Table 8.2*) to the people gathering the information, with appropriate training in its application. If new codes arise they should be documented as well.
- *Coded by letters*. Each code should consist of one to three letters. This makes them easier to record in the field than if they are words. Letters are preferable to numbers as they are easier to remember. For example, CD for 'crown damage' is easier to remember than '14'.

Some suggestions for plant condition codes are provided in *Table 8.2*. One plant may have more than one of these conditions applying to it simultaneously.

---

8 *Appendix K describes how to measure the diameter.*

9 *Appendix K describes how to measure tree height with a height pole.*

Table 8.2. Some plant condition codes

Code	*Meaning of code*	*Explanation of code*
DP	Dead plant	The plant is apparently dead, but remains standing.
FP	Fallen plant	The plant has completely fallen.
FW	Flowering/fruiting	This is noted if the plant is in flower, or is bearing or dropping fruit.
GD	Gaharu detected	The infection that causes gaharu has been detected in the tree (for gaharu).
BH	Bee hives	The tree has bee hives on its branches (for honey trees).
HS	Harvested stem	Stems have been recently harvested (for rattans or bamboo).
LS	Logged stump	A sawn stump, indicating logging.
RT	Rotten timber	Evidence of rot entering the tree from visible rotten pockets left by broken branches.

8.1.2. What range of plants to include in the inventory

The villagers will also have made general decisions about whether they will be including all plants of the resource species in the inventory or a limited range of the plants.[10] These decisions will relate to the inventory purpose. The inventory team should now determine the range required for each resource, bearing in mind the purpose of the inventory:

- *Age*: Not all ages of a particular resource need to be included in the inventory. For example, seedlings are almost never productive, and they are often time consuming to measure.
- *Size*: The inventory team may need to determine an exact size (in diameter, height or length) that divides non-productive individuals from productive individuals. It may be best to walk in the forest and measure trees of different sizes, in order to determine an exact measurement. This is because discussion of diameter, height or length in the village might be too abstract, especially if these measurements are not the villagers' usual way of thinking about plant size. A common lower limit for trees is 20 cm dbh.
- *Sex*: The inventory team will need to decide whether females or males should be excluded. This may be difficult to do in practise, especially if the two sexes cannot be differentiated out of fruiting season.
- *Condition*: The inventory team will need to decide whether plants displaying certain conditions should be excluded. For example, the team may decide not to include honey trees that do not currently have honey bee hives.

Example 8.1 provides an example of the specific information chosen for one particular inventory.

[10] *Chapter 3 (Objective 2) describes how the villagers determined the information that is wanted about the forest resources.*

Example 8.1. The specific information chosen for seven resource species by one village inventory team

The purpose of the inventory in one village was to determine the economic value of the most important resources existing in their forest. The villagers had chosen two timber species, one fruit tree species, three rattan species and one shrub species as their most important forest resources. The villagers had also decided that an enumeration of all productive individuals would be sufficient for their inventory purpose.

The inventory team held a planning meeting in order to define what specific type of information they wanted for each resource and the range of plants of each resource that they wanted in their inventory. The result of their meeting was that they decided to enumerate these resources in the following manner:

Resource species	*Type of information*	*Range of plants*
Timber trees (all 2 species)	dbh	All healthy (i.e. not dead or sick) trees with dbh of 50 cm or greater
Fruit trees (1 species)	dbh	All healthy female trees with dbh of 30 cm or greater
Rattans (all 3 species)	number of mature stems in clump	All healthy clumps containing at least one mature stem ('mature' being defined as having a bare, dry stem of 4 m length or longer)
Shrubs (1 species)	height	All healthy shrubs greater than 50 cm in height

8.2. Plan how to gather information on the environment

Environmental information is obtained by assessing or measuring the environment in which the resources are found. This information can be used to classify or zone areas according to their potential for resource availability or productivity, or according to their ecological sensitivity to disturbance. The villagers will already have decided in a general way about the environmental information they would like to gather.[11]

This section discusses some simple standardised methods for assessment or measurement of environmental information. In most cases, environmental measurements should be made for each of the five 10 metre by 10 metre subplots that comprise the 50 metre by 10 metre plot. It is best to make site measurements for each subplot rather than for the whole plot. This is because the entire area of the subplot can be seen at one glance, whereas that of the larger plot cannot. As well, the variation covered by the larger plot could possibly be too large for one measurement to be applied to the whole area. However, in some cases, the measurements of the subplots will

[11] *Chapter 3 (Objective 5) describes how the villagers determined the information that was wanted about the environment.*

have to be combined in order to obtain an overall reading for the plot. For example, even if a boundary between two forest types occurs halfway through the plot, the team will have to determine which forest type predominates in the plot and assign that forest type to the plot.

Three basic types of site indicators are discussed in the remainder of this section:

- Topographic indicators,
- Vegetation indicators, and
- Site description codes.

8.2.1. Topographic indicators

Topographic indicators assess the natural shape and position of the land on which the plots have been placed. They might include altitude, slope, aspect or slope position.

Altitude

The altitude is a measurement of the vertical distance from sea level. The altitude affects the average air temperature, which in turn has a direct influence on the type of vegetation that can grow in that environment. Thus it can be a useful indicator of forest type.

The altitude of an area can be determined from topographic maps. It can also be measured in the field, but only with special equipment such as an altimeter or a GPS instrument.

Slope and aspect

The slope is a measurement of the angle of the slope in the steepest direction of the plot. The aspect is the bearing taken when facing down the slope. Slope is commonly used to classify land for appropriate land uses (i.e. it may not be appropriate to cut trees on slopes over 31° (60%) due to the risk of promoting soil erosion). Both the slope and the aspect are useful information to have for mapping the shape of the land.

The slope is measured using a clinometer, a compass with slope needle, or a home-made slope-measuring tool. The reading must be taken in the steepest direction of the slope. The aspect is measured by taking a bearing of the direction of the slope with a hand held compass. The person taking the bearing must take it facing down the slope.[12]

Slope position

Slope position describes where the site is located in relation to the shape of the surrounding land (i.e. whether it is on a valley, slope or ridge). It indicates the movement and presence of water at the site (i.e. whether water accumulates or disperses from that site). This is an important factor in site productivity and ecological sensitivity to disturbance. Thus, slope position provides important information about how an area may be zoned and managed. Slope position is also useful information for mapping the shape of the land and possibly for confirming on the inventory map where the plot is. Inventory area boundaries are often delineated along major rivers and ridges.

---

[12] *Appendix H describes how to measure the angle of a slope with different instruments and how to take a bearing with a compass.*

The slope position of a plot is scored as follows (see *Figure 8.8*):

- 1: valley or gully
- 2: lower slope
- 3: mid slope
- 4: upper slope
- 5: hill top or ridge

The slope position is taken from the central point of each plot. If a small gully or embankment dissects the plot, this should be noted with a descriptive code (i.e. GU for gully; see section on site description codes, below), and the general slope position of the plot considered apart from the local features within it.

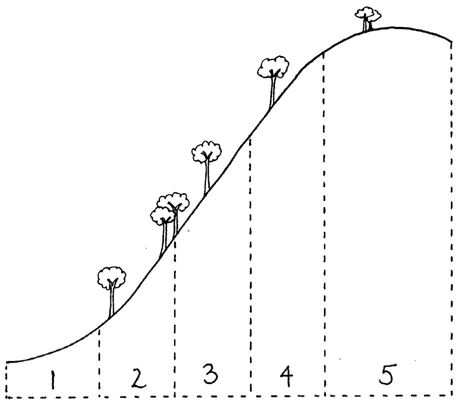


Figure 8.8. The slope position of a plot is scored as follows: 1) valley or gully, 2) lower slope, 3) mid slope, 4) upper slope, and 5) hilltop or ridge.

8.2.2. Vegetation indicators

If the inventory area has been divided into specific forest types, the villagers should now be asked to decide how they are going to determine the forest type that each plot is in. They should be encouraged to use their own categories for forest types, in their own language. They may decide that it is sufficient for them to determine and record the forest type directly, rather than record information that can be used as indicators of forest types. However, if they decide to record the presence or absence of indicators of forest type, a number of choices await them.

The presence of certain plant species, called indicator species, is sometimes used to determine specific forest types. For example, the presence of a certain tree species (i.e. *Macaranga* sp.) might indicate that the plot is in 'young secondary forest'. Other indicators of a specific forest type might include the approximate canopy height, the number of trees with a diameter at breast height of 50 centimetres or more, etc.

Table 8.3, below, provides an example of some forest types and the type of indicators that might be appropriate for them.

Table 8.3. An example of some forest types and the indicators used to identify them.

Forest type	*Description of forest type*	*Indicators*
Agroforest	Cultivated trees of a mixture of species.	Cultivated fruit tree species (e.g. Rambutan, or *Nephelium lappaceum*)
Young secondary forest	Secondary forest two to approx. ten years after shifting cultivation.	Pioneer species (e.g. *Macaranga* sp.
Old secondary forest	Secondary forest approx. ten to thirty years after shifting cultivation.	Late succession species (e.g. *Pentace laxiflora*)
Primary forest	Primary lowland dipterocarp forest	Lowland dipterocarp species (e.g. Ironwood, or *Eusideroxylon zwageri* with more than 50 cm dbh)

8.2.3. Site description codes

Site description codes describe the overall character of an area, or standard natural features. For example, site description codes often assess human disturbance of various types and degrees, including burning, farming, or logging. They can also be used to describe important natural features such as tree fall gaps, gullies or streams. These codes can be useful for mapping the inventory area, for identifying forest types or for identifying the boundaries of specific areas.

As with plant condition codes, site description codes should be flexible, carefully defined and coded by letters. Several site description codes can be applied to the same plot. *Table 8.4* lists some suggested indicators.

Table 8.4. Some suggested site description codes (adapted from Alder and Synnott, 1992).

Code	*Meaning of code*	*Explanation of code*
AG	Agricultural land	Site of permanent agricultural land.
AL	Alang-alang land	Site of degraded grassland.
CA	Campsite	Indications of a recent campsite.
CS	Cultural site	A site of cultural importance, such as an abandoned village, graveyard or monument.
FI	Fire	Indications of recent forest fire.
FP	Footpath	A footpath crosses the plot.
GA	Gap	A natural gap formed by tree fall.
GU	Gully	A dry gulley (as opposed to stream) intersects the plot.
LO	Logging	Signs of recent logging.
LR	Logging road	A skid trail, a logging road, or part of the cleared margin for one intersects the plot.
RK	Rock outcrop	Rock outcrops intersect part of the plot.
RS	River, stream or lake	A river, stream or lake intersects the plot.
SC	Shifting cultivation	Part of the plot has been recently felled and burned for cultivation.
SM	Settlement	Presence of permanent human habitation.
SW	Swamp	Indications of extensive and continuous waterlogging of the soil, including the presence of swamp species, dark black soils, standing water (the latter may be absent during the dry season).
TC	Tree crops	Tree crops (i.e. rubber, oil palm) are growing on the plot.

Where to next

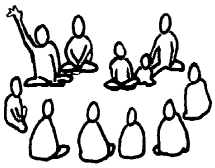
Having planned the information that you want and the way in which you will measure it, you should now prepare data sheets for recording the information and field reference sheets to guide the inventory work teams in information gathering. This step is described in the next chapter.

9

Design the Data Form and Field Reference Sheets

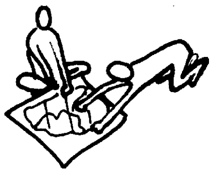
Where you are in the participatory inventory method:

I Decision making in the village



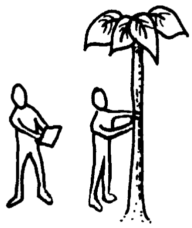
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



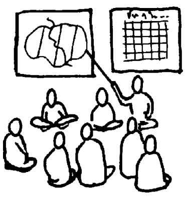
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

9.1. Design the data form, and

9.2. Prepare field reference sheets.

Skills/information required

The skills or information that you will require include:

- *Appendix P*. Data forms.

Materials required

- *If recording data on sheets of paper*: Regular photocopy (A4 or legal size) paper, access to a photocopy machine, a ruler, a black pen, a typewriter (optional) and a computer (optional).
- *If recording data in exercise books*: exercise books with grid lines on the pages, scissors, a ruler and a ballpoint pen or pencil.

Introduction

You have now established what information you want to collect about the resource plants and their environment and how you want to collect this information. Your next step is to design a data form on which this information can be recorded. As well, you must prepare field reference sheets to accompany the people who will be recording the data. These sheets should contain all information necessary to make the gathering and recording of data as accurate and consistent as possible.

9.1. Design the data form

9.1.1. Choosing the materials for the data form

Designing the data form begins with choosing the materials that you will use to make the data form. There are two choices:

- Sheets of paper, or
- Exercise books.

The advantages and disadvantages of each are discussed below.

Individual sheets of paper

A data form can be designed on an individual sheet of paper (of standard photocopy size, usually A4 or legal). The form can be designed by hand, using a ruler and black pen, by typewriter or by computer. The sheet of paper containing the form can then be photocopied to make as many copies as are desired.

The advantage of this type of data form is:

- It will take less time to photocopy a data form than to copy it by hand onto each page of an exercise book.

The disadvantages of this type of data form are:

- The pages are easier to damage or lose in the field, and
- A photocopy machine may not be available or more expensive to use, compared to exercise books.

Exercise books

The design of a data form can also be written on the pages of a small standard-sized exercise book. It is best if these books have squared (simple grid) paper because the vertical and horizontal lines on the pages can be used to draw the columns and rows of the form. The exercise books should also have a reasonably tough cover to protect the information inside.

The advantages of this type of data form are:

- Exercise books are usually easier to find in small towns and cheaper than a photocopy machine, and
- Exercise books are more robust in the field, and less easy to lose than individual sheets of paper.

The disadvantages of this type of data form are:

- It is time and labour intensive to prepare exercise books by hand.

An efficient way of preparing each exercise book by hand is described in *Box 9.1*.

Box 9.1. Preparing an exercise book by hand

If you use this method, you will not have to rewrite the column headings on each page. The steps to follow are (see *Figure 9.1*):

1. Open the exercise book in the middle, and cut away the top 3 centimetres of the pages with scissors until only the outer sheet on both the left and right hand sides is left uncut,
2. Draw the column lines on the first and last double pages of the book with the use of a ruler and waterproof pen or pencil. Write the column headings on the top of each column on the uncut outer sheet of paper, and
3. Draw the column and row lines on the remaining pages with the use of a ruler and pen or pencil.

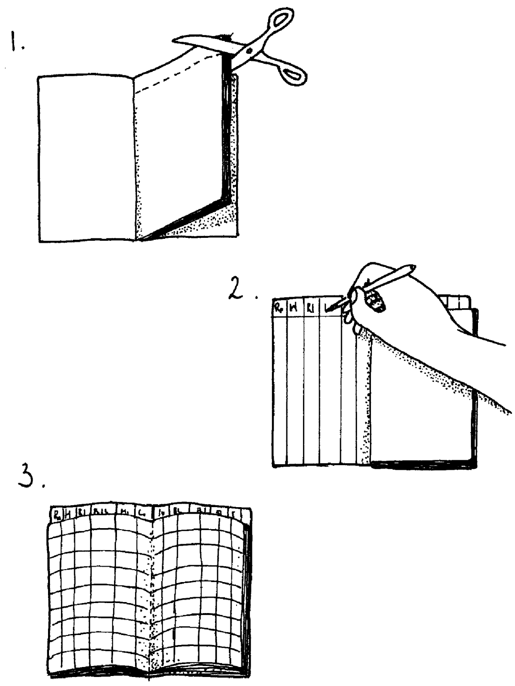


Figure 9.1. How to prepare an exercise book to be used for recording data.

9.1.2. Design the data form

There are several principles involved in designing a good data form. A data form should be:

- Clear and simple to follow,
- Easy to fill in, involving as little writing as possible in the field,
- Compact enough to not be too cumbersome in the field, yet sufficiently large to allow all the important information to be included without the writing being too small, and
- Easy to read later, in order to transfer the data to the compilation form.

Begin by thinking about the information that you need to record in the field for your inventory. Think about the data form layout that will make the recording of this information as easy as possible. Data forms can range from simple to complex, depending upon how much information is required. Examples representing the two extremes are provided below. They are:

- A simple tally form for counting plants but recording no further information, and
- A full data form for recording information on the plants and their environment.

Simple tally form

This simple data form can be found in *Figure P.1* in *Appendix P*. It consists of:

- *A heading*. This contains information about the area/forest type and/or working unit from which the page's data was collected, the team that collected the data, the date it was collected, the inventory line the data was collected from and the bearing the team was following along the inventory line. This information is important because it ensures that the large amount of information collected during inventory fieldwork can be sorted and stored in a systematic way.
- *The remainder of the page*. This contains information about the quantity of each resource species in each subplot.

Full data form

This data form can be found in *Figure P.2* in *Appendix P*. It consists of three sections, each section referring to a different level of information (these levels of information are separated so that unnecessary repetition is eliminated).[1] The form is arranged as follows:

- *Plot data*. In the first section, all information is about the plot (there is one plot per page). This section contains information about the area/forest type and/or working unit the plot is in, the team that enumerated it, the date it was enumerated, the inventory line it was on, the bearing in which the team was moving along the line, and the plot number itself.
- *Subplot data*. In the second section, one line of data represents one subplot. This section contains information about the environment.
- *Resource data*. In the third section, one line of data represents each resource plant (if the plant is not clumped) or shoot of the clump (if the plant is clumped). This section contains information about the resource plants or shoots.

9.2. Prepare field reference sheets

You should also prepare field reference sheets to accompany the data form. Field reference sheets help the inventory work teams to fill in the data forms correctly and consistently. They might contain:

- Instructions for how to gather the information (i.e. how to make the measurement or assessment),
- Instructions for filling in the data form, and
- Tables listing codes to write in the data form instead of writing words.

The remaining sections provide two examples of field reference sheets.

---

[1] *Chapter 8 describes the environmental and resource information listed in this data form.*

9.2.1. An example of field reference sheets for a simple tally form

This example of reference sheets is designed to accompany the simple tally form described earlier.[2]

Heading

Fill in the heading on every page. If the location, team, date or line changes, stop writing on this page and begin a new page. Fill in the heading's spaces as follows:

- *Area and forest type*. If the inventory area has been divided into areas or forest types, record the appropriate code for the area or forest type that the plot is in (see *Table 9.1* for codes for area and forest type).[3] There are spaces to record two codes, since a plot can be in an area and a forest type at the same time.
- Working Unit. If the inventory area has been divided into working units, record the appropriate code for the working unit here.[4]
- *Team*. Record the initials of every member of the inventory work team. There is space for six sets of initials.
- *Date*. Record the day, month and year that the data was collected.
- *Line number*. Record the number of the inventory line that the plot is on. For reference, the inventory lines drawn on the planning map should be numbered, and their numbers displayed on the map.
- *Bearing*. Record the bearing that the inventory work team is following in establishing the inventory line.

Remainder of page

Fill the remainder of the page in so that every row represents one of the resource species found in a subplot. Fill in the columns as follows:

- *Plot number*. Record the number of the 10 metre by 50 metre plot here.[5]
- *Subplot letter*. Record a letter denoting each of the five 10 metre by 10 metre subplots within the plot here. The subplots are labelled, in order, a, b, c, d and e.
- *Species code*. Record the appropriate code for the resource species (see *Table 9.2* for codes for resource species).
- *Number of plants (tally)*. Count the number of plants of the appropriate species that occur within the subplot and record the counts as a running tally of ticks (i.e. 'III').
- *Number of plants (sum)*. Record the sum of the tally here (i.e. '3'), either while in the field or afterward. This will make it easier to add up totals later.
- *Notes*. Record additional information here, such as information useful for mapping (e.g. 'subplot line crossed stream: local name 'Salak Stream'').

---

2 *Figure P.1 in Appendix P provides an example of this type of data form.*

3 *Chapter 3 (Objective 4) discusses subdivision of an inventory area into smaller areas or forest types.*

4 *Chapter 7 discusses dividing the inventory area into working units. It also explains the difference between smaller areas/forest types and working units.*

5 *Chapter 1 (Example 1.8) explains how plots and subplots are established along an inventory line.*

Table 9.1. Codes for area and forest type

Code	*Area or forest type*	*Name of area or forest type*
A1	area	Tebulo River watershed
A2	area	Alango River watershed
A3	area	Pujungan River watershed
A4	area	Uli River watershed
FT1	forest type	Old swidden rice fields
FT2	forest type	Primary forest

Table 9.2. Codes and specifications for resource species

Code	*Species*	*Specifications for including plants in count*
DUR	Durian tree	All living trees of 30 cm dbh and above
MUM	Mumpo bamboo	All living, mature culms ('mature' being defined as a culm of full height and suitable for harvest)
SEK	Seka rattan	All living clumps with at least one mature stem ('mature' being defined as a stem with at least 4 metres of dry, bare stem)

9.2.2. An example of field reference sheets for a full data form

This example of reference sheets is designed to accompany the full data form described earlier.[3]

Plot data

Fill in the spaces for every plot as follows:

- *Area and forest type*. If the inventory area has been divided into smaller areas or forest types, record the appropriate code for the area or forest type that the plot is in (see *Table 9.1* for codes for area and forest type). There is space to record two three letter codes, since a plot can be in an area and a forest type at the same time.
- *Working unit.* If the inventory area has been divided into working units, record the appropriate code for the working unit here.
- *Team*. Record the initials of every member of the inventory work team. There is space for six three letter codes.
- *Date*. Record the day, month and year that the data was collected.
- *Line number*. Record the number of the inventory line that the plot is on. For reference, the inventory lines drawn on the planning map should be numbered, and their numbers displayed on the map.
- *Bearing*. Record the bearing that the inventory work team is following in establishing the inventory line.

[6] *Figure P.2 in Appendix P provides an example of this type of data form.*

- *Plot number*. Record the number of the 10 metre x 50 metre plot here.
- *Notes*. Record additional information here, such as information useful for mapping (e.g. 'subplot line crossed stream: local name 'Salak Stream'').

Subplot data

Fill in this information for all five subplots:

- *Slope*. Record the angle of the slope of the steepest direction of the plot, in degrees.
- *Aspect*. Record the bearing of the slope, facing down the slope, in degrees.
- *Slope position code*. Record the slope position number (1 to 5) here (see *Figure 8.10*).
- *Indicator species 1*. Record the presence/absence of indicator species 1.
- *Indicator species 2*. Record the presence/absence of indicator species 2.
- *Indicator species 3*. Record the presence/absence of indicator species 3.
- *Site description code*. Record site description codes here. There is space for three codes. (see *Table 8.4* for examples).

Resource data

Fill in this information for all plants or shoots (if plant is clumped):

- *Subplot letter*. The subplots are labelled, in order, a, b, c, d and e.
- *Species code*. (see *Table 9.2* for examples)
- *Age class code*. This space will be filled in later, based on the size class of the plant.
- *Sex code*. Record the sex as 'M' if male, 'F' if female or '?' if unknown.
- *Condition code*. There is space for two condition codes (see *Table 8.2* for examples).

Fill in the information below for the appropriate growth form for your particular plant or shoot (if plant is clumped):

- For trees. *Diameter at breast height*. Record the tree's diameter at breast height (dbh). Only include trees with dbh of 30 cm or more.
- For palms. *Height*. Record the palm's height to base of shoot. Only include palms with heights of 3 metres or more.
- For rattans. *Clump number*. Record the clump number here. The clumps should be numbered in order, beginning at number 1 for each new plot. Only include clumps if there is at least one mature stem. Each row represents one stem of a clump. Only record the mature stems (i.e. with dry length of 4 or more metres).
- For rattans. *Ground length*. Record the length of the mature stem from its base to the point at which the above ground length begins.
- For rattans. *Above-ground length*. Record the length of the stem from the base of the shoot to the point at which the stem touches the ground, if it is pulled to be as vertical as possible.
- For bamboos. *Clump number*. Record the clump number here. The clumps should be numbered in order, beginning at number 1 for each new plot. Only include clumps with at least one mature culm. Only record the presence of all mature culms.
- For climbers. *Diameter at breast height*. Record the climber's dbh here. Only include those with a dbh of 5 cm or more.
- For shrubs. *Height*. Record the shrub's height here. Only include those shrubs with height of 50 cm or more.
- For herbs. *% Cover*. Record the percentage of the subplot area covered by this herb.

Where to next

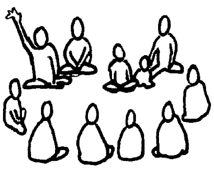
Now that you have prepared your data form and field reference sheets, you are almost finished planning your inventory. The final step in inventory planning is to organise the logistics of the work in the forest, as described in the next chapter.

10

Organise the Work in the Forest

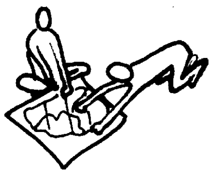
Where you are in the participatory inventory method:

I Decision making in the village



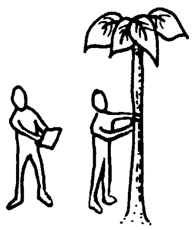
1. Introduce participatory inventory to the villagers
2. Determine the inventory purpose
3. Determine the inventory objectives
4. Select the inventory team and work dates

II Planning the inventory work



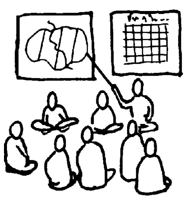
5. Assemble equipment unavailable in the village
6. Prepare the planning map
7. Use the planning map to plan the inventory
8. Plan the measurement of plants and site
9. Design the data form
10. **Organise the work in the forest**

III Inventory work in the forest



11. Train the inventory team
12. Locate the starting point in the forest
13. Conduct the inventory work
14. Check the inventory work
15. Collect botanical specimens

IV Presenting the results of the inventory



16. Prepare the final map(s)
17. Compile data and make calculations
18. Prepare the final report
19. Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

10.1. Assemble equipment and supplies to take to the forest,

10.2. Discuss and assign daily duties in the forest, and

10.3. Plan the schedule for the forest work.

Skills/information required

The skills or background information that you will require include:

- *Appendix F*. Five features of maps.

Materials required

- A planning map, pencil, ruler and notebook.

Introduction

Once the inventory team has located the inventory lines on the planning map, planned what information to gather along these lines and planned how to gather this information, they are almost ready to begin the work in the forest. The final planning step is to organise the logistics of the work in the forest. This will include assembling the equipment and supplies to take to the forest, discussing and assigning daily duties in the forest, and planning the schedule for the forest work.

10.1. Assemble equipment and supplies to take to the forest

Some of your equipment and supplies for the forest work have been brought from outside the village, but some still need to be gathered in the village.[1] You need to assemble equipment and supplies for the work itself. You also need to assemble equipment and supplies for setting up and living in camps, if you are camping in the forest.

10.1.1. Equipment needed for the work in the forest

The equipment needed for the work in the forest will include equipment for:

- Working on the inventory lines, and
- Taking botanical collections.

A list of the equipment needed for the work in the forest is provided in *Box 10.1*.

Box 10.1. Equipment for the work in the forest

Equipment for working on the inventory lines

From outside village:

- Compasses, diameter tapes, nylon rope, ribbon, thin nib permanent ink pens, pencils, pencil sharpeners, erasers, squared exercise books or data sheets with clipboard and folder, lined notebook, metre tapes (optional, depending upon methods of plant measurement), rulers (optional, depending upon methods of plant measurement), clinometers (optional, depending upon methods of plant measurement) and Geographical Positioning System or GPS (optional).

From village:

- Parangs, lunch containers, drinking water containers, raincoats or small tarps in case of rain in the forest and small backpacks for carrying equipment to and from the inventory line.

Equipment for collecting botanical specimens

- Photocopies of botanical collection forms, labels, rafia string, pencils, pens, notebook, newspaper, cardboard, field press, methylated spirits and strong plastic bags.

10.1.2. Equipment and supplies needed for camping in the forest

If you are camping in the forest you will need:

- Equipment for planning inventory work, preparing equipment and storing data in the camp,
- Equipment for setting up and living in camp, and
- Supplies for living in camp.

---

[1] *Chapter 5 discusses how to assemble equipment unavailable in the village, how it is used, and the quantities required for each inventory work team.*

A list of equipment and supplies needed for camping in the forest is provided in *Box 10.2*.

Box 10.2. Equipment and supplies for camping in the forest

Equipment for planning inventory work, preparing equipment and storing data in the camp

- Lined notebooks, pens, pencils, pencil sharpener, folders for data sheets (optional, only needed if data sheets are used instead of exercise books), Brightly coloured electrical (sticky) tape (optional, for marking sighting stick or height poles), metre tape, planning map, ruler and protractor.

Equipment for setting up and living in camp

- Parangs, tarpaulin for roof, rafia string, kerosene lamps, sleeping mats, jerry cans, cooking pots and pans, plates, cups, forks, spoons, etc.

Supplies for living in camp

- Food and other consumable supplies such as kerosene, matches, candles, soap, etc.

10.2. Discuss and assign daily duties in the forest

The duties that may need to be discussed by the inventory team in advance are:

- How many people will stay in camp each day and what their duties will be.
- Who will be on each inventory work team, and
- Who will be inventory work team leaders.

10.2.1. Camp duties

One or two people should remain in the camp each day while the rest of the team are working on the inventory lines. Their responsibility is to cook for the rest of the team, maintain the camp, and so on. Camp duties can be a welcome break from working in the forest so it is good if everyone on the inventory team shares them on a rotational basis.

10.2.2. Inventory work team duties

Each of the inventory work teams should consist of seven people. This permits one person to take a day off in camp. People should be divided amongst the teams so that there is a good combination of skills on each team. These skills include the ability to use a compass, to identify resource species and to record data.

The duties of the individual team members when working in the forest will be described later.[2] Team members should rotate these work duties so that each person can be replaced if he or she takes a day off in camp. Another advantage of rotating the duties is that people learn to do all of the different tasks.

[2] *Chapter 13 describes how to conduct the inventory work.*

Every evening in the camp the inventory work teams should hold a meeting to:

- Discuss the completed day's work (it is a good time to compare observations and share ideas between different inventory teams),
- Examine the planning map and make plans for the next day's work, including planning how each team should get to the starting points and determining the compass bearing for the inventory line,[3] and
- Decide who should remain in camp the next day.

10.2.3. Team leader's duties

There should be a team leader on each inventory work team. At the end of each day, the team leader's responsibilities include:

- Checking that all the equipment has been returned and is ready for the next day's work,
- Checking the data forms to see that all are complete and legible,
- Ensuring that the completed data forms (whether sheets or books) are safely stored in a dry place, and
- Keeping daily notes which record, for each day:
  - a) Which team members were working that day,
  - b) Where they went (in what area or forest type, what inventory line, at what bearing),
  - c) How many plots they completed,
  - d) How did they number the plots,
  - e) Problems encountered and possible solutions, and
  - f) Any other information of interest.

10.3. Plan the schedule for the forest work

The inventory team should plan the overall work schedule in advance of going to the forest. However, this schedule must be flexible, as it is difficult to predict exactly how long a planned amount of work will take.

The schedule needs to be planned at several levels, as there should be:

- Schedules for each working unit (if the inventory area has been divided into working units), and
- An overall schedule for all work in the forest.

These levels are discussed below.

[3] *Chapter 12 discusses how to find the starting point on the inventory line.*

10.3.1. Working unit schedule

This section describes how to plan the schedule for each working unit, or for the inventory area as a whole if it has not been divided into working units. This same type of planning can be used if the area is to be 100% enumerated.[4] You should account for the following activities when planning the working unit schedule:

- Setting up and taking down camp,
- The inventory work,
- Checks of the inventory work, and
- Collecting botanical specimens.

These activities are discussed in turn below.

Planning the setting up and taking down of the camps

Before planning the schedule of a given working unit, you should determine how many camps, if any, will be needed. Look at the working unit on the planning map:

- If the working unit is close to the village, there is no need for a camp.
- If it would take more than five hours to walk to the furthest point on an inventory line and back from the village, you will need to have one camp (or more) in the working unit. Place these camps inside the working unit such that there is never more than five hours of total walking time a day.

The way to determine how much time it would take to walk a distance on the planning map is to follow the steps below:

1. Locate the points that the team will want to walk between on the planning map (e.g. from a proposed camp location to the furthest point on the furthest inventory line in the working unit),
2. Measure the distance between these points on the planning map using a ruler,
3. Convert this distance from centimetres on the map to metres on the ground using the scale of the map,[5] and
4. Calculate how many hours it would take to walk the specified distance. To do this, use the rule of thumb that it is possible to walk approximately 3-4 km an hour under easy conditions (i.e. good path, flat terrain) and 1-2 km an hour under difficult conditions (i.e. no path, steep terrain).

Once you have decided how many camps you will need to have in your working unit, you will need to estimate how many days it will take to set up, move, and take down the camps in your working unit. Usually a full day is needed to set up or move camp. A half-day is usually sufficient for taking down camp and returning to the village.

---

4 *Chapter 7 discusses whether to use 100% enumeration or sampling and whether and how to divide a sampled inventory area into working units.*

5 *Appendix F describes how to convert distances from the map to the ground using the map's scale.*

Planning the inventory work

This section will not be necessary for those doing 100% enumeration.[6] However, for those doing sampling, you should plan the inventory work as follows:

1. Begin by approximating the number of plots that can be completed by one team in a day. If your inventory team has not yet done any work in the forest, use the following rules of thumb based on the experiences of previous participatory inventories:
   - 20 plots per team per day can be completed in hilly terrain, and
   - 30 plots per team per day can be completed in flat terrain.

   Later, after completing the first working unit, you will be able to determine more accurately the average number of plots that can be completed per day by your inventory work teams.
2. Multiply the number of plots that can be completed by one team in one day by the length of each plot (50 m), to get the length of inventory line, in metres, that can be completed in one day. Convert this distance to the appropriate distance on the map using the scale of the map.[7]
3. Your planning map should already display the inventory lines of each working unit. With a ruler and pencil, divide each inventory line into units, each of which is the length of one team day's worth of work.
4. Assign these units of line to each team in whatever manner seems reasonable. Some of the issues involved in assigning units include:
   - Making sure that no team does an unfair proportion of the difficult work (on the other hand, you may decide to form one particularly strong team to do the most difficult work),
   - Ensuring that the same team generally continues where they left off the previous day, as it is easier for them to find the finish point of their own work the next day than to find that of another team, and
   - Planning so that on the last day there are as many 'working ends' of lines as there are teams.

Planning the checks

Some of the plots that have been completed should be checked according to the following guidelines:[8]

- On the second day of the inventory, checks should be done of all the first day's work.
- There should be more checks at the start of an inventory.
- At least 10% of the plots should be checked, so for every ten days of work there will need to be at least one day of checks.
- At least some of the checks should be done on the last day of work in each of the working units.

---

[6] *Chapter 7 describes how to calculate how many team days you will require for the 100% enumeration.*

[7] *Appendix F describes how to convert distances from the map to the ground using the map's scale.*

[8] *Chapter 14 explains why checks are scheduled in this way, and how to make them.*

Planning the collection of botanical specimens

Any team should collect botanical specimens, if these are desired, when the opportunity presents itself.[9] For example, they may take the specimens during the course of the inventory work. Or, it may be apparent from looking at the planning map that the amount of inventory line to be completed will take only half a day of field work. In this case, the team could be asked to take collections on their way back to the camp. Another possibility is on the last day in the working unit, when there may not be enough inventory work left for all teams; some team(s) could be assigned to make botanical collections on that day.

Example 10.1 provides an example of how the work for three teams was arranged in one working unit.

Example 10.1. Planning the working unit schedule

The inventory planners divided the inventory lines in one of their working units into units of inventory line that one team should be able to finish in one day (see *Figure 10.1*). The letters in *Figure 10.1* stand for the three teams doing the work, called teams A, B and C. The numbers after the letters stand for the working days of each team, so that A1 signifies working day 1 for team A. The units of line were divided in the following way:

- Day 1: All the teams were assigned units reasonably near the camp (see A1, B1 and C1).
- Day 2: As this was the first working unit in the inventory, all of the teams were assigned to check their work on the second day. It was assumed that each team would have some time left over to do some additional plots, although not a full day's worth (see A2, B2 and C2).
- Days 3, 4, 5 and 6: The units of line were assigned to each team so that, if possible, each team could return to the point where they stopped on the previous day.
- Day 7: Only one unit of line has remained. This was assigned to team C (see C7), and teams A and B were assigned to take botanical collections.

In the working unit displayed in *Figure 10.1*, there is one camp. Thus the schedule should include two additional days to set up and take down camp, making a total of nine days.

[9] *Chapter 15 explains why and how botanical specimens should be collected.*

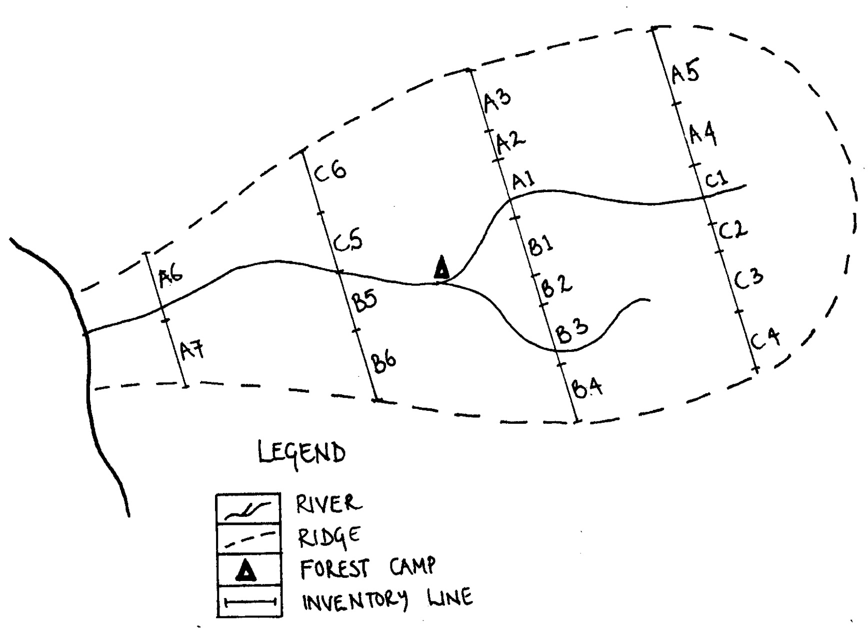


Figure 10.1. Dividing an inventory area into working day units.

10.3.2. The overall schedule for work in the forest

The overall schedule for all the work that is done in the forest should include the following activities:

- *One half to one full day for training.* A half to full day of training should be held on the first available day in the forest.[10]
- *The schedules for each working unit.* This has been described in the previous section.
- *Reassessment of cost and precision.* After one week of inventory work, the inventory team may want to reassess the data to determine whether the cost and precision objectives are being met, if they are reasonably confident about making the calculations.[11] This reassessment may cause a revision of the location of inventory lines and the overall schedule.
- *Days off.* The inventory team should discuss if and when they would like to have days off.

Where to next

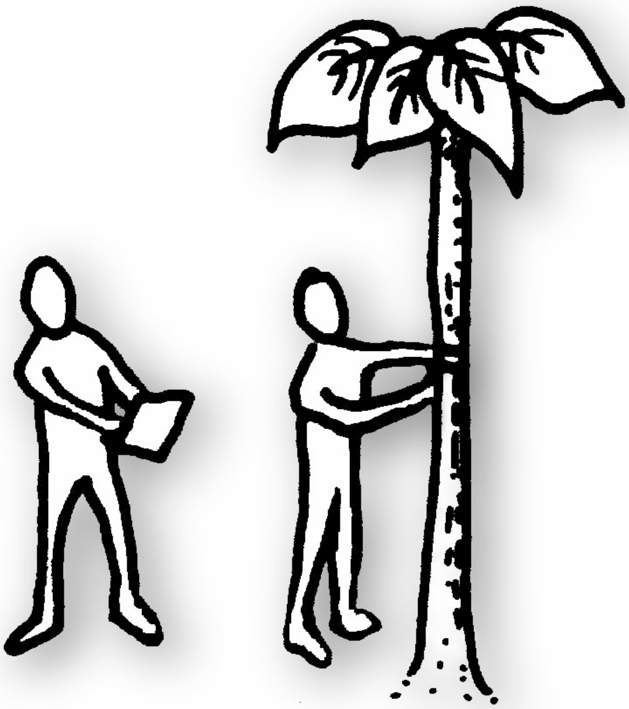
Now that you have organised the work in the forest, you are finished planning the inventory. You are now ready to begin the inventory work itself. The first step of the inventory work is the training of the inventory team. The next chapter describes ways of training the team in the concepts and practice of inventory work.

[10] *Chapter 11 describes the training of the inventory work teams.*

[11] *Appendix D describes the reassessment of cost and precision.*

III

Inventory Work in the Forest

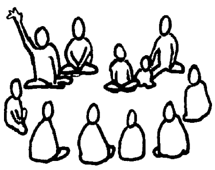


11

Train the Inventory Team

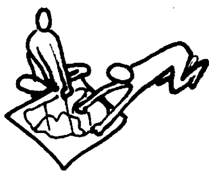
Where you are in the participatory inventory method:

I Decision making in the village



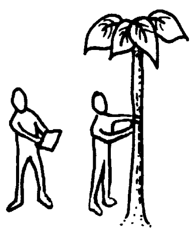
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



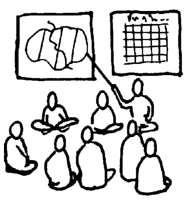
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

11.1. Plan a training session for the inventory team,
11.2. Train the inventory team to use a compass,
11.3. Train the inventory team to number and establish the plots along the inventory line, and
11.4. Train the inventory team to enumerate the plants and record information on the data form.

Skills/information required

The skills or background information that you will require include:

- *Chapter 13*. Conduct the inventory work (this chapter describes the inventory work that you are training the inventory team to do).
- *Appendix H*. Surveying techniques.
- *Appendix K*. Measuring plant size.

Materials required

- (Optional) Visual displays for training, as shown in *Figures 11.2*, *11.6*, and *11.7*.
- For each group of six people: A compass, a sighting stick marked with brightly coloured electrician's (sticky) tape, a parang, ribbon, thin nib permanent ink pens, a 10 metre nylon rope, two 5 metre nylon ropes, a data book or a clipboard with data sheets, pencils, an eraser, two diameter tapes (optional, depending upon method of plant measurement), a metre tape (optional, depending upon method of plant measurement), a ruler (optional, depending upon method of plant measurement) and a clinometer (optional, depending upon method of plant measurement).

Introduction

Before beginning the inventory work, you will need to train the inventory team. Everybody involved with the inventory work must train together to ensure that they will all do the work in the same way later. It is important that everyone understands how to do the inventory work, and why it should be done in this way. This chapter suggests some ways of teaching the inventory team how and why to do the different tasks involved in inventory work. The skills involved include using a compass, numbering and establishing the plots along the inventory line, enumerating the plants and recording the data on the data form.

11.1. Plan a training session for the inventory team

You (and other trainers) should prepare the training session in advance. You should begin by planning who will be involved, where and when the training will take place and how the training will be conducted.

11.1.1. Who will be involved

Everyone on the inventory team should attend the training session. Other villagers should be allowed to attend as well, if interested. The people attending the training will all have skills useful for doing the inventory work. However, some may be illiterate and unable to record data, whereas others may not be able to identify the resource species or use a parang. Your aim should be to teach everyone to do all the tasks, but at the same time you must recognise that some tasks may be too challenging for some people.

11.1.2. Where the training will take place

The best location for the training is in the forest where you will be conducting the inventory. This will ensure that the training is done under the same conditions as the inventory work. An alternative is to conduct the training in forest close to the village.

11.1.3. When to conduct the training

Ideally, the training session should take place just before the inventory team begins the inventory work. As it can last for up to a full day, you might schedule it for:

- The day before you leave for the camp,
- The afternoon of the day you set up camp, or
- The morning of the first day of inventory work (possibly followed by half a day of inventory work).

11.1.4. How the training will be conducted

You should begin planning the training by familiarising yourself with the tasks involved in inventory work.[1] After this, think about how best to train the villagers in the concepts and methods involved in each task.

There are a few general guidelines to conducting the training session:

- Make the training as interactive and informal as possible,
- Break up the training into small steps, each of which is discussed or practised briefly by everyone before moving on to the next step,
- Form training groups which are as small as possible (however, you will be limited by the number of available trainers and equipment),
- Encourage the villagers who learn more quickly to train the others (they can do the training in the local language, and the other villagers may feel more comfortable learning from them), and
- If it is obvious that the women feel inhibited from participating in the training, form a separate women's training group.

[1] *Chapter 13 describes the tasks involved in inventory work.*

The remaining sections of this chapter contain suggestions for training the inventory team in the different tasks of inventory work. You may or may not wish to use all of these ideas. You should feel free to add your own ideas.

11.2. Train the inventory team to use a compass

11.2.1. Explain what a compass is and why we use it

What is a compass?

Show the training group a compass, and explain that compasses are instruments that show us where North is. Place the compass on the ground and show the training group how the needle continues to point in the same direction (i.e. north) no matter how much you rotate the compass base plate. Place other compasses on the ground, with their base plates aligned towards different orientations (see *Figure 11.1*). Show that all the needles are pointing in the same direction.

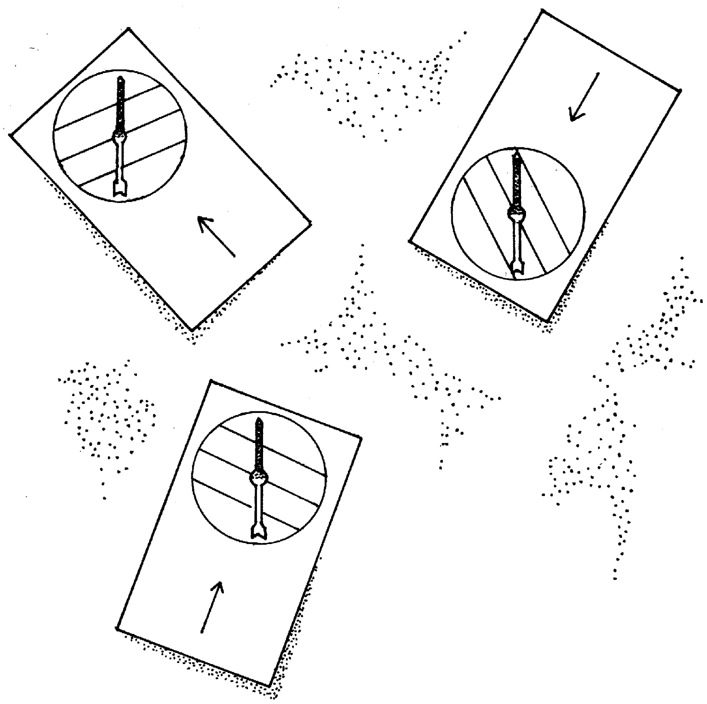


Figure 11.1. Even when compasses face in different directions, all have magnetic needles pointing north.

Why do we need to use a compass?

Draw a diagram that shows three people trying to walk straight, parallel lines in the forest. One set of people are using compasses and the other set are not. This diagram could look like *Figure 11.2*, or it could be much simplified and drawn with a stick on the ground. With the diagram, show that without a compass the lines may not be straight, but with a compass they should be.

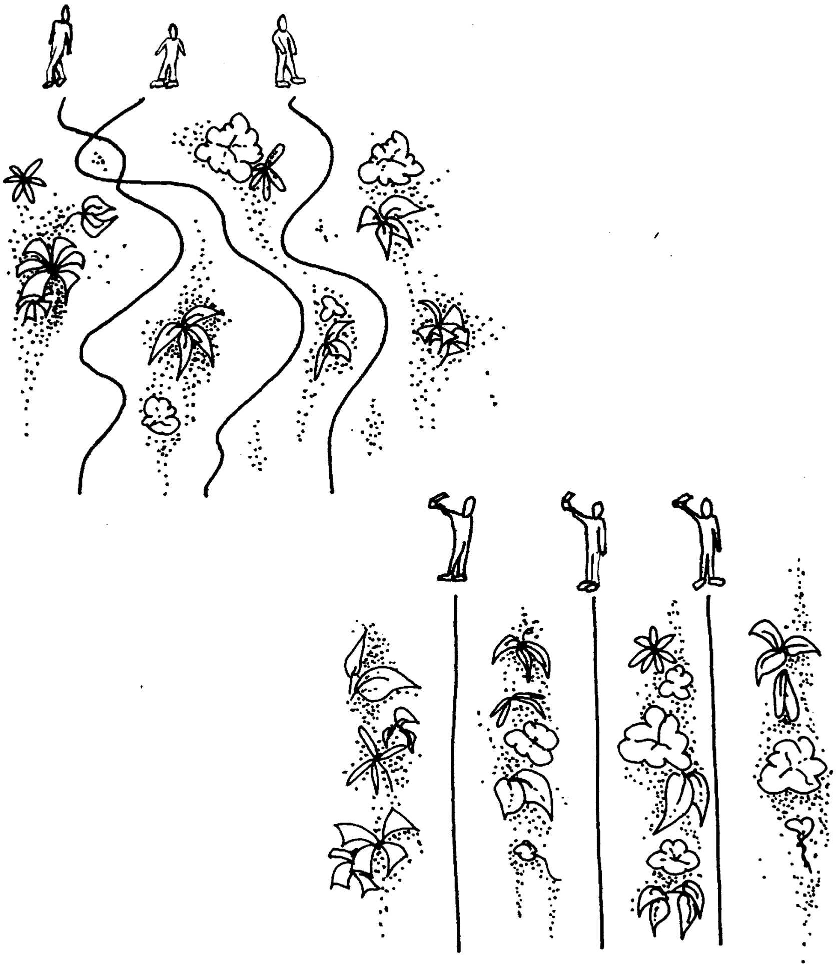


Figure 11.2. If you follow a compass in the forest then you will be more likely to be able to walk in a straight line in a known direction.

To illustrate this, show the training group how to hold a compass.[2] Three people should stand in a row, spaced approximately two metres apart. Each person should hold a compass with the needle pointing towards the North. All three people should walk forward, following the direction of the needle. If done correctly, they should walk in straight, parallel lines. These people should give the compasses on to others so that everybody gets a chance to try.

[2] *Appendix H describes how to hold a compass.*

11.2.2. Explain how to use a compass to walk in a chosen direction

Explain the four points of the compass

Place a compass on the ground and use it to place a stick or long thin cardboard strip on the ground on a North-South axis (see *Figure 11.3*). Write the word 'North' on a cardboard square, and put it at the end of the stick which is pointing North. Put another square at the South. If you want, discuss what you would meet if you walked in North or South, in both the short and long distance. Place another stick on the East-West axis, and place cards at East and West respectively. Discuss again what would be found to the East and West.

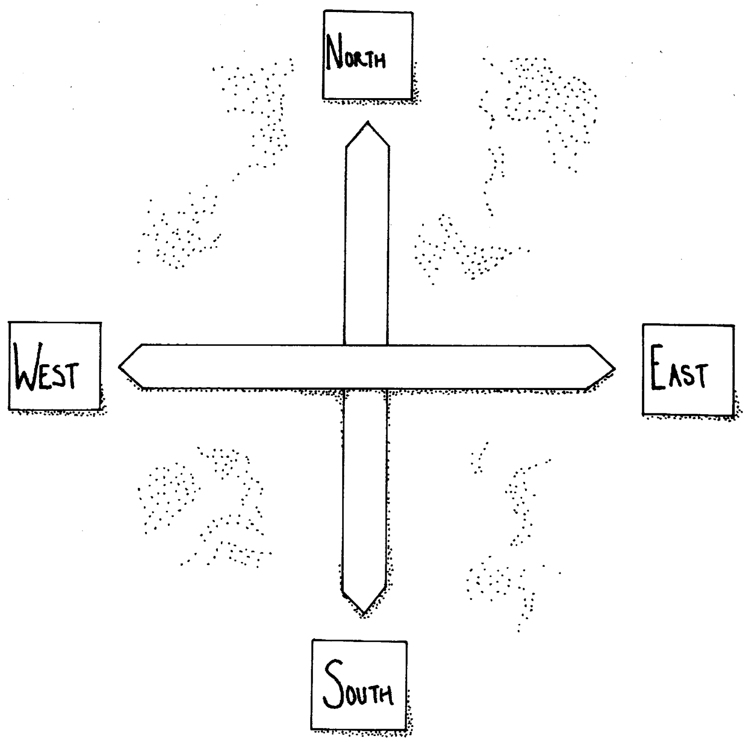


Figure 11.3. Use two cardboard strips to represent the four points of a compass. This can be used to explain compasses to a larger number of people during a training session.

Explain the degrees on a compass

Using the cardboard 'compass', explain that a compass has degrees in the same way that a clock has minutes, except a compass has 360 degrees rather than 60 minutes. Show that just after North is 1°, and count (briefly) around to 360° which is North. Write 360° in the earth with a stick. Ask the training group if they can tell you what degree South is at. Prompt them by saying it is halfway around the circle. After identifying South as 180°, ask them if they can tell you where East is (halfway to South (180°), which is 90°) and where West is (halfway between South (180°) and North (360°), which is 270°). Draw the degrees of S, E, W in the ground with a stick.

How to determine the degrees (or bearing) of a direction which is not North, South, East or West

Using a stick in the ground, draw a line from the centre of the cardboard 'compass' (i.e. the point where the North - South and East - West cardboard axes meet) outwards, in a direction which is not North, South, East or West. Place a real compass (with its dial turned so that 'N' is at the indicator mark) in the centre of the cardboard 'compass' and use it to determine the bearing of the line you have drawn (*Figure 11.4*). Repeat this exercise with a few more lines, and ask people to read the bearings.

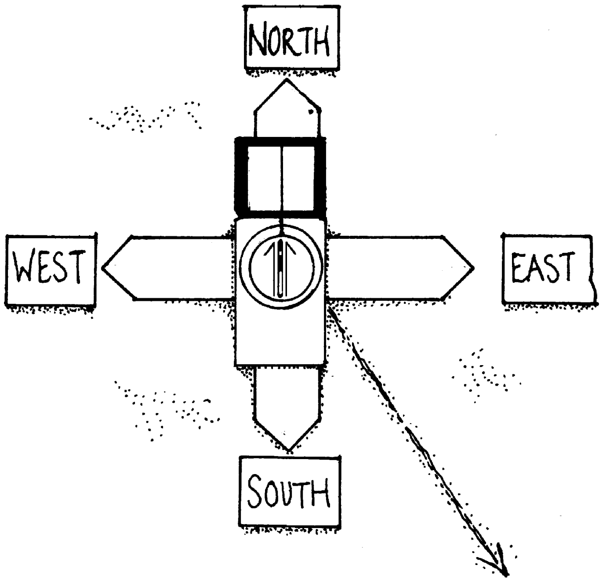


Figure 11.4. A compass can be used to determine the bearing from one point to another

How to set a chosen bearing on the compass.

Show the training group how to turn the compass dial so that the chosen bearing is aligned with the indicator mark. Then put the compass in the centre of the cardboard 'compass' and rotate the real compass' base plate until its needle is aligned with the orientation arrow on the base of the compass. Show that now the sighting notch and the mirror are pointing at the chosen bearing, and not North as before (*Figure 11.5*).

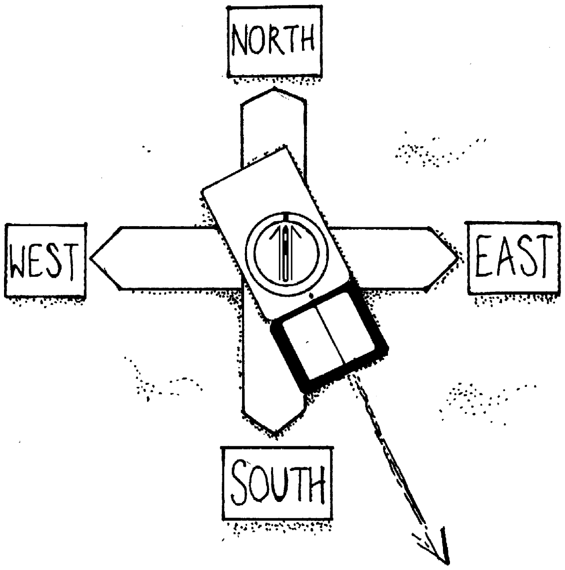


Figure 11.5. Once you know the bearing in which you want to move, rotate the compass dial until the desired bearing is aligned with the indicator mark. Rotate the compass base plate until its needle is aligned with the orientation arrow on the base of the compass.

How to walk in a straight line towards a chosen bearing

Show the training group how to take a sighting in the chosen direction.[3] Everyone should practise:

- Sighting on two objects at the same bearing (one near and one far) and walking towards these objects, and
- Directing a person (standing 10 metres away and holding a sighting stick) to move right or left until they are aligned with the chosen bearing.

11.2.3. Basic compass care

Explain that holding metal objects near a compass will affect the compass' orientation. Illustrate this by passing a parang, or other similar sized metal object, back and forth above the dial of the compass. The needle will tremble and follow the parang slightly. Explain that people using the compasses during the inventory work should not hold or wear a parang or any other metal object, unless it is very small.

[3] *Appendix H explains how to take a sighting.*

11.3. Train the inventory team to establish the inventory line

11.3.1. How to measure horizontal distance

What is horizontal distance and why do we use it?

Explain what horizontal distance is and why the inventory lines are measured using it.[4]

A good way of illustrating the difference between horizontal distance and slope distance is to take the training group to a hill with a slope (not too steep). One person should stand up the hill holding the ends of two ten metre ropes at the same height from the ground, as illustrated in *Figure 11.6*. Two people should stand down the hill from this person, each holding the end of one rope. One of these two should hold the end of the rope at the same set height from the ground as the other end of the rope. This person is measuring slope distance. The other person should hold the end of the rope so that it is level with the other end of the rope. This person is measuring horizontal distance. This example should make it clear to the training group that ten metres of slope distance is a shorter horizontal distance than ten metres of horizontal distance, and that the two distances can be very different from one another on steep slopes.

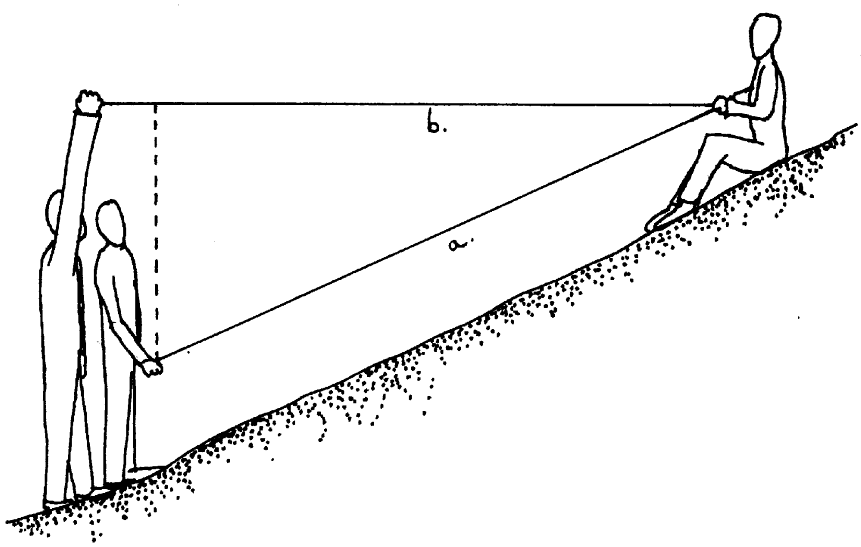


Figure 11.6. In this figure, rope a represents slope distance and rope b represents horizontal distance. This exercise shows the difference in horizontal distance between two ropes of the same length.

How to measure horizontal distance

There are a number of methods for measuring horizontal distance.[5] It is not necessary for the inventory team to know all of these methods. Train them in the method you think is most appropriate.

---

[4] *Appendix H explains what horizontal distance is and why we use it.*

[5] *Appendix H describes a number of options for measuring the horizontal distance.*

11.3.2. How to number and establish plots along the inventory line

Explain how the plots and subplots will look along the inventory line

This section will not be relevant for teams doing a 100% enumeration. If you are doing a 100% enumeration, you should train the team to use the method described in *Box 13.1*. If, however, you are doing sampling, you should begin by reviewing the concept of sampling, and by explaining that the inventory team will be sampling the forest using plots.[6]

You should also review what a plot will look like in the forest if seen from above. You can draw a diagram to illustrate this (see *Figure 11.7*). Explain that a plot is 50 metres long and 10 metres wide, and that this width is divided into 5 metres to the left and 5 metres to the right of the central line. Explain that because 50 metres is too long a distance to measure easily in the forest, the length is divided into five subplots, each 10 metres in length.[7]

How to number plots along the inventory line

The 'front person' on the inventory work team marks the plots with numbered, tagged sticks. Use the plot diagram to explain how to number the plots and subplots.[8]

How to establish plots along the inventory line (two team formations)

Explain how the 'compass person' and 'rope person' work together to establish the central inventory line and the 10 metre subplot lengths along this line. Describe the two team formations used to establish plots on flat and steep terrain.[9]

11.3.3. Practise numbering and establishing the plots along the inventory line

The training group should now divide into groups of three. Each group of three should practise numbering and establishing an inventory line for the length of at least five subplots. They should try out both team formations.

After this practice session, the training group should meet again to discuss:

- What to do when the inventory line reaches the boundary of the inventory area or the boundary of a smaller area or forest type,[10]
- What to do when the line reaches an obstacle or an inaccessible area.[10]

---

6 *Chapter 1, Example 1.7 explains the concept of sampling.*

7 *Appendix I explains why this plot width and length are recommended.*

8 *Chapter 13 explains how to number the plots along the inventory line.*

9 *Chapter 13 describes the two team formations for establishing plots along the inventory line.*

10 *Chapter 13 explains what to do when the line reaches a boundary, obstacle or inaccessible area.*

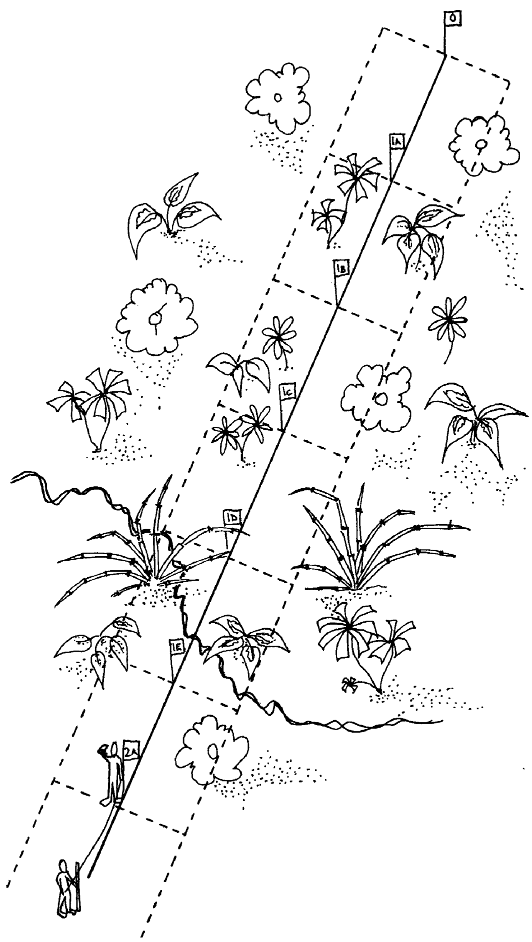


Figure 11.7. An example of a diagram which demonstrates how an inventory line appears from above.

11.4. Train the inventory team to enumerate the plants and record information on the data form

11.4.1. How to enumerate the plants

Describe what information is wanted on the plants and environment

List the resource species that are being enumerated (including the range of plants from that species that are being included in the inventory, for example 'all trees over 30 cm dbh').

Explain, using the plot diagram (see *Figure 11.7*), how the two enumerators walk on either side of the central inventory line, counting those plants that are within 5 metres of the line. Discuss how to tell if a plant is in or out of a plot, and explain that it is important to do this as carefully as possible, as this is a major source of inaccuracy.[11] After this discussion, practice determining whether a plant is in or out of the plot in the plot diagram. Move on to practice on real plants near a practice inventory line.

[11] *Chapter 13 explains how to tell if a plant is in or out of a plot.*

How to gather information on plants and environment

The inventory team should already have selected the type of information that they want to gather about the plants and their environment.[12] You will need to explain how the enumerators will be doing this. Get people to practise gathering this information, especially if it involves measuring or estimating plant size.[13] Explain again that it is important to gather this information as carefully as possible, to ensure accuracy. Ask members of the inventory team who are knowledgeable about the resource species to provide other people with training in species identification.

11.4.2. How to record information on the data form

Show the training group an example of a data form (this form can be drawn on a large sheet of paper for everyone to see during the training session). Discuss some guidelines for good data recording.[14] Explain why and how to write down plot information such as the area or forest type, working unit, team, date, line number and bearing. Explain (if relevant) how to record information about the plants and their environment.

11.4.3. Practise enumerating the plants and recording information on the data form

Finally, divide the training group into groups of three again. One group of three should establish an inventory line. The remaining groups of three should each enumerate the plants and record the data, starting ten minutes apart along the same inventory line.

The groups of three should meet together after completing the first plot (five subplots). They should compare data and discuss and check any differences. This gives the inventory team another opportunity to make final decisions on what information they want and how they should gather it. Next, the group that was establishing the line should switch tasks with another group of three, and all groups should continue this exercise for another plot. Continue establishing and enumerating plots until the differences between groups are gone. If necessary spend the rest of the day working at this. This training must be done thoroughly, to eliminate differences between teams, which can be a serious source of inaccuracy, and to determine what tasks can be done properly by whom.

Where to next

Now that the team is trained, it is ready to begin the inventory work. This work begins with the inventory teams finding the way to their starting points on the inventory lines. The next chapter explains several ways for the inventory work teams to find their starting points.

---

[12] *Chapter 8 explains how the inventory team determined what information they wanted to gather.*

[13] *Appendix K explains how to measure plant size.*

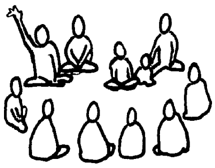
[14] *Chapter 13 discusses guidelines for good data recording.*

12

Locate the Starting Point in the Forest

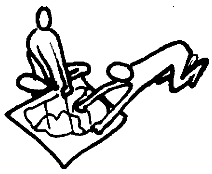
Where you are in the participatory inventory method:

I Decision making in the village



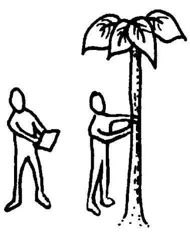
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



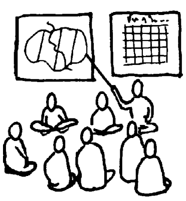
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

12.1. Choose which of three methods to use to find the starting point,

12.2. Option 1. Find a starting point by walking from a reference point,

12.3. Option 2. Find a starting point by walking from an inventory line that has already been completed, and

12.4. Option 3. Find a starting point by using Geographical Positioning System (GPS) equipment.

Skills/information required

The skills or background information that you will require include:

- *Appendix F*. Five features of maps, and
- *Appendix H*. Surveying techniques.

Materials required

- Equipment required in the village or camp: Planning map, ruler, protractor, pencil and notebook.
- Equipment required in the forest: Compass, 50 metre nylon rope, and GPS receiver (if Option 3 is used).

Introduction

Your planning map should show the location of the inventory lines, whether in areas for 100% enumeration (if any), or areas for sampling. The inventory work teams must now use this map to locate their starting points, or the points at which they begin each day's inventory work, in the forest. There are three methods for locating a starting point on an inventory line. These are by walking from a reference point, by walking from an inventory line that has already been completed, and by using GPS equipment. This chapter explains how to determine which method is most suitable and how to use each method.

12.1. Choose which method to use to find the starting point

There are two types of starting points: those for areas under 100% enumeration and those for areas for sampling:

- Areas for 100% enumeration: The starting points for these areas will already have been located and marked on the planning map.[1]
- Areas for sampling: All the inventory lines displayed on your planning map should already have been divided into units that represent the work that one inventory work team can complete in one day.[2] The beginning of each unit is the starting point for one day. Therefore, if inventory lines are longer than one day's worth of work they will contain more than one starting point. Every time you begin a new inventory line, you must choose which will be the first starting point on that line. Next you must choose which method to use to find this starting point in the forest.

There are three ways for a team to find their way to either type of starting point. The descriptions below should enable you to choose which method is most appropriate for your situation.

1. *Walk a measured distance from a reference point on the planning map to the starting point.*[3] This method is suitable when there is a reference point on the planning map that can also be easily found in the forest, and when this reference point is nearer to the starting point than an inventory line that has already been completed.
2. *Walk a measured distance from an inventory line that has already been completed to the starting point.* This method is more suitable than the first method when a suitable reference point on an inventory line that has already been completed is nearer to the starting point than any available (and reliable) reference point on the planning map. This method cannot be used for locating the first starting point in a working unit.
3. *Locate the starting point using Geographic Positioning System (GPS) equipment.* If there is GPS equipment available, this might be a convenient method. However, it should only be used when a place with suitable conditions for the equipment to take a clear reading (i.e. when the machine can be pointed directly at the sky away from the cover of trees) is closer to the starting point than any other available reference point.

12.2. Option 1. Find a starting point by walking from a reference point

You should start by looking at the planning map in the camp or village. Select a reference point on the planning map.[3] A reference point on the map can be a river junction, a branch in the road, or the point where a river crosses the road (see *Figure 12.1*). This reference point should be as close as possible to the location of the starting point on the new inventory line.

---

[1] *Chapter 7 explains how to locate the starting point for areas for 100% enumeration.*

[2] *Chapter 10 explains how to divide the inventory lines into one day units for areas for sampling.*

[3] *Chapter 6 discusses the importance of having reference points on the planning map.*

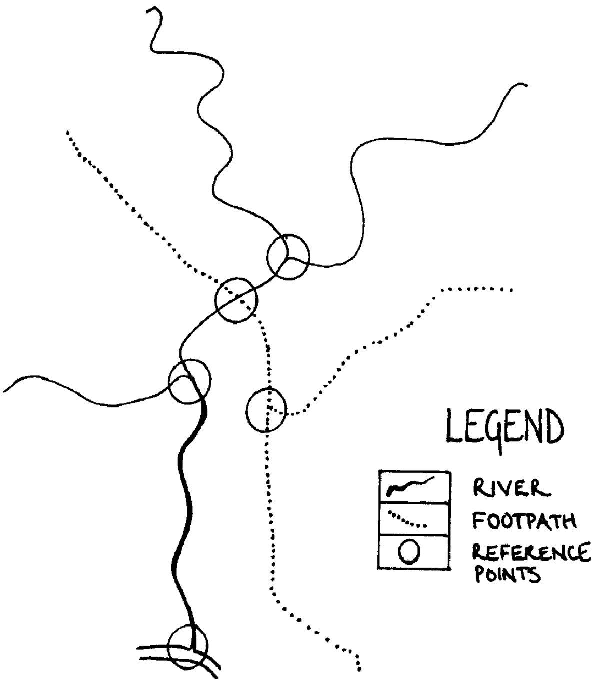


Figure 12.1. There are usually a number of distinct points on a map that can be easily located on the ground, these are referred to as reference points.

You then calculate the distance and bearing from this reference point to the starting point on the new inventory line. The way to do this is described in *Box 12.1*.

Box 12.1. Calculating the distance and bearing on the planning map

To calculate the distance and bearing on the planning map, you should follow the steps below (see *Figures 12.2, 12.3* and *12.4* for Options 1, 2 and 3, respectively)

1. Draw a straight line on the planning map, using a ruler and pencil, which goes from a reference point (if Option 1), a point on a neighbouring inventory line (if Option 2) or a point that can be found using GPS (if Option 3) to the starting point on the inventory line.
2. Measure the distance between the two points on the map with the ruler, and convert this distance on the map to the real distance on the ground using the scale of the map.[4] Record this distance in a notebook.
3. Work out the bearing of this line using a compass or protractor.[5] Record this bearing in a notebook.
4. Work out the bearing that the inventory team will be following along the inventory line. Record this bearing in a notebook as well.

[4] *Appendix F explains how to convert a distance on a map to a distance on the ground using the scale of the map.*

[5] *Appendix H explains how to determine a bearing on the map.*

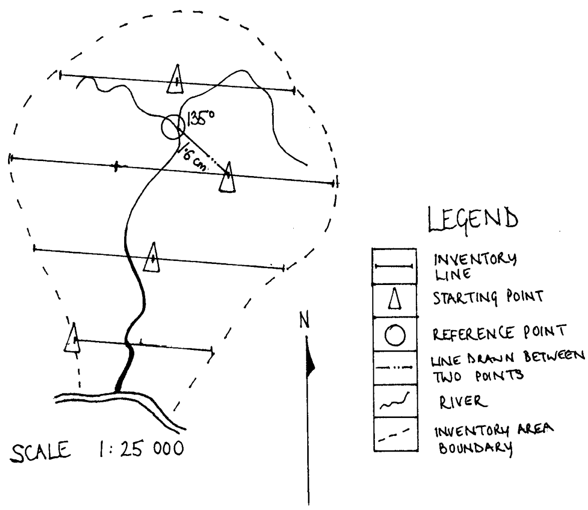


Figure 12.2. Finding a starting point from a reference point.

Once the distance and bearing from a reference point to the starting point is known, the inventory work team is ready to follow this distance and bearing in the forest. The way to do this is described in *Box 12.2*.

> **Box 12.2. Following a distance and bearing in the forest**
>
> The inventory team walks to a previously determined point in the forest. It can be a reference point (Option 1), a point on a neighbouring inventory line (Option 2) or a point that can be found using GPS (Option 3). When the team reaches this point, they determine an exact point by marking a tree or cutting a stick.
>
> From this exact point the team walks the previously determined distance, following a previously determined bearing.[6] A compass person follows the bearing, walking in the front of the team with the end of a 50 metre nylon rope tied around his or her waist (a nylon rope is best because it is less likely to get caught or snagged in the undergrowth). After he or she has walked 50 metres, another person on the team, who has stayed at the starting point, should call out to the compass person. When this happens another member of the team should cut a stick and place it at the 50 metre point.
>
> The compass person will then continue to follow the bearing for another 50 metres until a person remaining at the 50 metre mark calls out. This procedure continues for every 50 metres until the total distance has been covered, at which point the inventory team will have reached their starting point on the new inventory line. They should now begin to establish the inventory line, following the bearing (for the line) that was determined from the planning map.

[6] *Appendix H describes how to follow a compass bearing.*

12.3. Option 2. Find a starting point by walking from an inventory line that has already been completed

As with the first method, the inventory work team begins by examining the planning map in the camp or village. They should look at a completed inventory line which neighbours the new inventory line and determine a point on this completed line which can act as a reference point, such as a point where the inventory line crosses a river or a road (see *Figure 12.3*).

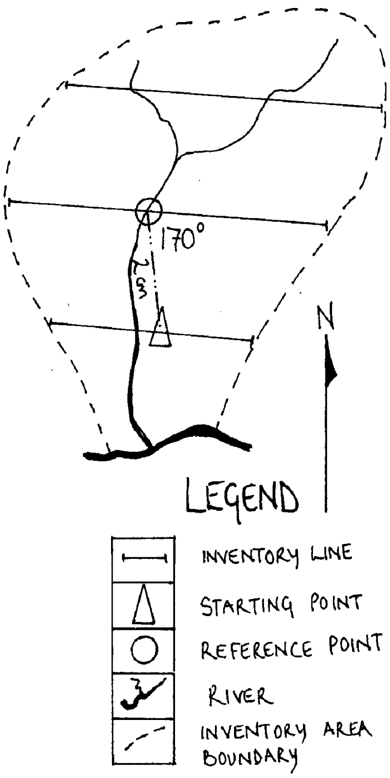


Figure 12.3. Finding a starting point from an inventory line that has already been completed.

The inventory work team should determine the distance and bearing from this point to the starting point, as is described in *Box 12.1*. The team should follow this distance and bearing in the forest. The way to do this is described in *Box 12.2*.

12.4. Option 3. Find a starting point by using Geographic Positioning System equipment

When finding a starting point using a GPS receiver, you must have a planning map with an accurate grid system (either latitude and longitude or UTM).[7]

A GPS receiver is an electronic instrument that receives signals sent from satellites. These satellites provide information about the accurate location of the GPS receiver with respect to latitude

[7] *Appendix F explains the two types of grid reference.*

and longitude. This chapter will not explain how to use the GPS equipment, as different machines vary. Instructions should be included with the machine.

It can be difficult or else time consuming to take readings with a GPS receiver when under the forest canopy, although this is changing as the technology improves. With older models, GPS equipment can only locate the position of a point on a wide road (at least 7 metres wide), river (with few overhanging trees), or cleared area (such as a swidden rice field).

Using a planning map, determine a point along a road, river or in a cleared area in the forest which could act as a reference point for finding your starting point (see *Figure 12.4*). Using the grid reference on the planning map, determine the exact co-ordinates of the road, river or clear area. The inventory work team should determine the distance and bearing from this point to the starting point, as is described in *Box 12.1*.

The inventory work team will then go to the road, river or clearing and move down it monitoring the GPS display until they reach the point where the co-ordinates on the display are the same as those determined in the village. They then walk the previously determined distance and bearing, as explained in *Box 12.2*. This will bring them to their starting point for the day's work.

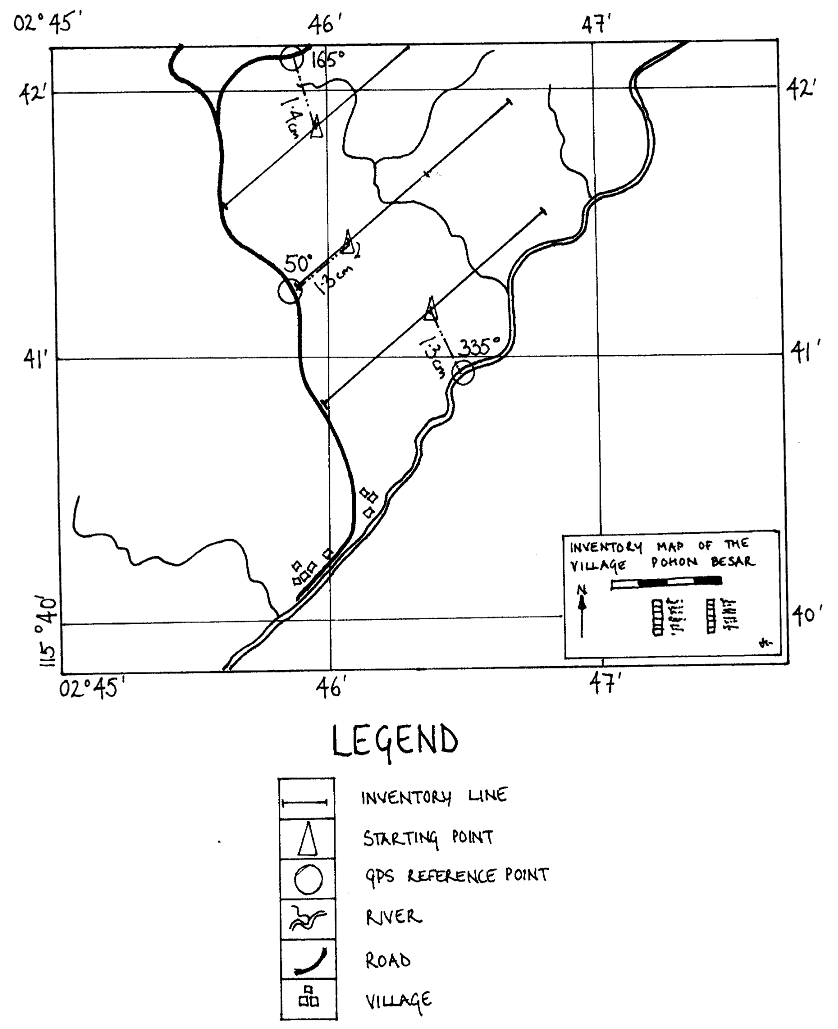


Figure 12.4. Finding a starting point using GPS equipment.

Where to next

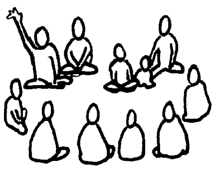
Once the inventory work team has arrived at their starting point, they can begin the inventory work. The next chapter describes the different tasks involved in the inventory work, such as numbering and establishing the plots along the inventory line, enumerating the plants and recording the data in the data form.

13

Conduct the Inventory Work

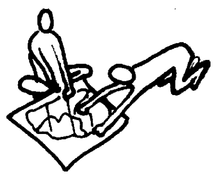
Where you are in the participatory inventory method:

I Decision making in the village



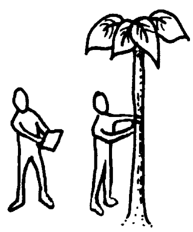
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



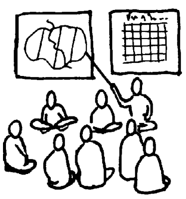
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, the following people will be able to complete the following tasks:

13.1. Front person: clear the trail and number the plots along the inventory line,

13.2. Compass person and rope person: establish the plots along the inventory line,

13.3. Enumerators: enumerate the plants and gather information on plants and environment, and

13.4. Recorder: record the information on a data form.

Skills/information required

The skills or background information that you will require include:

- *Appendix H*. Surveying Techniques.

Materials required

For each inventory work team:

- A compass, a sighting stick cut in the forest and marked with brightly coloured electrician's tape, a parang, ribbon (12.5 metres per day), one 10 metre nylon rope, two 5 metre nylon ropes, thin nib permanent ink pens, pencils, erasers, data book or data sheets with clipboard, two diameter tapes (optional, depending upon method of plant measurement), metre tape (optional, depending upon method of plant measurement), ruler (optional, depending upon method of plant measurement), clinometer (optional, depending upon method of plant measurement or plot establishment), 3 metre height pole cut in the forest and marked with brightly coloured electrician's tape (optional, depending upon method of plant measurement), lunch, drinking water, raincoats or small tarps in case of rain and small packs for carrying the equipment.

Introduction

Now that the starting points of the inventory lines have been located, the inventory work team is ready to begin the work of collecting inventory data along the inventory lines. This chapter describes the specific tasks of the six members of the team, who include:

- A front person, who clears the trail and numbers the plots along the inventory line,
- A compass person and rope person, who establish the plots along the inventory line,
- Two enumerators, who count the plants and gather information about the plants and environment, and
- A recorder, who records the information on a data form.

These tasks are done in this way in all areas that are being sampled. There are some differences for areas which are being 100% enumerated. *Box 13.1* explains these differences.

Box 13.1. Conducting the inventory work in areas for 100% enumeration

Counting every plant in a given area is not a complex task, however, it is important to count the plants using a systematic method. This ensures that plants are not missed or counted more than once. It is not advisable to walk through an area of forest counting all plants of a particular resource in a haphazard or unmethodical way.

One system for counting all the plants in a given area involves a team of six people, with the same tasks as for a sampled area, described in the remainder of this chapter. The method used is as follows (see *Figure 13.1*):

1. The compass person, rope person and front person start from a marked starting point and cut a line along a previously determined bearing[1] until they reach the other edge of the area being enumerated. The methods that they use to establish the line are the same as for a sampled area. The enumerators and recording person walk to one side of the line, counting and recording all the plants between the line and the edge of the area being enumerated. As they count the plants the enumerators mark them in some way so that the plants will not be counted twice.
2. When the people establishing the line reach the other edge of the inventory area they turn 90 degrees inwards, away from the edge that their line has been following. Whether they turn to the left or right will depend upon on the shape of the inventory area and the location of the starting point on it. These people should establish a line in this direction for 10 metres. The enumerators and recording person do not enumerate and record during this step.
3. At this point the people establishing the line may be inside or outside the boundary of the area. They should check where the boundary of the area is, and turn 90 degrees to either the left or the right, whichever brings them to face the boundary. These people then cut a line in this direction until they reach the boundary. The enumerators and recording person do not enumerate and record during this step.
4. The people establishing the line now check whether they are facing in the opposite direction of their original inventory line. If they are not, they should turn so that they are. They now cut a second inventory line across the area to the opposite edge. The enumerators and recording person count and record all the plants between this inventory line and the previous line, with the enumerators marking each of the plants they have counted. Unlike for systematic strip sampling, both the enumerators walk on the same side of the line.

[1] *Chapter 7 describes how to determine the orientation of the first inventory line and a convenient starting point for the inventory work team.*

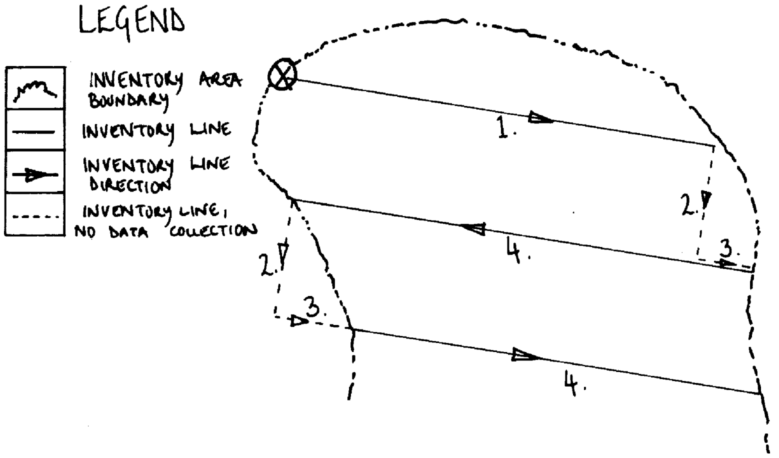


Figure 13.1. How to 100% enumerate all the plants of a certain resource in an area. The numbers refer to the steps outlined in *Box 13.1*.

13.1. Front person: clear the trail and number the plots along the inventory line

A front person cuts the trail to ensure a clear path for the compass person, rope person and recorder to follow. It is very important to have good visibility along the centre line. This person also cuts small stakes and numbers them to mark each individual plot, using the numbering system described below

Each inventory plot will have its own number (see *Figure 13.2*). Plots are typically numbered in sequence, which means that the first plot in an inventory line will start at 1, the second will be 2 and go on to 3, 4 and so on. The five subplots within each plot are called a, b, c, d and e. Thus each subplot will be written with a number that corresponds to the plot number and a letter relating to the subplot (for instance 5a).

The sticks that mark these plots will begin with the starting point of '0'. The second stake will be tagged '1a', the third '1b', and so on to '1e'. The stake that follows this will be '2a', and so on.

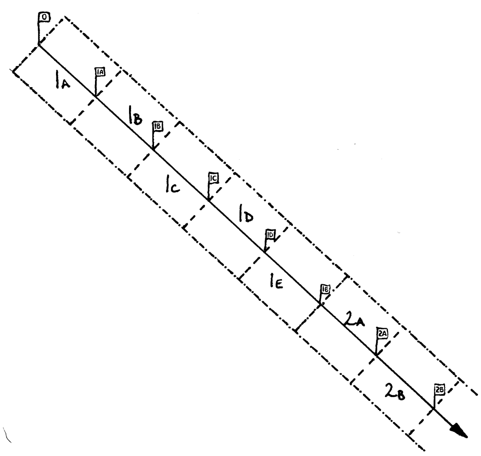


Figure 13.2. The numbering sequence of an inventory line uses numbers to determine plots and letters (a, b, c, d and e) to determine subplots.

The numbering along an entire inventory line may not always be in sequence. For example, if access to the line is by a river that runs halfway through it, two teams may start at this access point and work in opposite directions along the same inventory line. Both will begin with plot 1a, and their numbering will be the same but they will move off in opposite directions. If the same teams or other teams continue either end of this line, they should continue the numbering of the plots from where it left off. Having plots of the same number on the same line is confusing, but it is difficult to avoid if two teams are working on the same line at the same time. Team leaders should keep records of starting points, inventory line numbers and bearings, and plot numbers, so as to minimise the likelihood of confusion.

13.2. Compass person and rope person: establish the plots along the inventory line

A compass person determines the bearing of the inventory line using a compass. This person also helps measure each subplot's length in horizontal distance using a 10 metre nylon rope. The 10 metre nylon rope indicates the centre line of the plot. A rope person holds the other end of the 10 metre nylon rope to measure the subplot's length in horizontal distance. This person may also hold a sighting stick, depending upon which of two team formations (described below) is being used to mark out the inventory line.

13.2.1. Two team formations for establishing plots along the inventory line

The compass person and the rope person can work together in two slightly different formations, depending upon the terrain in which they are working:

- In areas where the terrain is flat, an inventory team will move faster if the compass person is in front of the rope person (see *Figure 13.3*). This is because in flat areas it will be possible for the compass person to sight an object 10 metres or more away and walk directly to it.
- In areas where the terrain is steep, the rope person should be in front of the compass person, holding the sighting stick for the compass person to sight on (see *Figure 13.4*). A sighting stick is used because a steep slope often obscures most other objects from sight.

These two formations are described in more detail below.

Inventory team formation for flat terrain

The inventory team formation for flat terrain works as follows (see *Figure 13.3*):

1. The compass person takes the bearing from a marked starting point to an object 10 metres or longer away.[2]
2. The compass person guides the front person along the bearing by telling the front person to go left or right around any nearby obstacles. The front person clears the trail while walking along the bearing.
3. The compass person walks towards the sighted object, with one end of the 10 metre rope tied around his or her waist.
4. The rope person remains at the marked starting point, holding the 10 metre rope, which slips through his or her hand as the compass person moves away. Once the full 10 metres has been covered the rope person calls to the compass person to stop.

[2] *Appendix H describes how to take a bearing with a compass.*

5. The compass person and the rope person measure 10 metres of horizontal distance.[3]
6. The front person meanwhile cuts a stake and tags it with ribbon. The number of the plot and the letter of the subplot should be written on the tag. The front person places this stake 10 metres horizontal distance from the starting point. This stake indicates the end of one subplot and the beginning of another.
7. The compass person takes a new bearing and all steps are repeated as described above (however, see *Box 13.2* for a way of simplifying the compass person's work). At the same time, the rope person walks to the tagged stake, leaving the rope lying on the ground to indicate the centre of the plot.

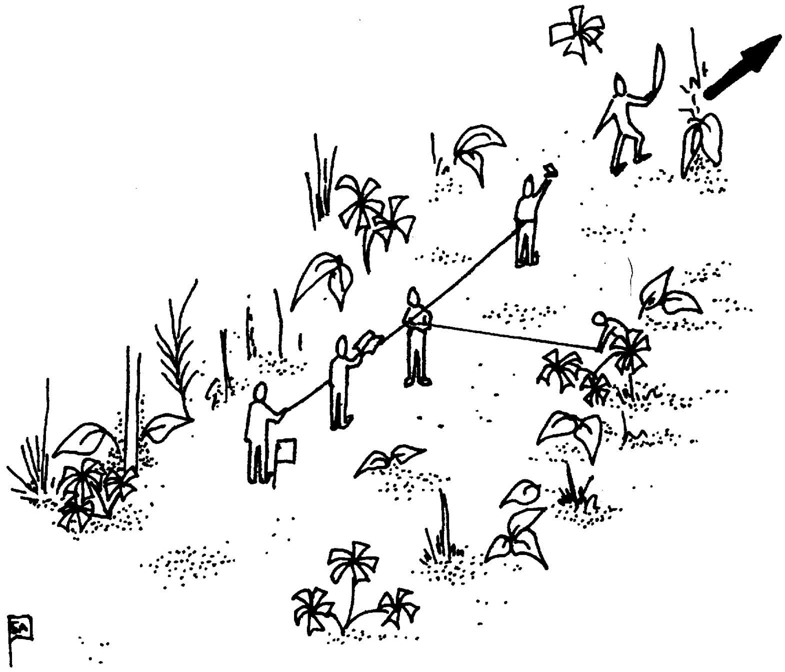


Figure 13.3. Inventory team formation on flat terrain, with the compass person in front of the rope person.

Inventory team formation for steep terrain

The inventory team formation for steep terrain works as follows (see *Figure 13.4*):

1. The compass person takes the bearing from a marked starting point to an object 10 metres or more away. If the slope is very steep (i.e. >45 degrees), it will be difficult to sight an object 10 metres or more away. Instead, the team should use step chaining, where they take the bearing several times over the length of a 10 metre subplot, in a series of smaller steps.[4]
2. This step is the same as Step 2, above.
3. This time it is the rope person who follows the front person along the bearing instead of the compass person. The rope person should carry one end of the 10 metre rope and an easily visible sighting stick approximately 2 metres in length.

---

[3] *Appendix H explains how to measure horizontal distance.*

[4] *Appendix H describes step chaining in more detail.*

4. The compass person lets the rope slip through his or her hands until the end of the rope is reached. At this point the compass person calls to the rope person to stop. The compass person then directs the rope person to move the sighting stick either to the left or right until it is accurately positioned at the desired bearing.
5. This step is the same as Step 5, above.
6. This step is the same as Step 6, above.
7. The compass person walks to the tagged stake and begins to repeat all the steps described above (however, see *Box 13.2* for a way of simplifying the compass person's work).

Figure 13.4. Inventory team formation on steep terrain, with the compass person behind the rope person.

Box 13.2. A simpler method for establishing the plots along the line

Some people may not be very confident about using a compass, and may spend a lot of time trying to take a good bearing. Or, they may begin to take poor bearings once they become tired.

For both formations, it often works better if the compass person takes careful bearings for the first few stakes only. Following this, the compass person or rope person can place the remaining stakes by aligning them with the previous stakes. Occasionally, if the team encounters an obstruction, the compass person will have to use the compass to start the line again. If the centre line has been cleared properly, and if the line has been established correctly, then when the compass person or rope person sights back along the line all the stakes should be lined up, as illustrated in *Figure 13.5*.

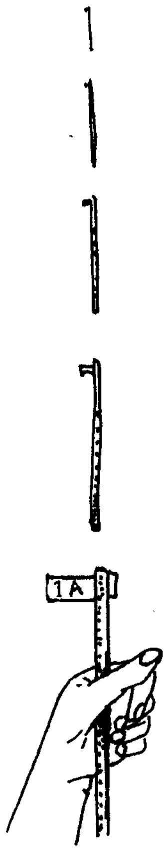


Figure 13.5. When you sight back along the inventory line, the stakes should be lined up like this.

13.2.2. What to do when the inventory line reaches a boundary

The inventory line will eventually end at the inventory area boundary. The line may also cross boundaries between areas or forest types. When a boundary is met, the team will have to decide whether the plot that they are working on is more than halfway within the boundary or not:

- If more than half of the middle subplot (subplot c) is within the boundary, then the plot is counted as being in.
- If less than half of the middle subplot (subplot c) is within the boundary, then the plot is counted as being out. The first few subplots that may have been completed should be disregarded.

13.2.3. What to do when the inventory line reaches an obstacle or an inaccessible area

An inventory work team may come up against an obstacle (e.g. a large tree, a big rock, a cliff) or inaccessible area (e.g. a swamp) that they will not be able to place an inventory line across. There are two options, depending upon the obstacle or area:

- Side step the obstacle or area, if it can be stepped around, or
- Sight on a landmark on the other side to the obstacle or area and continue the line from there. This option should be taken if the obstacle cannot easily be stepped around (i.e. if it is a long cliff with very few pathways to get up or down it).

Both options are discussed below.

Side stepping an obstacle or area

The inventory work team can make a side step by following the steps below (see *Figure 13.6*):

1. The compass person takes a bearing at ninety degrees to the left or right of the inventory line (i.e. at right angles to the inventory line).[5]
2. The rope person walks in the direction of the new bearing, holding the rope end and the sighting stick. The distance of the side step (i.e. the distance that the rope person walks) should be 5 metres, unless the obstacle is larger. The rope person places the sighting stick at the appropriate distance (which should be in horizontal distance),[6] and waits for the compass person to walk to it.
3. The inventory work team measures the next subplot length (or lengths) from this point, using the same bearing and numbering sequence of the original line, until the obstacle has been passed. The enumerators, however, should continue to enumerate the plants in the original subplot area.
4. Once the obstacle has been passed the compass person will again take a compass bearing at right angles to the inventory line but in the opposite direction. The compass person and rope person should measure the same horizontal distance along this bearing as the horizontal distance of the first side step away from the inventory line. This should bring the inventory line back to its original course.

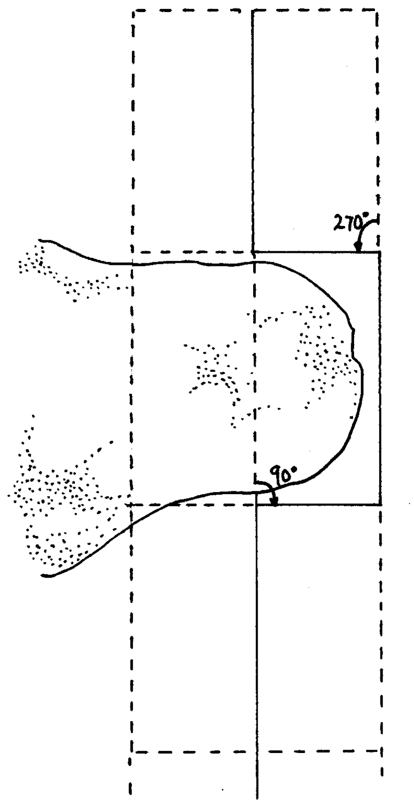


Figure 13.6. A side step is used to avoid obstacles such as large trees or boulders, which lie in the path of the inventory line.

[5] *Appendix H explains how to calculate bearings that are at right angles to the compass bearing.*

[6] *Appendix H explains how to measure horizontal distance.*

Sighting on a landmark beyond the obstacle or area

If an obstacle such as a long cliff cannot be side stepped, the compass person should sight along the inventory line bearing to an obvious landmark on the top of the cliff, such as a tree or rock (see *Figure 13.7*). The inventory team moves to this point by whatever route is possible and continues the inventory line from there. The recorder should record this action on the data form and try to estimate the horizontal distance of the line that has been missed, if any of it has been missed. Information on the distance that has been missed will be important for mapping.

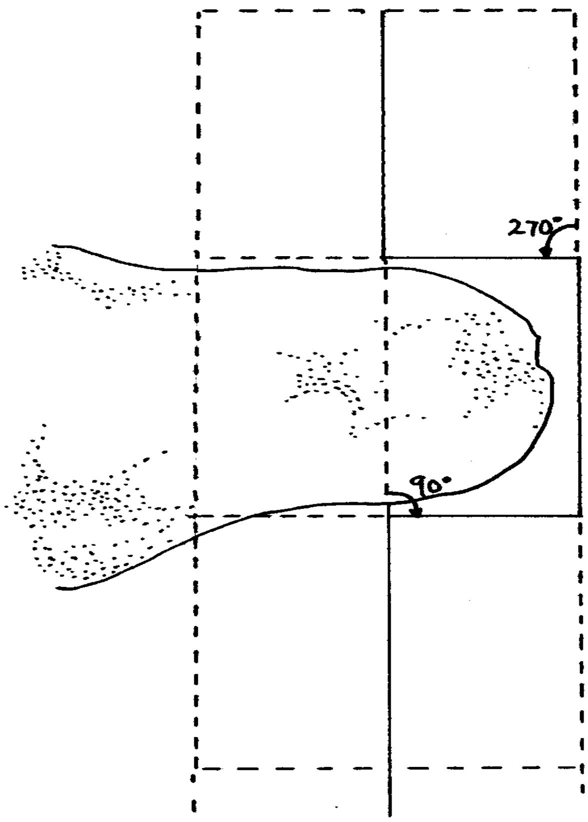


Figure 13.7. If an obstacle such as a cliff blocks the inventory line, the compass person should sight on a recognisable feature on top of the cliff. The inventory line will then continue from this feature.

13.2.4. What to do when the inventory line crosses an area excluded from the inventory area

The villagers have already discussed what areas they want to include in the inventory area and what areas they want to exclude.[7] Some of the excluded area, for example an area of swidden rice fields, may occur as a patch inside the boundaries of the inventory area. Or, the boundary between the included and excluded area may be very uneven, with an inventory line near the boundary crossing over both areas several times.

[7] *Chapter 3 describes how the villagers chose the inventory area, and the areas within it that they wanted to exclude.*

If an inventory line crosses an area that has been excluded from the inventory area, the inventory team should continue the line across this area in order to measure and record the distance that it covers. However, the plots should not be numbered and the enumerators and recorders should stop their activities. Once the line reaches the boundary of the inventory area on the other side of the patch, the plots can be numbered from where they left off and the usual inventory work can continue.

13.3. Enumerators: Enumerate the plants and gather information on plants and environment

The two enumerators walk on either side of the central line, at a distance approximately half way between the central line and the outer edge of the plot. They look for all resource plants that have been chosen for inclusion in the inventory. When they encounter the appropriate plants, they check whether the plants are inside or outside the plot. If the plants are inside the plot, the enumerators count them, and, if required, gather other information about them. The enumerators may also gather information about the environment. They call out all information that they obtain to the recorder, who writes it on a data form.[8]

It is very important that the enumerators check all borderline plants very carefully. Carelessness in checking whether a plant is in or out of a plot is a major source of inaccuracy in inventories. This is especially true when using a method that does not actually stake out the boundary. In order for a plant to lie within a plot, its centre point must be five metres either to the left or right of the central line of the inventory plot. If a plant is close to the central line of plot there will be no doubt about whether it lies within the plot or not. If a plant is close to the edge of the plot (i.e. the five metre limit from the plot's central line), the enumerators should use a five metre nylon rope to check if the plant is inside the plot.

The guidelines below should be followed when checking whether a plant is in the plot or not:

- *The measurement should be made using horizontal distance*. The enumerators must make sure to measure horizontal distance when there is a steep side slope. This is because a plant which is downslope from the central line may appear to be further away than a plant which is upslope from the central line.[9]
- *The distance should be measured at right angles to the central line* (see *Figure 13.8*). If the rope is not at right angles to the central line, a plant that is actually in the plot may be measured as out. This concept of right angles is also useful if the enumerator is unsure about which plot a plant is in.

[8] *Chapter 8 describes how the inventory team determines the methods to use to gather this information.*

[9] *Appendix H describes how to measure horizontal distance.*

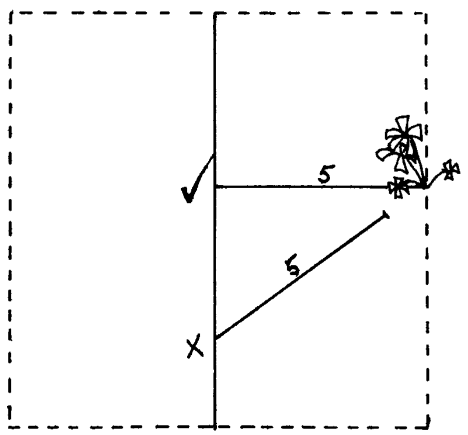


Figure 13.8. When measuring to see if a plant is within 5 metres of the plot's centre line make sure that the measurement is taken at right angles to the centre line or else the plant may appear to be outside the plot.

- *The plant should be measured at its centre point*. A plant on the edge of the plot is inside the plot if the centre point of the plant lies within the plot (see *Figure 13.9*). If the plant is a tree, the centre point is approximately in the centre of the trunk. If it is a clump, the enumerator must estimate where the approximate centre point of the clump is. With rattans, whose long winding stems may grow quite far from the clump, the enumerator must measure from the source of the stem (i.e. the centre point of the clump).

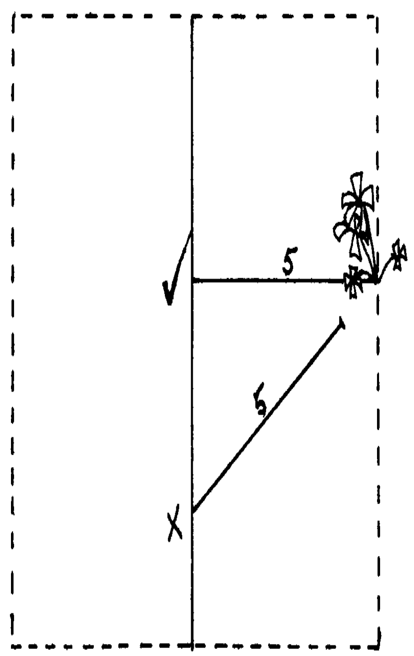


Figure 13.9. When determining whether a plant lies in or out of a plot, you must measure to the centre point of the plant. This is true for all plants, whether a. a tree, b. a clump, or c. a climbing palm.

Sometimes there are few, if any, people who can identify all species. For example, it may be that only men can identify timber species, and only women can identify species used for cooking. Or, only some individuals in the village may have the ability to identify and find medicinal species. Each inventory work team must have all of the specialists necessary to cover the range of species that have been chosen for enumeration.

Resource species that are small in size (i.e. herbs, ferns, etc.) pose particular problems for enumerators. One problem is that if the majority of resource species included in the inventory are large in size, those few that are small in size may often be overlooked. Another problem is that if these small resource species are very numerous, it may take a great deal of time to count them all in each 10 metre x 10 metre subplot. Some possible solutions include:

- Assigning one specialist enumerator the task of looking for the small plants, as described above.
- Taking the time to count the small resource species carefully in every 25th subplot rather than try to do so in all of the subplots in each plot.[10]

13.4. Recorder: record the information on a data form

The recorder walks up the central line of the plot writing the information called out by the two enumerators on the data form. The recorder should also talk to the enumerators, asking them for information and reminding them of what they should be looking for. The recorder might also gather and record information on the environment.

The recorder should follow the guidelines below for good data recording:

- Fill in the data form clearly, so that other people can read and understand it. Do not crowd the data. Make sure to print, not write, the data.
- Write using a pencil. A pencil will not run under wet conditions, whereas many pens will run if the page is wet.
- Never erase a number or write a number on top of another number. Instead, cross out the wrong number by drawing one line through it and write the correct number above it.
- Fill in all sections of the data form completely, so that there are no missing data. If the recorder leaves spaces to be filled in later he or she may make mistakes and fill them in incorrectly.

Where to next

Care must be taken to do the inventory work properly, or the quality of the inventory data will be poor. One way of monitoring the inventory work, and of improving it if necessary, is called checking the inventory work. The next chapter will describe when and how to conduct these checks.

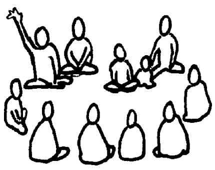
[10] *Appendix L describes how to enumerate the youngest age classes of plants in every 25th subplot. You can use the same procedure to enumerate plants that are small in size.*

14

Check the Inventory Work

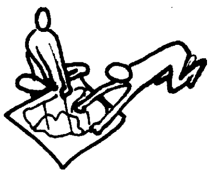
Where you are in the participatory inventory method:

I Decision making in the village



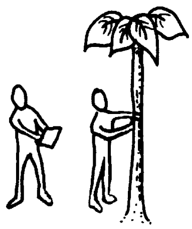
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



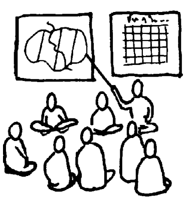
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

14.1. Plan checks of the inventory work,

14.2. Conduct the checks, and

14.3. Assess the checks.

Skills/information required

- None

Materials required

For each checking team:

- A compass, a parang, one 10 metre nylon rope, two 5 metre nylon ropes, pencils, erasers, data book or data sheets with clipboard, two diameter tapes (optional, depending upon method of plant measurement), metre tape (optional, depending upon method of plant measurement), ruler (optional, depending upon method of plant measurement), clinometer (optional, depending upon method of plant measurement or plot establishment), lunch, drinking water, raincoats or small tarps in case of rain and small packs for carrying the equipment.

Introduction

Occasionally, each inventory work team should check some of their plots and compare the two sets of data. This is called checking the inventory work.

Despite the best intentions, the accuracy of inventory data tends to drop over time, especially if the team experiences fatigue, difficult terrain or bad weather. Checks can prevent this drop, as teams that are aware that their plots might be checked often keep their quality higher than those that are not. Checks can also give dropping accuracy levels a boost, as they provide the team with a chance to assess the quality of their data and discuss how it can be improved. For these reasons it is a standard procedure in all inventories to conduct checks; they are not done out of a sense of mistrust.

This chapter discusses how to plan, conduct and assess checks of your inventory work.

14.1. Plan checks of the inventory work

14.1.1. Set the check objectives

The inventory team as a whole should set the check objectives. This is done by setting the limit to the number of errors or inaccuracies between two sets of data, that they can accept. The team will need to define what constitutes an error and what does not, as well as the action to be taken if the limit is exceeded. *Example 14.1* describes the check limits set by the inventory team in one village, and the actions they decided to take if limits were surpassed.

Example 14.1. Setting the check objectives

In one inventory, the inventory team as a whole agreed that there should not be more than 1 error amongst every 10 items of data collected. They defined errors as follows:

- An incorrect plot number,
- A compass bearing which is more than 15 degrees off,
- A horizontal distance between subplot stakes being inaccurate by 1 metre or more,
- A plant that is counted by one team but not by another, and
- More than a 10 cm difference between measurements of diameter at breast height.

The team decided that if the number of errors of a particular inventory work team were higher than the limit that they had set, they would have to have an additional half-day of training.

14.1.2. Schedule the checks

The inventory team should have scheduled time for checks when planning each working unit schedule, according to the guidelines listed below:[1]

- *On the second day of the inventory, checks should be done of all of the first day's work.* This will allow many of the sources of errors to be identified and improved at the start of the inventory.
- *There should be more checks towards the start of the inventory.* As teams become more experienced and accuracy starts to improve, there should be less need for checks.
- *At least 10% of the plots should be checked, so for every ten days of work there will need to be at least one day of checks.* This level of checking is standard in inventories.
- *At least some of the checks should be done on the last day of work in each of the working units.* Sections of line should be selected randomly for checking. *Box 7.2* describes how to make a truly random selection. At least some of the checks should be done on the last day, so that all of the work has some chance of being checked.

[1] *Chapter 10 discusses how to include the checks in the working unit schedules.*

14.2. Conduct the checks

It is best if a new and independent person joins the inventory work team to conduct the checks. One way of doing this is to switch the inventory work team leaders around on check days. This will have the added benefit of increasing consistency between inventory work teams.

The inventory work team members should not see the original data before they make their checks, as this may influence their work. Only the inventory work team leader should hold the original data.

When a check is made, the following could be remeasured:

- The numbering of subplots and plots,
- The horizontal distance between plot number sticks,
- The compass bearing between plot number sticks,
- The number of plants of each resource category, and
- The information gathered about the plants and environment.

When checking a plot, the path will already have been cleared and the plot number sticks will have been cut, tagged and set in position. Thus, the roles of the team members can change slightly. One formation is:

- Two people check the plot numbering, orientation and distance,
- Three people enumerate the plants in the plot, and
- One person records the check data.

This arrangement should ensure extra care with enumeration. This is because three people are more likely than two people to see all of the plants in the plot.

There are two options for data forms to use in checks:

1. Use the same data forms as are used for the inventory work. However, the recorder should make sure to write 'CHECK' on the top of each page.
2. Design special data forms for recording check data. These should be similar to the original data forms but might include:
   - Space for recording plot number, orientation and distance,
   - Space beside the check data for adding the original data later, and
   - Space at the bottom of each page for a tally of errors and a tally of correct observations.

Immediately after checking a subplot, the inventory work team leader should look at the original data and tell the rest of the team whether there have been any errors. This gives the team the chance to determine the cause of the error, and confirm which of the sets of data is correct.

14.3. Assess the checks

Later, on the evening of the check day, members of the inventory team should compare the two data sets and count and classify the errors. The entire inventory team should discuss these results at the evening meeting.

When they set the inventory objectives, the inventory team should have set a limit to the number of errors that could be made in a given check. If the number of errors found in a check are greater than this limit, then the inventory team will have to follow the predetermined action that was to be taken if the limit was exceeded.

If desired, the check results can also be discussed in the final inventory report.[2] The report might include a display of how many errors of each type have been made, so that readers of the report can judge the quality of the data for themselves.

Where to next

As well as conducting and checking the inventory work, there is one additional and optional activity for the inventory team to do in the forest. This is to collect botanical specimens of the resources that have been included in the inventory. This step is described in the next chapter.

---

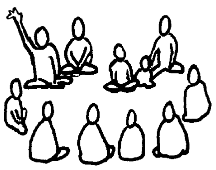
2 *Chapter 18 discusses options for writing the final report.*

15

Collect Botanical Specimens

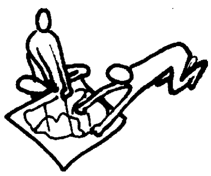
Where you are in the participatory inventory method:

I Decision making in the village



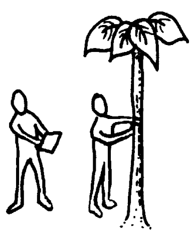
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



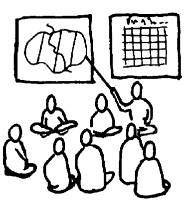
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

15.1. Collect the botanical specimens in the forest, and

15.2. Preserve the botanical specimens in the camp or village.

Skills/information required

The skills or background information that you will require can be found in:

- *Appendix N*. Botanical specimen forms

Materials required

- For collecting in the forest: Copies of the botanical specimen forms, metre tape, notebook, pens, pencils, labels, rafia string, parang or knife, newspaper, rice sacks or plastic bags, cardboard (optional) and field press (optional).
- For preserving in the camp or village: Parang or knife, newspaper, cardboard, field press, methylated spirits, rafia string, tape and strong plastic bags.

Introduction

In addition to conducting and checking the inventory work, the inventory team may choose to collect botanical specimens of the resource species that have been included in the inventory. Botanical specimens are collections of a plant's leaves and stems, and sometimes its flowers, fruit, bark, wood and roots. A specimen is collected and preserved so that it can be taken to a herbarium, a place that contains a large collection of botanical specimens. Here, the specimen can be compared to other specimens, or shown to the people who work at the herbarium, in order to identify the plant's botanical name in Latin. The Latin name is recognised by people around the world, unlike the local name, which may only be known to people in a few villages.

Knowing the Latin name of their plants will therefore greatly improve the village's ability to communicate the information gathered from the inventory to outsiders. Another reason for identifying and using the Latin name of a plant species is that one Latin name is always linked to one distinct species, whereas with local names, some species do not have a local name, some local names apply to more than one species, or more than one local name may be used for the same species.

At the same time, it will not always be necessary or advisable to collect botanical specimens for every participatory inventory. If the results of the inventory are meant for the villagers alone, they will not need to know the botanical names of the plants. Even when the results of the inventory are meant for outsiders, it may not be necessary to take a botanical collection if the resource species is widespread and its name in Indonesian is widely known (e.g. rambutan, durian or langsat fruit trees). Also, villagers should be cautious about taking botanical collections of potentially valuable medicinal plants, as outsiders may use this information for their own commercial benefit.

15.1. Collect the botanical specimens in the forest

15.1.1. Before collecting the botanical specimens

Consult with villagers

Before taking a botanical specimen, you must check whether someone owns the plant, and ask permission from the owner. The plant you want to collect may be cultivated or managed, or have social or cultural significance. Make sure all villagers agree that you may take the specimen.

Timing

It is best to collect botanical specimens when the plant is in flower or fruit. It is even worth collecting dead flowering parts of the plant if there is no fresh material available. If a plant has neither flower nor fruit, but only leaf, stem and root specimens it is referred to as a 'sterile specimen'. This might be more difficult to identify in a herbarium because there is less information by which to recognise the plant. You can collect vegetative material during one collection trip and return later to the same plant to collect the fruit or flowers.

15.1.2. Writing notes in the field

Each botanical specimen should be complemented by some basic information. This information can be written in a:

- *Notebook*. This should be robust (preferably hard bound) and pocket sized, or
- *Botanical specimen form*. Examples of these can be found in *Appendix N*.

For all specimens, information should include:

- The collector's name (or names, if there is more than one collector),
- The date the collection was taken,
- The specimen's collection number (this is explained more below in *Section 15.1.4*),
- The botanical (Latin) name. This can be filled in later if not known at the time of collection,
- The local name and other local information. Local information might include the meaning of the local name, what the villagers use the plant for, what cultural significance the plant has, and so on. It is a good idea to include the name of the informant so the information may be checked later, if necessary,
- The location where the specimen was taken. This information should enable someone else to return to the same area and should include the district, sub-district, nearest village, and distance and direction from nearest village. If at all possible it should include the latitude and longitude.
- Environmental information about the location. This might include the altitude, the forest type, soil colour and composition, topography, whether the plant was exposed to sun or shade, and what direction the slope was facing.

You should try to record all characteristics of a plant that might not be apparent in the preserved specimen. You may find it easier to record some of this information by drawing a rough sketch of the plant (e.g. trunk shape or leaf type). The information to record about each plant depends upon whether it is a:

- Tree, climber, shrub and herb,
- Palm (including rattan), or
- Bamboo.

The remainder of this section describes the information that is needed for each of the above categories.

Writing notes for trees, climbers, shrubs and herbs

Figure N.1 shows an example of a botanical specimen form for trees, climbers, shrubs and herbs. The information required for this form includes:

- A description of the plant's general appearance. This includes whether it is a tree, shrub, climber or herb, whether it is single stemmed or clumped, the shape of the trunk (if a tree), the height and the diameter,
- A sketch of the plant's general appearance, and
- A description of the plant's parts, including:
    - *Outer and inner bark*: colour, consistency and smell of the outer and inner bark, and whether they change colour after being exposed to air,
    - *Sap or latex*: colour, consistency and smell of the sap or latex, and whether it changes colour after being exposed to air,
    - *Wood*: hardness, colour and the smell produced from a cut in the trunk,
    - *Leaf type*: whether simple, compound pinnate or compound palmate (see *Figure 15.1*), if compound a sketch of the pattern of the leaflets (this information will not be necessary if a proper collection of the whole leaf is taken),
    - *Leaf*: colour, consistency and smell (crush the leaves in your hands before smelling),
    - *Flower*: colour and smell,
    - *Fruit*: colour, consistency, smell and taste (check first with villagers that it is safe to taste the fruit), and
    - *Roots* (any special characteristics).

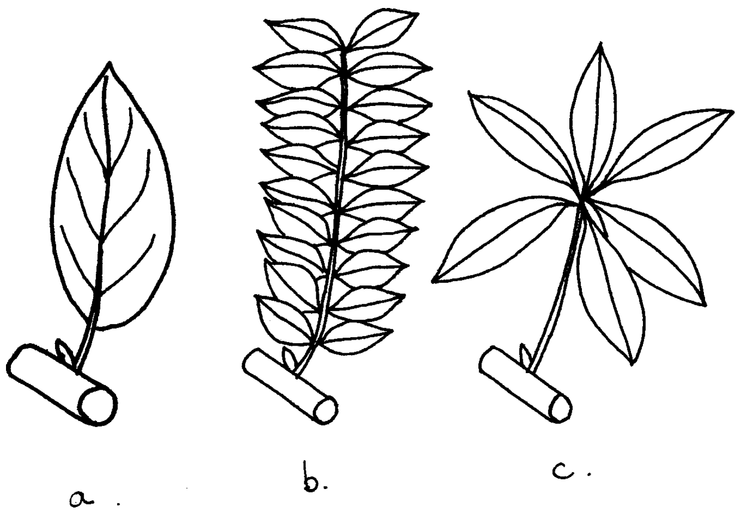


Figure 15.1. Leaf types can be a) simple, b) compound pinnate, and c) compound palmate.

Writing notes for palms (including rattans)

Figure N.2 shows an example of a botanical specimen form for palms. The information required includes:

- A description of the plant's general appearance (whether a palm is single stemmed or clumped, and if clumped whether the stems are close together or spread out), and
- A sketch of the general appearance of the plant, and
- A description of the plant's parts, including:
  - *Stem*: the height of the stem (length if a rattan stem), the internode length, and the diameter of the stem (the diameter with and without leaf sheaths if a rattan stem) (see *Figure 15.2*),
  - *Leaf*: the petiole length and midrib length for pinnate leaves or the petiole length alone for palmate leaves (see *Figure 15.3*),
  - *Leaflets*: the number of leaflets on one side of the leaf and whether they are arranged regularly or in groups (and if in groups, how many leaflets per group),
  - *Flowers/fruit*: colour, smell and taste, and
  - *Roots*: any distinctive characteristics.

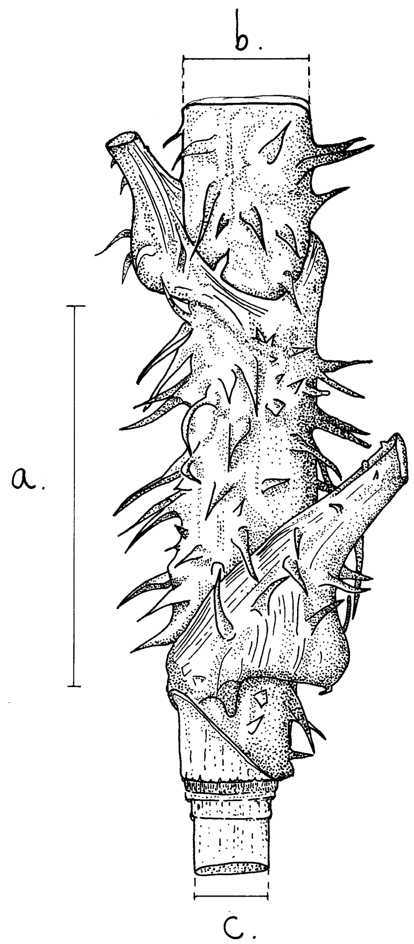


Figure 15.2. When taking specimens of rattans you will need to record: a) the internode length, b) the diameter of the stem including the leaf sheaths, and c) the diameter of the stem not including the leaf sheaths.

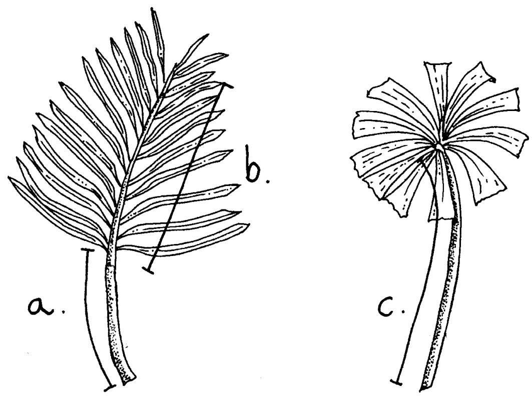


Figure 15.3. **With pinnate palms you will need to measure and record: a) the length of the petiole and b) the length of the midrib. For palmate palms you will need to measure: c) the length of the petiole alone, as there is no midrib.**

Writing notes for bamboo

Figure N.3 shows an example of a botanical form for bamboo. The information required includes:

- A description of the clump, including whether the clump is solitary or one of many, and the diameter of the clump,
- A description of the largest accessible stem (called the culm), including the height of the culm, the length and diameter of the fifth internode from the base of the culm (see *Figure 15.4*), and the length of the longest internode and its number from the base of the culm.

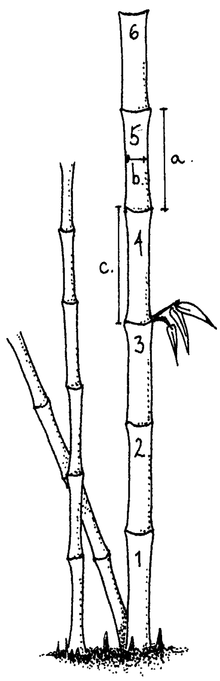


Figure 15.4. **With bamboo you will need to measure and record: a) the length and b) the diameter of the fifth internode from the base of the culm, and c) the length of the longest internode on the stem.**

15.1.3. Making botanical specimens

You should collect enough material to make two sets of each specimen. This is in case one set is damaged, destroyed or given away.

Carefully remove the specimen from the plant using whatever cutting tools are available. Limit the size of the specimen so that it can later be flattened in a standard sized piece of newspaper. Tag the specimen immediately with a unique collection number (numbering and labelling will be described later). Loosely wrap the specimen in newspaper and place it in a large rice sack or plastic bag.

If the parts of the plant are delicate and likely to wilt before they can be preserved, use a field press to take the collection. A field press consists of two lightweight boards containing paper folders or pieces of newspaper (see *Figure 15.5*). After collecting the specimen, place it in the field press and bind it tightly using string or straps. This will protect the collection from wilting.

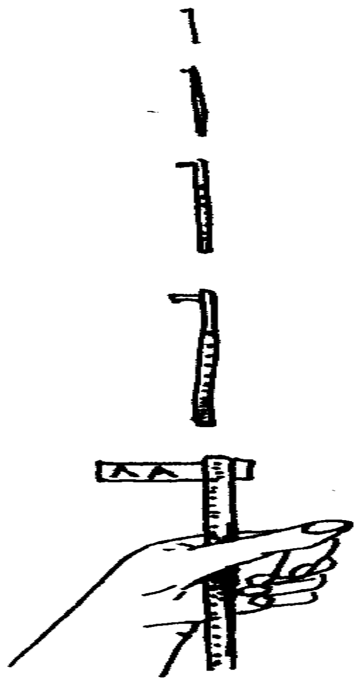


Figure 15.5. If you are collecting plants which are likely to wilt fast you will need to put the specimen into a field press.

Making botanical specimens of trees, climbers, shrubs and herbs

The botanical specimen form for trees, climbers, shrubs and herbs (*Figure N.1*) contains a check-list of plant parts to collect. These parts include leaves, stem, flowers, fruit and roots.

The specimens should try to represent all the most important and obvious features of a plant. This includes:

- Collecting young, as well as older, leaves,
- Cutting a branch to represent as much of the branching pattern as is possible (see *Figure 15.6*),

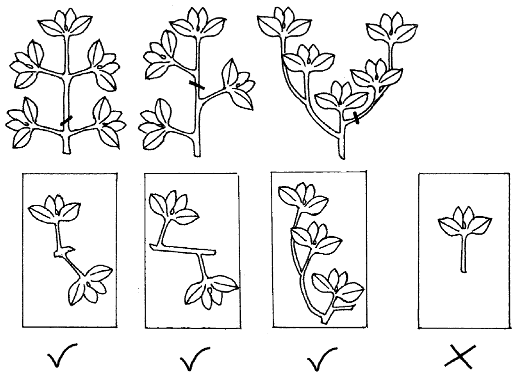


Figure 15.6. Specimens should try to represent different types of branching pattern as clearly as possible.

- Detaching any flowers or fruits growing on the trunk or stem so that they are still attached to a small area of bark, and
- Collecting a bark specimen from trees. A bark specimen is a chunk of wood cut from the tree that contains the bark and wood (see *Figure 15.7*).

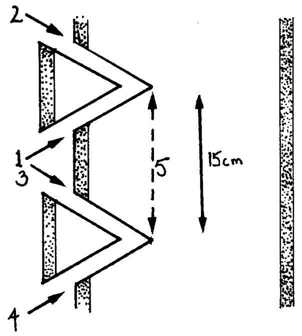


Figure 15.7. Using a parang or saw follow the incisions 1-5 to take a good bark specimen.

Trees can be very difficult to collect from because the material needed for the collection is in the canopy. This will mean that in order to take the collection:

- The tree may be climbed to collect a specimen leaf or fruit,
- A nearby tree may be climbed and a specimen may be collected from the tree under study, if it can be reached,
- Specimens may be shot down with catapults or rocks or hooked down with 5-6 m saplings, or
- The tree may be felled to collect a specimen.

Making botanical specimens of palms (including rattans)

Palm leaves and stems are often bulky, and many palm stems are spiny, making it a challenge to collect a botanical specimen. The botanical specimen form for palms (*Figure N.2*) contains a checklist of plant parts to collect. These parts include:

- *Stem*. With small palms collect a length of stem. With large palms take a specimen of the outer bark as if for a regular tree bark specimen.
- *Leaf sheath*. This is the part that wraps around the stem of the palm and attaches to the base of the leaf (see *Figure 15.8*). Collect the whole leaf sheath if it is small enough to be packaged in a standard sized piece of newspaper. If the leaf sheath is large, collect the base and apex of the sheath. With rattans, take the leaf sheath specimen as a section of the stem.

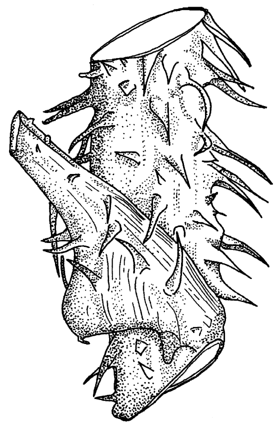


Figure 15.8. For identifying palms it is useful to collect the leaf sheath.

- *Leaf*. Collect the whole leaf if it is small. If the leaf is large collect representative segments of the leaf as described below:
  - *Petiole*. This is the stalk that attaches the leaf to the stem. If this is short collect the whole petiole. If long collect portions that represent any change in form along its length.
  - *For pinnate leaves* (see *Figure 15.3*): Collect three sections of the leaf, all approximately the same size. These sections should be the apex or upper portion of the leaf, the middle section, which reveals the size, shape and distribution of the leaflets, and the base of the leaf, including its attachment to the stem (see *Figure 15.9*). The leaflets can be removed from one side of the specimen.

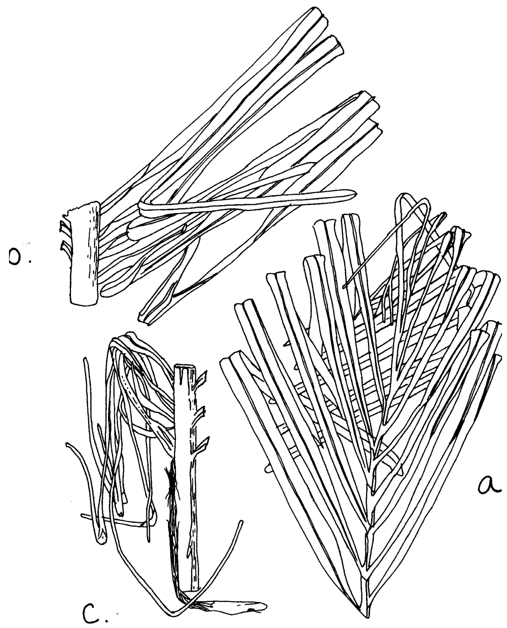


Figure 15.9. With pinnate palm leaves collect three sections of the same size. These should be the: a. upper, b. middle, and c. base sections of the leaf. The leaflets can be removed from one side of the specimen.

- *For palmate leaves* (see *Figure 15.3*): Collect the hastula, or the tip of the petiole where the leaflets are attached (see *Figure 15.10*). Keep some leaflets attached, although the rest can be removed from the specimen.

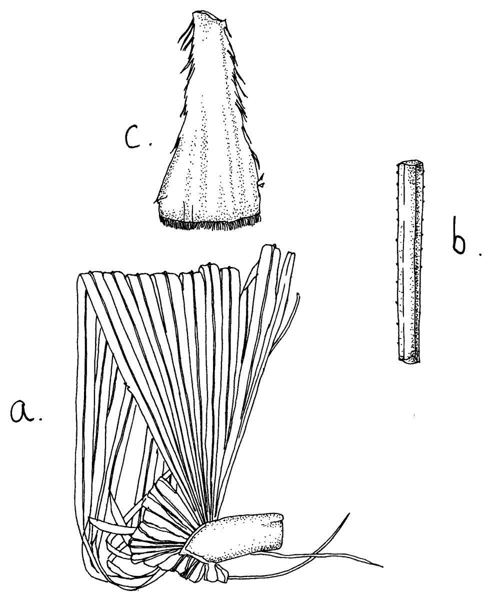


Figure 15.10. With palmate leaves collect the: a) hastula, or the tip of the petiole where the leaflets are attached, b) part of the leaf stem, and c. the leaf sheath. You should keep some leaflets attached to the hastula.

- *Climbing whip of rattans*. This is called the cirrus if it grows from the end of a leaf or the flagellum if it grows from the leaf sheath on the stem (see *Figure 15.11*). Collect it as part of a leaf specimen (if it is a cirrus) or a leaf sheath specimen (if it is a flagellum). Coil the whip into a bundle, and tie the bundle with string.

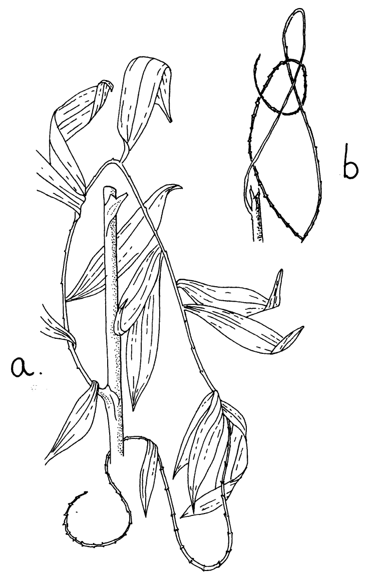


Figure 15.11. The climbing whip of rattans called the a) cirrus if it grows from the end of a leaf, or b) flagellum if it grows from the leaf sheath on the stem.

- *Inflorescence/Infructescence*. This is a cluster of flowers or fruits that grows from the stem (see *Figure 15.12*). Collect the whole inflorescence if it is not too large. If it is large, collect the part where the inflorescence joins the stem, as well as other parts that represent any change in form. Even a fallen, old or dried inflorescence can be useful.

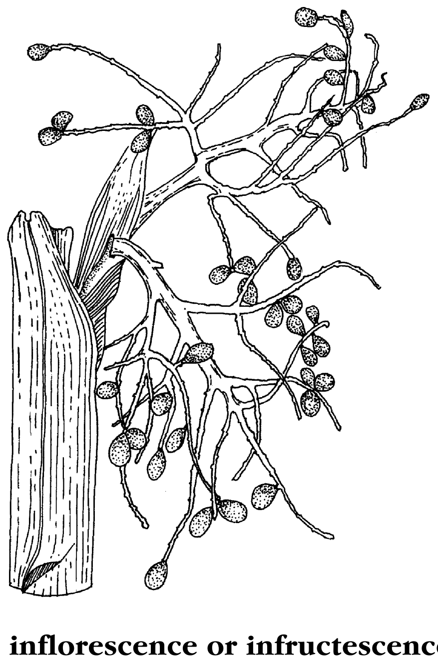


Figure 15.12. The inflorescence or infructescence is the cluster of flowers or fruit that grow from the leaf sheath of a palm.

Making botanical specimens of bamboos

It is often very difficult to collect fertile material because bamboos usually flower only once in their lifetime after many years of growth. Because of this, ways of identifying the different types of bamboo from the other parts of the plant have been developed. Therefore it is not essential to collect bamboo specimens when they are in flower.

The botanical specimen form for bamboo (see *Figure N.3*) contains a checklist for plant parts to collect. These include the:

- *Culm nodes and internodes*. The culm is the name for the stem of a bamboo. A node is the bump between the sections of the bamboo. An internode is the length of stem between the nodes (see *Figure 15.13a and b*). Collect a segment of mature culm including the fourth and fifth nodes above ground which have the fifth internode between them.

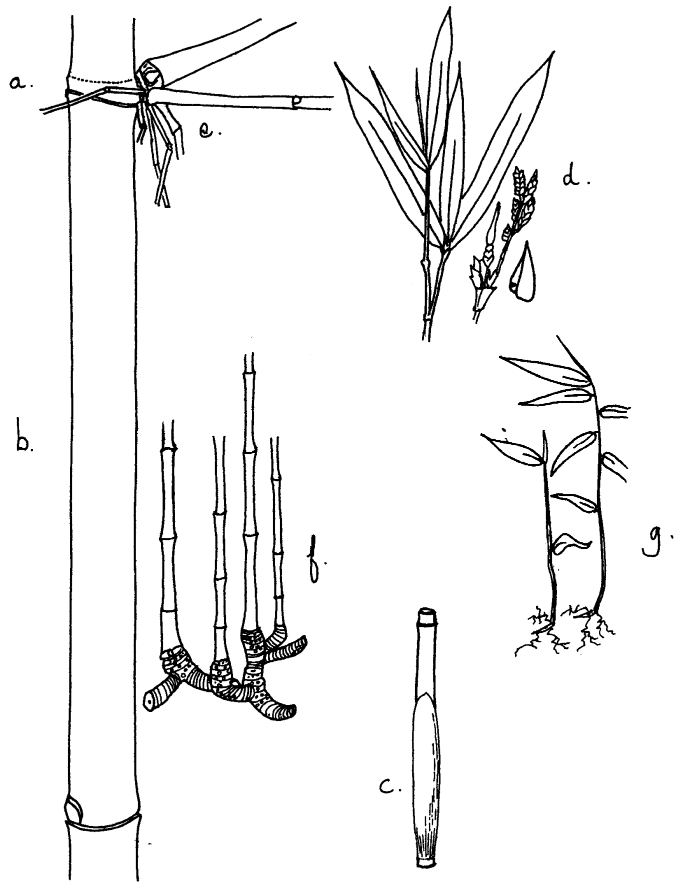


Figure 15.13. The important identifying features of a bamboo include a) the culm nodes, b) the culm internodes c) the culm sheath, d) leafy twigs, e) the branch complement, f) rhizome and g) seedlings (if available).

- *Culm sheath*. This is the papery covering found around the separate nodes on the culm of the bamboo (*Figure 15.13c*). It is very important for the identification of bamboo. Collect at least two of these sheaths, if possible from the fifth internode of two different culms. If the sheath is brittle, wrap it in paper and put it somewhere protected. If a sheath is still attached to the culm, collect the culm and sheath together as a single specimen.
- *Leafy twigs*. Collect a range of large and small leaves (*Figure 15.13d*).

- *Branch complement*. This is the point where the branches which the leaves are attached to join the culm (see *Figure 15.13e*). Collect about 15 centimetres of the culm with the branch complement still attached, if possible from the fifth internode of two different culms. If the specimen is large, cut a branch 5 centimetres from the culm and discard the leaves. Split the culm and discard the half not carrying the branch complement.
- *Rhizome*. This is the root of the bamboo (see *Figure 15.13f*).

15.1.4. Numbering and labelling the botanical specimens

Give each plant its own unique collection number. Seedlings should be given a separate collection number from the supposed parent plant, but there should be a cross-reference in the notes pointing to the relationship between the two specimens. Write this number on a label and attach the label to all the separate pieces of the plant that have been collected. Numbering specimens ensures that collections of different plants do not become mixed and that any pieces of the plant that might fall out of their sack or bag can be returned to their proper set.

The numbering system is best kept simple, as there is little benefit in making a complicated series of numbers. It is important that the same number is not used more than once as this will lead to confusion. In addition to numbers is it usual to include the collector's (or village's) initials on the label (e.g. the Long Tebulo team might decide to label their specimens 'LT 1', 'LT 2', etc). The numbers on the plant labels should be written in pencil or in ink which is not soluble in either water or methylated spirits. Write the same number on the outside of the bag in which each specimen is placed.

15.2. Preserve the botanical specimens

Fresh plant material will very quickly become wilted or mouldy in a humid climate. Thus, almost all botanical specimens need to be preserved in some way. The two most common ways of preserving specimens is to:

- Preserve the specimens in methylated spirits, or
- Press the specimens. These are described below.

15.2.1. Preserving the specimens in methylated spirits

The advantages of preserving specimens in methylated spirits are:

- The specimens will not become mouldy in humid conditions,
- You will not need to dry the specimens until a later date, which will save time in the forest,
- You require little equipment in the forest (only methylated spirits, newspaper, cardboard supports and strong polythene bags), and
- You can preserve plant specimens that are large or awkward in size or shape, such as bark, palm or bamboo specimens. These specimens take a long time to dry, which can be inconvenient in the forest.

The disadvantages of methylated spirits collection are:

- Specimens preserved in methylated spirits are heavy and bulky compared to pressed specimens,
- Once dried, specimens become brittle and black or brownish in colour, and
- Flowers can lose their colour altogether.

The way to preserve specimens in methylated spirits is to:

1. Cut the specimen with a pair of scissors or parang until it is a manageable size. Remember to check that the numbered label attached to the specimen is written in pencil.
2. Wrap the specimen in newspaper. If there are thorns or spines use extra layers of newspaper.
3. Carefully place the wrapped specimen into a plastic bag. The bag should have no holes in it and, if available, have a sealable mouth.
4. Pour in methylated spirits, so that the newspaper becomes damp.
5. Seal the bag swiftly by pressing out the air and closing the mouth of the bag. If sealable bags are not available fold over the mouth of the bag several times and tape it shut. Write the collection number on the outside of the bag.
6. Place this bag in a larger bag. Place cardboard supports between specimens or else they may sag because of the weight of the spirit.
7. When it is time to dry the specimens, press and dry them as described below.

Palm specimens should be preserved in methylated spirits because they are usually very bulky and it will take a long time to dry them in the field. However, they are difficult to preserve in methylated spirits because their spines can puncture the plastic bag in which the specimen is stored. One way to preserve palm specimens in methylated spirits is described in *Box 15.1*.

Box 15.1. Preserving palm specimens in methylated spirits

With palms, begin by laying down four double thickness of newspaper flattened out (see *Figure 15.14*). This becomes the wrapping for the finished bundle. Begin with flat leaf fragments, placing them in double or single folds of newspaper, and progress inwards to spiny or bulky fragments in the middle (to prevent puncturing of the plastic bags), followed by less bulky, flatter material at the top.

Tie the bundle up within the four folds of double thickness of newspaper. Put this bundle into a plastic bag, douse it with methylated spirits, press out the air before sealing the mouth of the bag with tape. It may be necessary to make holes in the top end of the newspaper folds to allow methylated spirits to soak to the middle of the bundle. Put the whole package inside a second plastic bag for safety. If well packaged and soaked in methylated spirits, the specimen can be preserved up to five months.

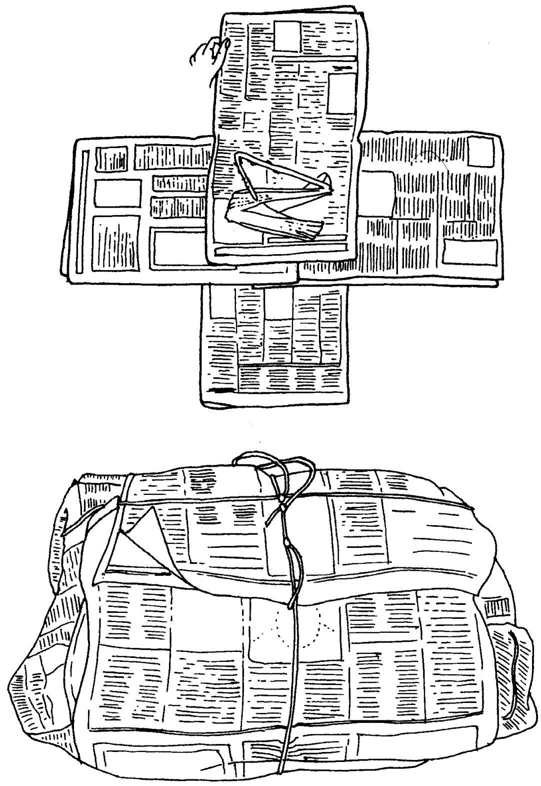


Figure 15.14. In order to preserve rattans and other spiny palms you will need to wrap the palms in several layers of newspaper before storing the parcel in an airtight plastic bag.

15.2.2. Pressing the specimens

The advantages of pressing specimens are:

- Specimens are easily stored and transported when dry, and
- The specimens maintain their colours better and are not brittle as with methylated spirits preserving.

The disadvantages of pressing specimens are:

- It is difficult to dry the specimens in the field because pressing requires a large amount of equipment and is time consuming, and

The way to press specimens is to:

1. Fold or cut the specimens so they can be flattened into a standard sized piece of newspaper (see *Figure 15.15*). *Box 15.2* explains what to do with specimens that are bulky, large or too delicate. Arrange the specimens so that maximum information about the plant is displayed. The best time to arrange them is when the plants are still supple but not too fresh. However, once the plant is dried it is very difficult to re-arrange them. Spread the leaves so that they are not touching one another. Remove some leaves if there are too many. Turn over at least one leaf to expose the under surface.

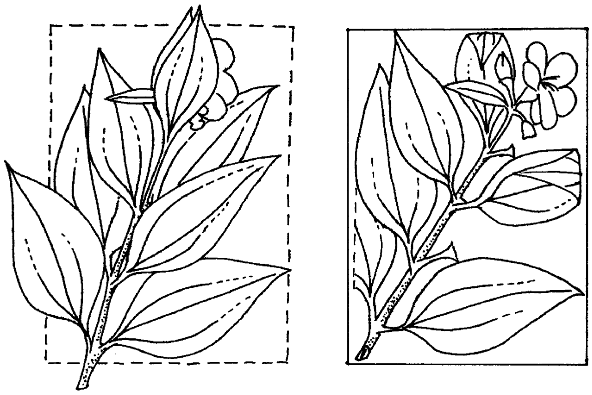


Figure 15.15. Large plant specimens will need to be folded or cut so they can be flattened into a standard sized piece of newspaper.

2. If specimens are sticky because they contain a resin or sap, dry them between pieces of cloth and not newspaper.
3. Place the specimens between two 'press ends' while still inside the newspaper. These are the rigid wooden ends that provide the structure of the press (see *Figure 15.5*). A number of collections can be put between a pair of press ends.
4. Fill the press, alternating layers of specimens in newspaper and cardboard. The cardboard will absorb moisture so the specimens dry faster. They will also help to dry the specimens flat.
5. When the press is full, bind straps or string around the press and tighten them until the press is compressed.
6. Place the press or presses in a vertical position above a fire or gas stove so that the specimens can dry as quickly as possible. It is good if warm air can flow continuously through the press.
7. Keep the presses tightly bound. If the straps or string slacken there is a chance that the specimens might not dry flat inside the press.

Drying by this method can take any time from eighteen hours to four days. You should change and dry the paper in the presses at least once a day, as otherwise the specimens may be attacked by fungi.

Once they are dry, put all of the plant parts from one plant together in one newspaper page. Add a copy of the botanical specimen form (or a sheet of paper with the same information recorded on it) to each collection, so that all the information is now in one place. Store the newspaper pages between cardboard in a flat, dry place. You may want to take or send these collections to a herbarium at a later date.

Box 15.2. Preserving difficult plant parts

Large fruits

If a fruit is large and fleshy it will be difficult to press in the standard way. Cut the fruit in half and remove the flesh and tissue from the specimen. Then, press this half. Fleshy parts may first be sterilised by dipping them in boiling water, although this may change the colour. Another option is to preserve and store the bulky specimen in a jar filled with spirit. Remember to label these parts as you would for other plant parts.

Large leaves and stems

With large leaves or stems it might not possible or practical to present the whole specimen as one piece. One option is to cut it into several parts, each of which should be carefully labelled (see *Figure 15.16*). You can also fold large leaves to fit them into a standard sized newspaper page.

Delicate flowers

Many short-lived flowers will disintegrate soon after collection and should be either pressed or placed in spirits immediately. Sometimes the petals of certain flowers will also stick to the paper in which they are being pressed. Detach some flowers, spread the petals and press each in an individual fold of tissue. Do not open this folder until the flowers are fully dry. Another option is to preserve flowers in bottles of methylated spirits. These bottles should be completely filled with methylated spirits because air bubbles in the bottle may damage the flowers when the bottles are moved. Remember to label.

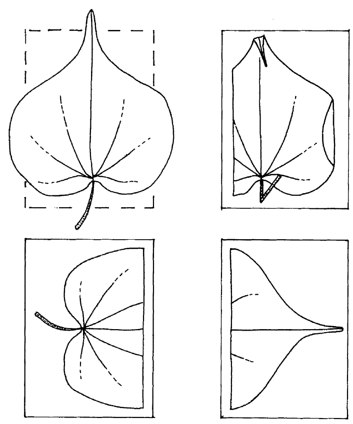


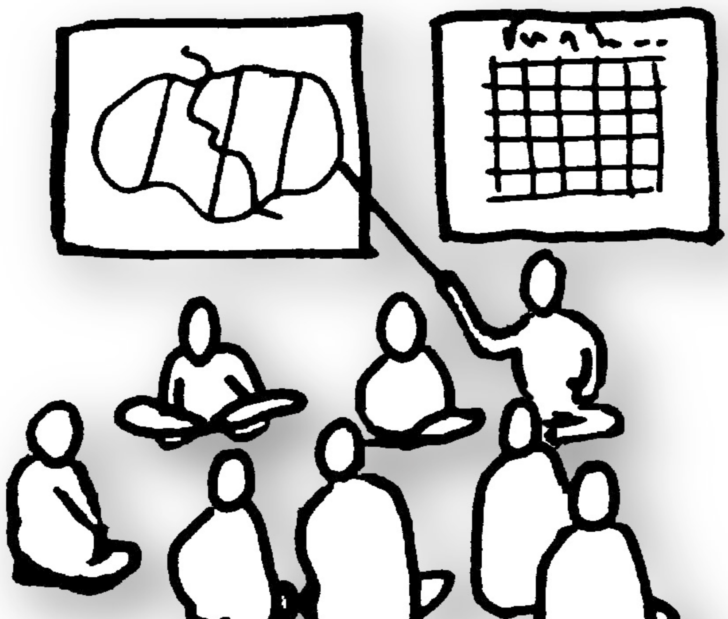
Figure 15.16. Cut leaves or stems too large for a standard sized piece of newspaper into several parts so they fit.

Where to next

After collecting the botanical specimens, the work in the forest is completed. The inventory team should now return to the village to plan how to present the results. The first step in this final stage of the inventory is preparing the final map. The way to make the final map is described in the next chapter.

IV

Presenting the Results of the Inventory

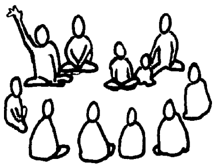


16

Prepare the Final Map(s)

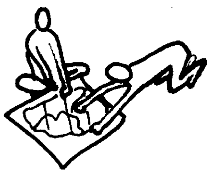
Where you are in the participatory inventory method:

I Decision making in the village



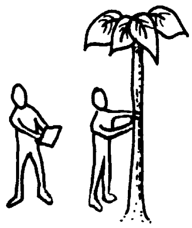
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



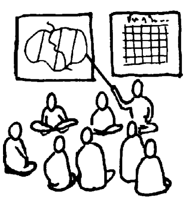
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Locate the inventory lines on the planning map
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the inventory lines in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical samples

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

16.1. Prepare the final base map,

16.2. Prepare the final map(s), and

16.3. Calculate the size of the inventory area and its subdivisions.

Skills/information required

The skills or background information that you will require can be found in:

- Appendix F. Five features of maps

Materials required

- A clean copy of the planning map which was not drawn on during the planning stage, completed inventory data forms, ruler, protractor, pencils, erasers, pencil sharpeners, transparent plastic sheets on which simple grid graph paper has been photocopied, thin nib permanent pens, methylated spirits, a calculator, a notebook, black and coloured thin nib permanent ink pens, correction fluid (Tippex) and a large sized piece of tracing paper (optional).

Introduction

One important step in the final stage of the participatory inventory method is to make an improved version of the planning map called the final base map. This map combines information from the planning map with information that has been gathered while working along the inventory lines. There are two reasons for making a final base map.

- *To use it as a base for making different types of final maps*. One type of final map is an inventory methods map, which shows the inventory area, its subdivisions, and the sampling design (i.e. the location of the inventory lines and possibly areas of 100% enumeration). Another type is an inventory results map, which can be used to show the densities or quantities of resources in different areas.
- *To use it to calculate the size of the inventory area and its subdivisions* (i.e. the smaller areas and forest types within the inventory area). This is essential information for estimating resource quantity.

16.1. Prepare a final base map

A final base map provides an accurate base or skeleton to which additional information can be added to make a final map or maps. This map should show the location of rivers, ridges, roads and other immovable features. Some of this information will come from the original planning map, some from information gathered from the inventory lines.

A final base map must show the location of the inventory area boundary (and its subdivisions) so that you can calculate the size of the inventory area. The inventory area boundary (and subdivision boundaries) may originally have been drawn very approximately on the planning map.[1] Whether approximated or not, you should now check the original boundary using information gathered from the inventory lines, and if necessary, draw the boundary more accurately.

The steps below will help you to make a final base map which combines information from the planning map with information from the inventory lines:

1. Determine what version of the planning map is available to use,
2. Draw the completed inventory lines on the planning map,
3. Draw information from the inventory lines (i.e. information about boundaries, rivers, roads and ridges) on the planning map,
4. Check the information from the inventory lines with the original information on the planning map and make improvements to the map if necessary, and
5. Check final base map with villagers.

Each of these steps is described in more detail below.

16.1.1. Determine what version of the planning map is available to use

You will need to use the planning map to make the final base map. You will find it easier to use an earlier version that has not been drawn on during the planning stages of the inventory (i.e. a planning map without any inventory lines drawn on it). However, you may also use the marked planning map, if this is the only version that you have.

16.1.2. Draw the completed inventory lines on the map

Draw each of the inventory lines that were actually established in the forest on the planning map as follows:

1. Refer to the inventory data forms and the notes of the team leaders to calculate the length of the inventory line in horizontal distance. The total number of plots established on the line should be multiplied by the length of each plot (50 metres) to get the length of the line. Many inventory lines will have been completed in two sections, whenever two teams have gone to a starting point in the middle of the inventory line and worked in opposite directions. If so, calculate the lengths of both sections.
2. Convert this length, or possibly two lengths, from metres on the ground to centimetres on the map using the map's scale.[2]
3. Using a pencil, mark the starting point of the inventory line on the planning map.

---

[1] *Chapter 6 describes drawing the approximate location of the inventory area boundary.*

[2] *Appendix F explains how to convert distances using the map's scale.*

4. Using a protractor, ruler and pencil, draw a straight line on the planning map that passes through the starting point and follows the bearing of the inventory line. This line will represent the inventory line.
5. Using a ruler and pencil, measure and mark the length of the inventory line on the planning map. The length of the line, or possibly the lengths of the two sections of the line, should be measured from the starting point.

The steps described above are illustrated in *Example 16.1*.

Example 16.1. Drawing an actual inventory line on the planning map

---

Members of an inventory team examined their inventory data forms and determined that:

- 22 plots were established at a bearing of 260° from the starting point of one inventory line, and
- 5 plots were initially established at a bearing of 80° (in the opposite direction). The line then crossed an area of swidden rice fields (this area had been excluded from the inventory area) for a distance of 450 metres, followed by another 21 plots.

The inventory team calculated the lengths of these two sections of line. These lengths were:

- 1100 metres (22 x 50 = 1100) for the line with the bearing of 260°, and
- 1750 metres ((5 x 50) + 450 + (21 x 50) = 1750) for the line with the bearing of 80°.

The scale of the planning map was 1:25 000. Therefore, the lengths on the map of the two segments were:

- 4.4 centimetres (1100/250 = 4.4), and
- 7.0 centimetres (1750/250 = 7.0).

These were measured on the map from the starting point, at the appropriate bearings (see *Figure 16.1*).

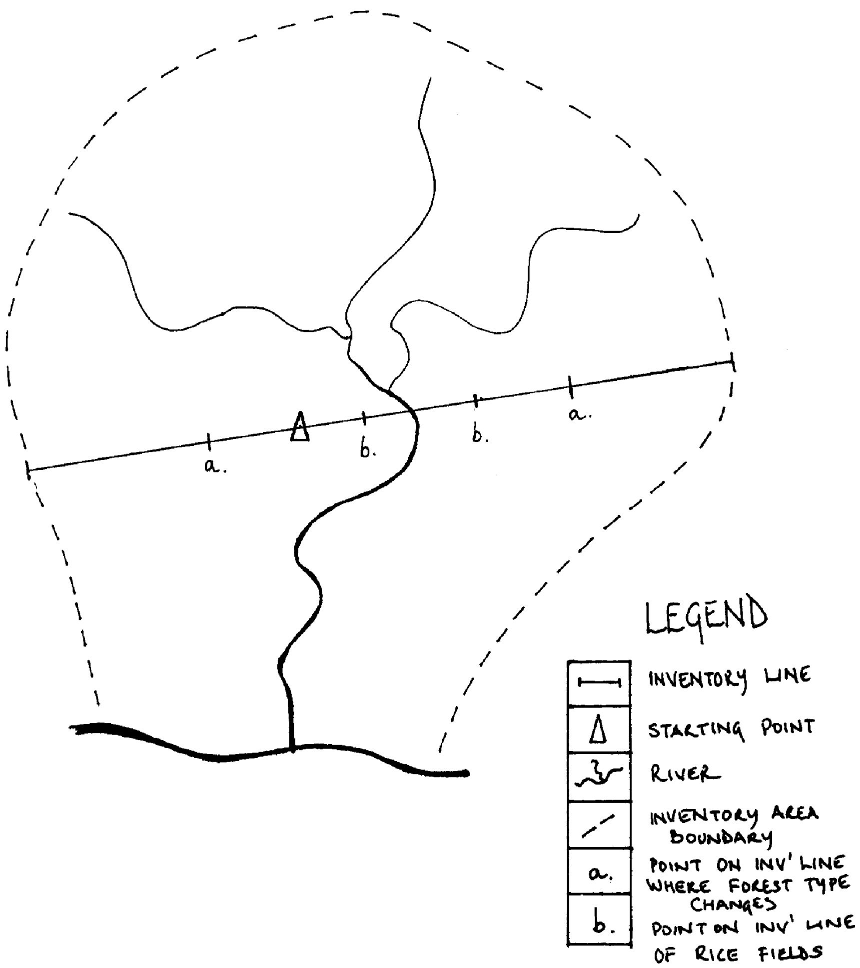


Figure 16.1. Drawing information from the inventory work in the forest onto a final map.

16.1.3. Draw information from the inventory lines on the map

Mark the following information in pencil at the appropriate points along each inventory line:

- The location of the inventory area boundary at the two end points of the inventory line,
- The points where other boundaries cross the inventory line. These boundaries might be of smaller areas, forest types or areas that were excluded from the inventory, and
- The points where ridges, rivers, roads and features of importance cross the inventory line.

The steps to follow in marking this information on the map are as follows:

1. Refer to the inventory data forms to find out the plot number and subplot letter at which the inventory line crosses the boundary or feature,
2. Calculate the distance in metres from the starting point to this subplot,
3. Convert this distance from metres on the ground to centimetres on the map using the scale of the map, and
4. Measure and mark this distance on the inventory line on the map.

The steps described above are illustrated in *Example 16.2*.

Example 16.2. Drawing information from the inventory lines on the map

In the working unit in *Example 16.1*, a subdivision boundary between secondary forest and primary forest was recorded at:

- Subplot 7c on the first line segment, and
- Subplot 13e on the second line segment.

The inventory team members calculated the distance of these points from the starting point as follows:

- Subplot 8c is 38 subplots from the starting point. This number of subplots is multiplied by the length of each subplot (10 metres) to get a distance from the starting point of 380 metres (38 x 10 = 380).
- Subplot 13e is 65 subplots from the starting point. 65 subplots is multiplied by 10 metres to get a distance of 650 metres, to which the 450 metres that was walked through by the inventory team is added to get a total distance of 1100 metres ((65 x 10) + 450 = 1100).

When converted to centimetres on the map, the locations of the subdivision boundary were found to be:

- 1.5 centimetres (380/250 = 1.5), and
- 4.4 centimetres (1100/250 = 4.4) from the starting point.

These locations were measured and marked on the map (see *Figure 16.1*).

16.1.4. Check the information from the inventory lines with the original information on the planning map and make improvements to map, if necessary

Compare the points marking where the boundaries and other features were found on the inventory lines to the same features originally drawn on the planning map. If there are large differences between the two sets of information, judge for yourself which is more reliable. Remember that there is potential for error in both the information gathered on the inventory lines and that found on the original planning map.

If you think the data from the inventory lines is more reliable, then use it to improve your map. The data will give you a series of points on the inventory lines representing the locations where any given boundary or feature crosses the lines (see *Figure 16.2*). Join these points together to build up a picture of the location of the boundary and other features on the map. The boundary or feature may not be very straight between these points, especially if the distance between inventory lines is large. The shape of the boundary or feature between these points can be more accurately approximated by using its shape on the villagers' sketch maps as a guide, or by asking villagers to draw it.

Remove inaccurate information from the planning map using correction fluid (Tippex), and produce a final base map by photocopying this corrected map. Alternatively, trace the information that you want from the planning map to a final base map, leaving the inaccurate information behind. Tracing is recommended if you are working from a much used and marked version of the planning map.

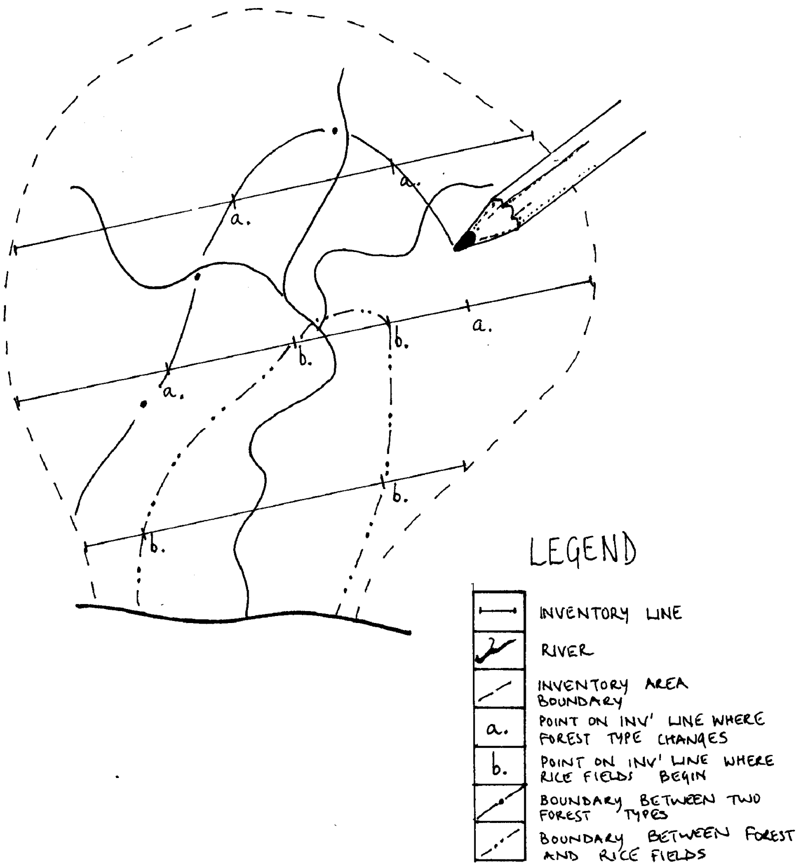


Figure 16.2. Points along the inventory line representing the locations of a given boundary or feature can be joined together to build up a picture of the boundary throughout the map

16.1.5. Check final base map with villagers

Once you have produced the final base map, show it to a number of villagers with a good knowledge of the inventory area. These people should make a final check of the locations of boundaries, ridges, rivers and roads.

16.2. Prepare the final map(s)

The final base map can be used to make several different types of final maps. These include:

- An inventory methods map, and
- An inventory results map.

The different types of final maps are described below.

16.2.1. Inventory methods map

An inventory methods map is a map that illustrates the sampling design chosen for the inventory (see *Figure 16.3*). It is useful to have this type of map if the methods used in the inventory need to be explained to villagers or outsiders.

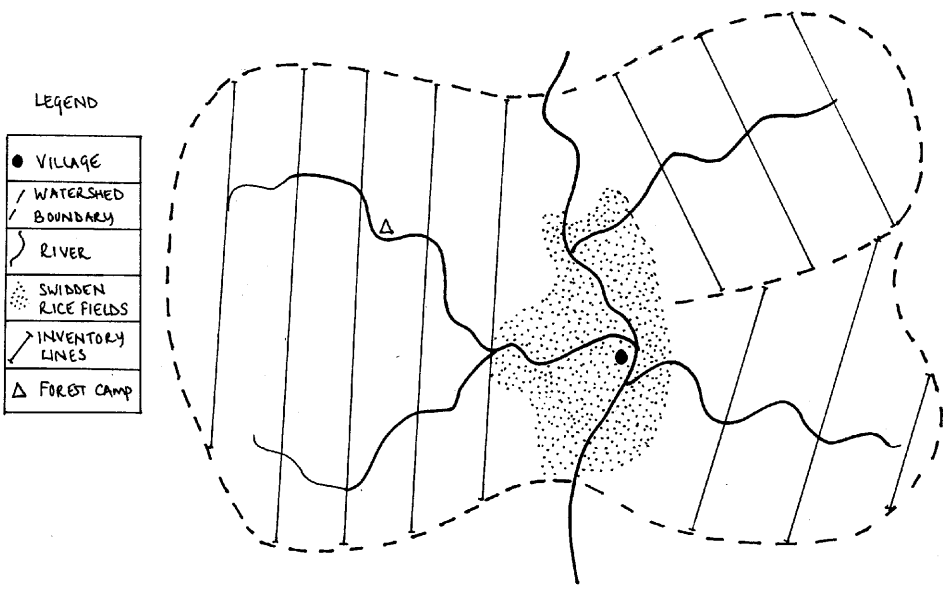


Figure 16.3. An inventory methods map illustrates the sampling design chosen for the inventory.

This type of map includes information about:

- The location, length and number of the inventory lines in the sampled area,
- The boundary of the inventory area, and
- The boundaries of all subdivisions within the inventory area (i.e. the different forest types and areas).

The inventory lines and all the relevant boundaries should already have been drawn on the map in pencil when preparing the final base map. Draw the lines again in ink and give them a number on the map that corresponds to their number in the field. For visual presentation, highlight different boundaries using different symbols and colours.

The inventory methods map should be finished as described in *Box 16.1*.

Box 16.1. Finishing touches for a final map

The final map may have other information added to it, if the villagers want. This information could be about different land uses (i.e. swidden rice fields, rubber plantations, gardens), sites of cultural significance (i.e. abandoned village sites, old graveyards), or other features chosen by the villagers.

As with all scale maps, the final map should include a:

- Scale,
- Symbol depicting North,
- Grid reference (this will not be possible if the map was made by ground surveying),
- Legend, and
- Date.

A final map which is likely to be presented to outsiders should also have a:

- Title, indicating the location of the area shown and the subject of the map (e.g. 'Forest resources map of Pohon Besar village'), and
- Description of all sources for the map (i.e. all sketch or scale maps, aerial photographs or radar images used to make the map). This should be written in small letters in the margin of the map. Provide all information necessary to locate the sources of the map (e.g. the title, index number, date and the department or organisation that made the map, photograph or image).

16.2.2. Inventory results map

The inventory results map, also called a forest resources map, provides a visual illustration of different densities or quantities of forest resources in different forest areas (see *Figure 16.4*). A forest resource map is a useful way of explaining the inventory results to villagers who may not be comfortable with data that is displayed as numbers in tables. It is mainly relevant in inventories where the purpose of the inventory involves comparing resource density or quantity between smaller areas.

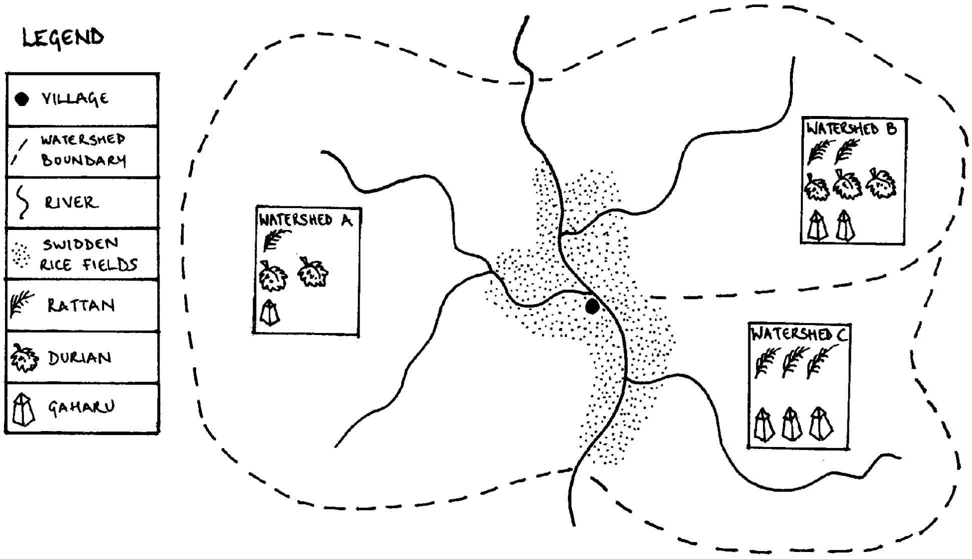


Figure 16.4. An inventory results map, also called a forest resources map, provides a visual illustration of different densities or quantities of forest resources in different forest areas.

You will have to state very clearly whether the map is depicting the density of each resource in each area (i.e. the number of plants per hectare in each area), or the absolute quantity of each resource in each area (i.e. the total number of plants estimated for the area). Choosing between density and quantity will depend upon the purpose of the inventory.

A simple way of showing the relative density or quantity of a given resource in each area is to:

1. Design a symbol for a given resource (villagers usually design very appropriate symbols for their resources),

2. Rank the areas according to the relative densities (or quantities) of the resource. If two areas are very similar in density (or quantity) you may give them the same ranking.[3]
3. Assign one symbol to the resource with the lowest density (or quantity), two symbols to the resource with the next lowest density (or quantity) and so on. If no resources were detected in an area and if the villagers also say that that resource is never found in the area, do not give it any symbols at all.
4. Draw the appropriate number of symbols in each area.

If you have a lot of resources, the map may become cluttered. You may choose to make several copies of your final base map and draw different resources (or groups of resources) on each copy.

The inventory results map or maps should be finished as described in *Box 16.1*.

16.3. Calculate the size of the inventory area and its subdivisions from the final base map

Now that you have completed the final base map, you should be able to calculate the size of the inventory area and its subdivisions more accurately than when you were planning the inventory. Calculate the size of an area using the same method as was used to calculate the size of the working units on the planning map.[4] Record the sizes of the areas in a notebook, as you will be using this information to calculate resource quantities. However, if you have some reason to doubt the accuracy of any of your estimates of size, you should be careful about using them to estimate resource quantity, as the same doubt must be applied to the estimates of quantity.

Where to next

You now have your final inventory map or maps. You also know the size of your inventory area, and if needed, of the subdivisions within it. You can use this information on the size of these area(s), plus the inventory data which you collected in the forest, to calculate resource density and quantity. The next chapter describes the process of compiling data and making calculations.

[3] *Chapter 17 describes how the inventory team calculates the density and quantity of the resources.*

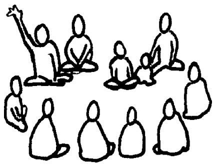
[4] *Chapter 7 (Section 7.3.3) describes how to calculate the size of an area on a map.*

17

Compile Data and Make Calculations

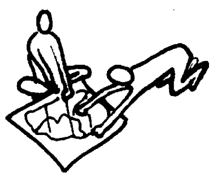
Where you are in the participatory inventory method:

I Decision making in the village



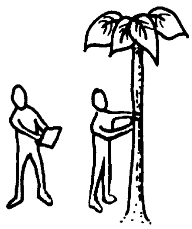
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



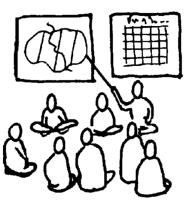
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

17.1. Compile the inventory data, and

17.2. Calculate the density and quantity of the forest resources, as well as their precision, if desired.

Skills/information required

The skills or background that you will require can be found in:

- *Appendix J*. The student's t table and how to use it
- *Appendix O*. Compilation and calculation forms

Materials required

- Copies of the compilation form and calculation forms, calculator, pencil and notebook.

Introduction

Once you have calculated the size of the inventory area or the smaller areas within it, you are ready to compile, or sort, the inventory data and calculate the inventory results. The main results of an inventory are the density and quantity of the chosen forest resources:

- The density describes the average number of plants in one hectare of a given area. The densities of a resource in different areas can be used to compare these areas, amongst other uses.
- The quantity describes the total number of plants in a given area. The quantity of a resource in an area can be used to estimate the economic value of the area, amongst other uses.

Estimates of density and quantity often are presented with their estimated precision[1] (e.g. a density of 4 plants per hectare may be written with its precision, ±1 plant per hectare). However, calculating the precision is more complicated than calculating density and quantity, and for this reason it is optional, although recommended. This chapter describes how to obtain estimates of density and quantity, and their precisions, if desired.

---

[1] *Box 3.3 in Chapter 3 defines the precision in more detail.*

17.1. Compile the inventory data

Compiling data involves transferring the inventory data gathered in the forest from data forms to compilation forms.[2] The compilation forms will sort and arrange the data, making it easier to calculate resource density and quantity.

The upper and lower portions of a compilation form are displayed in *Figure 17.1*, below. This form may be photocopied and used directly, or it may provide ideas for designing your own compilation form.

There are three steps involved in filling in the compilation form:

- Filling in the first row,
- Filling in the middle fifty rows, and
- Filling in the final two rows.

Each are described below.

Area and Forest Type: *Tebulo watershed* *Primary forest* Page 1 of 6				Resource Category 1: *durian trees* *<10 cm dbh*		Resource Category 2: *durian trees* *10-29 cm dbh*		Resource Category 3: *durian trees* *≥30 cm dbh*		Resource Category 4: *all durian trees*		Resource Category 5:	
Team	Date	Line	Plot	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)
A	21/7/97	1	1	2		1		1		4			
			2	2		0		0		2			
			3	1		1		0		2			
			4	5		0		1		6			
			5	0		1		0		1			
			50	3		2		1		6			
Total for page				27		12		8		47			
Total for area or forest type													

Figure 17.1. Example of the upper and lower parts of a compilation form (data have been included as an example).

17.1.1. Filling in the first row

Area and forest type

If the inventory area is not subdivided, it will not be necessary to fill in the space for area and forest type provided in the upper left corner of the form. However, if the inventory area has been subdivided, each subdivision must have its own clearly marked page or set of pages. In this case,

[2] *Appendix O provides an example of a compilation form.*

the name of the subdivision (whether area, forest type or both) should be written on each page in the space provided. A new page must be begun for data coming from a new subdivision.

Page ___ of ___

You will only need one page of this form if there are five or fewer resource categories in the inventory and fifty or fewer plots in the area or forest type. However, if this is not the case, more than one page will be required. This space informs the reader of what place this page takes in the total set of pages.

Resource categories 1-5

To start, decide whether you want to:

- Combine together all of the plants counted for this resource and calculate one set of results for the resource, or
- Divide these plants into a number of age, size, sex or condition categories and calculate a set of results for each resource category, and for a total for all resource categories, if desired.

If you want to calculate one set of results for a resource, write the resource name in one of the spaces provided. Alternatively, if you want to calculate sets of results for a number of categories of a resource, write the resource name and the category in the spaces provided. You may also want to assign a space for a total for all these resource categories.

For example, in *Figure 17.1* four resource categories have been chosen. Three are size categories (i.e. durian trees <10 cm dbh, 10-29 cm dbh, $\geq$30 cm dbh) and the fourth is a total of the three categories (i.e. all durian trees).

This form has enough columns for five resource categories. Additional pages will be needed if there are more than five resource categories.

17.1.2. Filling in the middle fifty rows

In the central part of the compilation form, each row is for writing information about one plot. Fill the columns in for each row, or plot, as follows:

Team, date, line and plot

The first four columns are for recording:

- The name of the inventory team that recorded the plot data,
- The date on which the plot data was recorded,
- The number of the inventory line in which the plot occurred, and
- The number of the plot from which the data was recorded.

No. of plants (y)

The 'number of plants' columns are for recording, for each resource category, the total number of plants that occur in each plot. This value is symbolised by a 'y'. Calculate the plot totals for each resource category by totalling the data from each of the five subplots that comprise a plot. Write these plot totals in the appropriate spaces in the compilation form. Ask someone else to double check these plot totals and show that the second check has been made by writing a check-mark next to the plot totals.

No. of plants squared (y^2)

The 'number of plants squared' columns are for recording, for each resource category, the total number of plants that occur in each plot, multiplied by itself, or squared. This value is symbolised by a 'y^2'. You will only need to fill in these columns if you have decided to calculate the precision of your estimates. To square a value, multiply it by itself. For example, to square the number 3, a calculation that is usually written as '3^2', multiply 3 by 3 to obtain the answer of 9. An easy way of doing this is by using a calculator. Press the '3' button on the calculator, then press the 'x^2' button. When you do this, the number '9' should appear on the calculator's screen. Ask someone else to double check these squared numbers and show that the second check has been made by writing a check-mark next to the numbers.

17.1.3. Filling in the final two rows

Total for page

The spaces in the 'total for page' row are for recording, for each resource category, the totals for all the number of plants (y) or squared number of plants (y^2) which have been recorded on the page. Add together the plot totals that have been written on the page. If you are calculating the precision add together the squared plot totals as well. Write the page totals in the appropriate spaces in the row. Ask someone else to double check these page totals and show that the second check has been made by writing a check-mark next to the page totals.

Total for area or forest type

The 'total for area or forest type' row is only filled in on the final page of a set of pages for a particular area or forest type. The spaces in this row are for recording, for each resource category, the totals for the number of plants (y) or squared number of plants (y^2) from this and previous pages in the set of pages. Add together the page totals (i.e. all the values in the row above this row) and write the result in the appropriate space. Ask someone else to double check these area or forest type totals and show that the second check has been made by writing a check-mark next to the totals.

17.2. Calculate the density and quantity of the forest resources, as well as their precision, if desired

This section explains how to use the compiled inventory data to estimate the density and quantity of a resource in a given area, and if desired, to calculate the precision of these estimates. If the inventory area has been subdivided into smaller areas or forest types, and if the villagers want to calculate the density and quantity (and their precisions, if desired) for each smaller area or forest type, then repeat the calculations described below for each smaller area or forest type.

17.2.1. How to use the calculation forms

There are standard procedures for making calculations, involving the use of calculation forms.[3] The calculation forms provide a framework for recording the steps of the calculations. Even if you do not use a form it is a good idea to write all the steps of the calculations in an exercise book. Below are some guidelines for using the calculation forms:

- Decide whether you will be calculating the precision or not. Calculation Form 1 in *Appendix O* describes how to estimate the density and quantity without calculating their precisions. Calculation Form 2 describes how to calculate density and quantity with their precisions.
- Photocopy the calculation forms, if possible, before going to the village, so that they can be written on. The number of pages that will be needed for one particular inventory can be calculated as follows:
  - The number of resource categories, multiplied by
  - The number of smaller areas within the inventory area (if there are any), multiplied by
  - The number of forest types (if there are any).
- Compile the inventory data before beginning calculations, and have the compilation forms to hand.
- The calculation form consists of a series of steps. Follow these steps in order, and write down the results of each step's calculation. For guidance, read the next two sections of this chapter. These sections use worked examples to explain how to use, respectively:
  - Calculation Form 1, and
  - Calculation Form 2.
- Calculations are described using symbols. One symbol is assigned to each variable. For example, the size of an area is assigned the symbol 'A'. The symbols used are standard symbols that can be recognised by people familiar with statistics. In this chapter, the symbols are explained so that they can be used by people not familiar with their meaning.
- Two different people should separately make all calculations, if possible, in order to ensure that they have been done correctly.

17.2.2. (Optional) Calculation Form 1: Calculating density and quantity without their precisions

Calculation Form 1 in *Appendix O* provides a series of steps for making calculations of density and quantity for a given area. All steps in the calculation form, from 1 to 7, must be repeated for each resource category.

Calculating density in units of number of plants per plot

1. To find the density of plants per plot, consult the compilation form or set of forms and find the final row, titled 'total for area or forest type'. This row contains, for all resource categories, the total number of plants in all the plots in the area. This value is symbolised by $\sum y$. Write one of these values in the space provided in step 1 of Calculation Form 1. To use a simplified example, 3 plots are set up in an area. All the bamboo plants are counted in each plot, and it is found that there are 9 plants in one plot, 10 in the second and 11 in the third. Summing them up results in a total of 30 plants, thus:
   1. Sum of the plants in all plots: $\sum y = 30$ plants

---

[3] *Appendix O provides some examples of calculation forms.*

2. Count the number of plots in the given area or forest type. This can be determined from the compilation form. The number of plots is symbolised by n. Write this value in the space provided in step 2. Using the bamboo example from above, there are 3 plots, thus:

   2. Number of plots: $n = 3$ plots

3. Divide the sum of the plants in all the plots ($\sum y$) by the number of plots (n). This results in the density, or average number of plants per plot, symbolised by $\overline{y}$. Write this value in the space provided in step 3. In the above example, 30 plants divided by 3 plots gives a results of 10 plants per plot, thus the density is:

   3. Density in units of number of plants per plot: $\frac{\Sigma y}{n}$, $\overline{y} = 10$ plants/plot

Changing the density to units of number of plants per hectare

4. The above calculation of density is in units of the number of plants per plot. However, the usual way to write the density in inventory results is in units of number of plants per hectare. The first step for changing the units is to determine the size of the plot in hectares, a value which is symbolised by a. Write this value in the space provided in step 4. Normally, each plot in the inventory is 10 m by 50 m, or 500 m^2.[4] This 500 m^2 is divided by the area of one hectare, which is 10 000 m^2, to convert its size to hectares. The resulting answer is 0.05 ha, thus:

   4. Size of each plot in hectares: $a = 0.05$ ha

5. Divide the density in units of number of plants per plot ($\overline{y}$) by the plot size (a). The result is the density in units of number of plants per hectare, symbolised by $\overline{Y}$. Write this value in the space provided in step 5. In our example, the density of 10 plants per plot, divided by the plot size of 0.05 hectares, is converted to a density of 200 plants per hectare:

   5. Density in units of number of plants per hectare: $\frac{\overline{y}}{a}$, $\overline{Y} = 200$ plants/ha

Calculating quantity

6. In order to make an estimation of quantity, you must determine the size of the area being quantified, in hectares. This area might be the inventory area, or a smaller area or forest type within it. The way to do this is described in *Chapter 16*. The size of the area is symbolised by A. Write this value in the space provided in step 6. To continue the example used above, the inventory area was determined to be 1000 ha; thus:

   6. Size of area or forest type in hectares: $A = 1000$ ha

7. Calculated the quantity, or total number of plants in a given area, by multiplying the density, or the mean number of plants in one hectare ($\overline{Y}$), by the number of hectares that there are in the area or forest type (A). The quantity is symbolised by Y. Write the answer in the space provided in step 7. In the example, 200 plants per ha is multiplied by 1000 ha to give a result of 200 000 plants in the forest area:

   7. Quantity of plants in area or forest type: $\overline{Y}$ x A, $Y = 200\ 000$ plants

You have now completed the calculations for resource density and quantity. Please see *Box 17.1* to assess how reliable these estimates are likely to be.

[4] *However, if you decided to count the smaller resource species in every 25th subplot, as described in Section 13.3 of Chapter 13, the plot size will be 10 metres x 10 metres, or 0.01 hectares.*

Box 17.1. How reliable are your estimates of density and quantity?

The reliability of your estimate of density will depend upon how accurate and how precise it is.[5] If you have followed the recommendations in this manual about how to improve accuracy then it is likely your density estimate is reasonably accurate (and you can partially examine this by looking at the results of your checks in the field). If you have followed the guidelines about precision and have tried to establish as many plots as possible, it is likely your density estimate is reasonably precise as well (and you can confirm this by calculating the precision, as described in *Section 17.2.3,* below).

The reliability of your estimate of quantity will depend not only upon the reliability of your estimate of density, as discussed above, but upon the reliability of your estimate of the size of the inventory area as well. The reliability of the latter estimate depends upon the accuracy of your planning map, and how well you have located the inventory area boundary on the map. If you do not feel confident about the estimate of the inventory area size, you should not feel confident about the estimate of quantity for that area, even if you consider the estimate of density to be accurate and precise.

17.2.3. (Optional) Calculation Form 2: Calculating the density and quantity with their precision

Calculation Form 2 in *Appendix O* provides a structure for making calculations of density and quantity for a given resource category in a given area. It also provides a structure for calculating their precision, expressed as their respective confidence ranges, as well as the sampling error %.[6] All of the steps on Calculation Form 2, from 1 to 17, must be repeated for each resource category.

Calculating the density in units of number of plants per plot

1,2 and 3. To begin, steps 1 to 3 must be completed, as has already been described for steps 1 to 3 of Calculation Form 1. These values must be written in the space provided in steps 1 to 3 of Calculation Form 2.

Calculating the confidence range in units of number of plants per plot

4. Consult the compilation form or set of forms and find the final row, titled 'total for area or forest type'. This row contains, for all resource categories, the sum of the squared number of plants in all the plots in the area. This value is symbolised by $\sum(y^2)$. Write one of these values in the space provided in step 4 of Calculation Form 2. To use a simplified example, the squared number of the bamboo plants enumerated in the 3 plots that were established in an inventory are 9^2, 10^2, and 11^2. The sum is (9 x 9) + (10 x 10) + (11 x 11) = 81 + 100 + 121 = 302, thus:

   4. Sum of the squared number of plants in all plots: $\Sigma(y^2) = 302$

---

[5] *The Introduction to this manual defines accuracy and precision and summarises how to achieve them.*

[6] *Box 3.3 in Chapter 3 defines the confidence range and sampling error %.*

5. The sum of the number of plants in all plots is squared, then divided by the number of plots. This produces a value called the 'correction for the mean', which is written in the space provided in step 5. In the example, the sum of the number of plants in all plots is 30 (9 + 10 + 11 = 30). 30^2 is 900, and 900 divided by 3, the number of plots, is 300. Thus the correction for the mean is:

   5. Correction for mean: $\frac{(\Sigma y)^2}{n} = 300$

6. Now the 'correction for the mean' in step 5 is subtracted from the sum of the squared number of plants in all plots in step 4, to produce a value called the 'sum of squared deviations from the mean', symbolised by a '*SSy*'. Write this result in the space provided in step 6. To use the example, the 'sum of squared deviations from the mean' is 302 - 300, or 2. Thus,

   6. Sum of squared deviations from the mean: $\Sigma(y^2) - \frac{(\Sigma y)^2}{n}$, $SSy = 2$

7. The 'variance of the mean', symbolised by V, is calculated by dividing the 'sum of squared deviations from the mean'(*SSy*) by the number of plots (n). The result is then divided by the number of plots minus 1 (n - 1). Write this result in the space provided in step 7. In the example, 2 divided by 3 and divided again by 2 (i.e. 3-1) results in 1/3 or 0.33. Thus,

   7. Variance of mean: $\frac{SSy}{n(n-1)}$, $V\,\overline{y} = 0.33$

8. The 'standard error of the mean', symbolised by $SE\ \overline{y}$, is obtained by calculating the square root of the variance of the mean. Write the result in the space provided in step 8. To get the square root of a value one must use a mathematical operation which is the opposite of squaring a value. For instance, if the number 3 squared is 9, then the square root of the number 9 is 3. This calculation is usually written as √9. The best way of making this calculation is by using a calculator. Press the '9' button on the calculator, then the '√' button; the number '3' should appear on the calculator's screen. In the example, the square root of the variance of the mean, √0.33, is 0.57, thus:

   8. Standard error of mean: $\sqrt{V\,\overline{y}}$, $SE\ \overline{y} = 0.57$

9. The next step is to consult a Student's '*t*' table[7] to find the appropriate '*t*' value, symbolised by *t*. An acceptable probability level to use is 0.1 or 90%, although 0.05 or 95% is even better. The degrees of freedom (*df*) that is used to look up the *t* value in the table is equal to the number of plots minus 1 (*n* - 1). The '*t*' value that you obtain from the table using this probability level and degrees of freedom should be written in the space provided in step 9. To use an example, the number of plots is 3, meaning that there are 2 degrees of freedom. At a probability level of 0.1 (90%), the appropriate *t* value in the table in *Appendix J* is 2.92. Thus:

   9. Student's t value at P = <u>0.1</u>: $t = 2.92$

10. The confidence range is one way of expressing the precision. The confidence range for the density, in units of number of plants per plot, is symbolised by *c*. To calculate it, multiply the student's *t* value by the standard error of the mean. Write the result in the space provided in step 10. Using the example, the confidence range is (2.92 x 0.57) or 1.66. The '±' symbol indicates that the confidence range extends from the mean minus 1.66 to the mean plus 1.66. This means that the upper confidence limit is 10.00 ± 1.66 = 11.66, and the lower confidence limit is 10.00 - 1.66 = 8.34. When presenting the inventory results, sometimes we use the lower confidence limit instead of the mean, if we want to err on the side of safety. Thus:

    10. Confidence range in units of number of plants per plot: $\pm(t \times SE\ \overline{y})$, $c = \pm 1.66$

[7] *Appendix J contains a t-table and explains what it is and how to use it.*

Whenever you display an estimate with its confidence range, you should state the probability level that you used to select your *t* value (see Step 9). Thus you should write the above result as '10.00 ± 1.66 plants per plot (at P = 0.1)' (or 'at P = 90%').

Calculating the density and confidence range in units of number of plants per hectare

11, 12. To change the confidence range from units of number of plants per plot to units of number of plants per hectare, steps 11 and 12, which change the units of the density, must first be completed. These are identical to steps 4 and 5 described for Calculation Form 1.

13. The confidence range, c, can also be changed to units of number of plants per hectare by dividing it by the size of each plot, a. Write the result in the space provided in step 13. Using the example, the confidence range is ±1.66 plants per plot ÷ 0.05 ha per plot. This is equal to 33.20 plants per hectare. The '±' symbol indicates that the confidence range extends from the mean (200 plants per ha) minus 33.2 to the mean plus 33.2. Thus:

    13. Confidence range in units of number of plants per hectare: $\pm \frac{c}{a}$, $C = \pm 33.2$

Whenever you display an estimate with its confidence range, you should state the probability level that you used to select your t value (see Step 9). Thus you should write the above result as '200.0 ± 33.2 plants per plot (at P = 0.1)' (or 'at P = 90%').

Calculating the quantity and confidence range in a given area

14, 15. To estimate the confidence range of the total number of plants in a given area (i.e. the quantity), steps 14 and 15, which calculate the quantity, must first be completed. These are identical to steps 6 and 7 described for Calculation Form 1.

16. The confidence range can be calculated by multiplying the confidence range, C, in units of number of plants per hectare, by the size of the area, A, in hectares. Write the result in the space provided in step 16. In the example, the confidence range is ±33.20 plants/ha x 1000 ha, or 33,200 plants. The '±' symbol indicates that the confidence range extends from the quantity (200,000 plants) minus 33,200 to the quantity plus 33,200. Thus:

    16. Confidence range of the number of plants in the area: $\pm C \times A = \pm 33{,}200$

Whenever you display an estimate with its confidence range, you should state the probability level that you used to select your t value (see Step 9). Thus you should write the above result as '200,000 ± 33,200 plants per plot (at P = 0.1)' (or 'at P = 90%').

Calculating the sampling error % of the density and quantity

17. The sampling error % is another way of expressing the precision. To calculate the sampling error %, the confidence range, *c*, should be divided by the estimated mean, $\overline{y}$, and the result multiplied by 100. Write this answer in the space provided in step 17. Using the example above, 1.66 divided by 10 and multiplied by 100 is 16.6%. Thus:

    17. Sampling error %: $100 \times \frac{c}{\overline{y}}$, $E\% = 16.6\%$

Whenever you display an estimate with its sampling error %, you should state the probability level that you used to select your *t* value (see Step 9). Thus you should write the above result as '10 plants per plot with a sampling error of 16.6% (at P = 0.1)' (or 'at P = 90%').

Note that the density and its confidence range, expressed in different units (i.e. $\overline{Y}$and C of steps 12 and 13), will have the same sampling error %. The same is true for the quantity and its confidence range (i.e. $\overline{Y} \times A$ and $C \times A$ of steps 15 and 16).

You have now calculated resource density and quantity with their precision. Please see *Box 17.1* to assess how reliable these estimates are likely to be.

Where to next

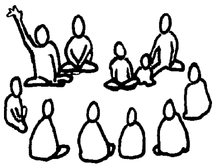
Now that the main results of the inventory have been calculated, you should begin to think about how you will present these results in the form of a final report. The next chapter describes how to write this report.

18

Write the Final Report

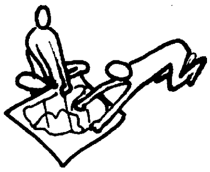
Where you are in the participatory inventory method:

I Decision making in the village



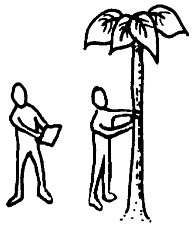
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



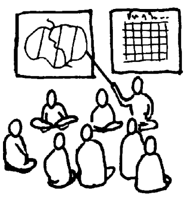
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following task:

18.1. Write the final report.

Skills/information required

- None

Materials required

- Paper, pen, typewriter (optional) and computer (optional).

Introduction

The results of the inventory should be presented in the form of a final report. The final report should inform villagers or outsiders about the purpose and objectives of the inventory, the methods used, the results obtained and the follow up activities planned. This chapter discusses how to design the report to suit the people who will be reading and using it. It also provides a suggested outline for writing the report.

18.1. Write the final report

18.1.1. Designing the report to suit the intended audience

The content and style of the final report will depend upon whether villagers or outsiders from government or companies are going to be reading the report.

Designing the report for villagers

If the report is to be used by the villagers, you should write it so that the villagers who were not closely involved in the inventory can understand the inventory methods and results by reading the report. It will be particularly important to explain the methods used, particularly the technical ones, as these are probably unfamiliar to the villagers.

A suggested procedure for writing a report intended for villagers is described below:

1. Plan the outline of the report with the villagers, using the outline described in the next section as a guide.
2. Hold the general village meeting to present the inventory results to the villagers before writing the report. If at all possible villagers who have participated in the inventory should do the presentation at the village meeting.[1]
3. Write the report. The villagers may write the parts of the report that they have explained in the village meeting themselves. Alternatively, they may prefer it to be written by someone with more experience in report writing. In the latter case, the report writer should try to see how the villagers explain the concepts in the village meeting and use those words to explain the same concepts in the report.
4. Write a first draft of the report and give it to villagers to read and make recommendations.
5. Write the final draft, incorporating the suggestions of the villagers.

Designing the report for outsiders

If the report is designed primarily for outsiders, such as government officials or company employees, the report may have to be written in a more formal, standard way. It will be important for the report to have a professional appearance. The report should provide more information about the village and its interaction with the forest and the issues or concerns being addressed by the inventory purpose. This information would be less necessary in a report for villagers. The report should also describe the technical details of the inventory.

A procedure for writing a report intended for outsiders is described below:

1. Plan the outline of the report with the villagers, using the outline described below as a guide.
2. Write a first draft of the report. The villagers may write the report themselves although they may prefer it to be written by someone with more experience in report writing.
3. Give the draft it to villagers to read it and make recommendations.
4. Write the final draft, incorporating the suggestions of the villagers.

---

[1] *Chapter 19 will describe how to present the results of the inventory at a general village meeting.*

18.1.2. A suggested outline for the final report

Below is a suggested outline for the final report. The points that are in a normal font should be included in every report. The remaining points, written in Italics, can be considered optional, depending upon the circumstances of any particular inventory.

Title page

- Title,
- Author(s),
- Date, and
- Location.

I. Introduction

A. Village background

- Where the village is,
- Who its people are,
- When the village was founded,
- The villager's way of life, particularly their interaction with the forest, and
- The villagers' dominant issues and concerns with regard to the forest.

B. Inventory background

- What participatory inventory is,
- Who initiated the inventory, and
- Who participated in the inventory (i.e. villagers, outsiders).

C. Purpose

- *How the purpose was determined,*
- The purpose of the inventory, and
- *A statement of inventory purpose signed by the village leaders (this could be attached to the report in an appendix).*[2]

D. Objectives

- *How the objectives were determined,*
- The objectives of the inventory, and
- *Background information on the objectives (e.g. information on the chosen resource species or the inventory area: what they are used for, why they are selected, etc.). It might be preferable to put this information in an appendix).*

II. Methods

A. Sampling design

- Explain whether you used 100% enumeration and why,[3]
- Explain what sampling design was used and why,[3] and
- *Illustrate the sampling design (i.e. the location of the inventory lines) with an inventory methods map.*

---

[2] *Chapter 2 explains how the statement of inventory purpose was composed with the villagers.*

[3] *Appendix I explains why we chose to sample with inventory lines.*

B. Methods used to gather inventory data

- Mention or describe the training of the inventory work teams,
- Describe the work on the inventory lines, including:
  - Establishing plots along the inventory line (e.g. what to do on steep slopes),
  - Enumerating plants,
  - *Gathering plant information,*
  - *Gathering environmental information, and*
  - Provide a sample data form and accompanying field reference sheets.
- *Describe the checks, including:*
  - *What were the set limits to errors and what was to be done if these limits were surpassed,*
  - *What percentage of original plots were checked,*
  - *How many errors were found and of what type,*
  - *Did these errors surpass the limits and what was done if so,*
  - *Was an improvement detected over time.*

C. Methods used to collect botanical specimens

- *Describe collecting botanical specimens.*

D. Methods used to present the results

- *Describe how the final maps were made, and*
- Describe how the data were compiled and the calculations made.

III. Results

A. Table(s) of results:

- Display table(s) of the results of the inventory, showing the densities and quantities of each of the resource categories in each area.
- *Include the precision of the densities and quantities in the above table. Whatever way you present the precision, remember to mention the probability level used.*[4]
- *Use Latin names as well as local names for resource species, if you have obtained them.*
- *Remember to separate results obtained from different inventories (i.e. results from a 100% enumeration should be described separately from those obtained from sampling, so that the reader can tell which method was used to obtain each result.*

B. Map of the results

- *Explain how the forest resource map shows the relative densities or quantities of forest resources using symbols.*

C. Discussion of the results

- Summarise main results of the inventory.
- Evaluate the reliability of these results (see *Box 17.1*).
- Discuss the implications of these results in relation to the inventory purpose (e.g. watershed A has more of the forest resources important to local people than watershed B, resource X has been more severely affected by a development activity than resource Y).

---

[4] *Chapter 17 describes ways of presenting the precision.*

IV. Follow up activities

Do not write this section until decisions about the follow up activities have been made at the final village meeting.[5]

A. ***Evaluate whether the inventory objectives were met***

- *If the objectives were not met, explain why the inventory team did not achieve the objectives (e.g. encountered inaccessible areas, discovered that one resource species had been incorrectly identified by one of the teams).*
- If the objectives were not met, describe what actions the villagers have decided to take in response.

B. ***Plan information storage and security***

- Where will the original data be stored,
- Where will copies of the data be stored,
- *Where will the botanical specimens be stored,*
- *Where will the original maps be stored, and*
- Who will be given copies of the final report and maps.

C. ***Plan how to use the inventory results in order to achieve the inventory purpose***

- Can the results be used directly to achieve the inventory purpose, or
- Must other information be gathered before the inventory purpose can be achieved, and how will this be done.

D. ***Evaluate their experience of participatory inventory***

- *Evaluate the inventory method,*
- *Evaluate the impact of the inventory, and*
- *Evaluate the level of participation by villagers.*

Where to next

In addition to presenting the results in a final report, the inventory team should also present them verbally to the villagers at a general village meeting. The next chapter discusses how to present the results of the inventory at a general village meeting, as well as how to facilitate a discussion of the follow up activities that should be conducted as a result of the inventory. Any plans for follow up to the inventory should subsequently be added to the final report.

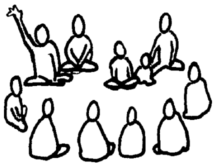
[5] *Chapter 19 describes how to plan the follow up to the inventory at the final village meeting.*

19

Present the Results to the Villagers and Plan Follow Up

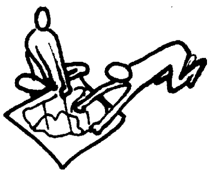
Where you are in the participatory inventory method:

I Decision making in the village



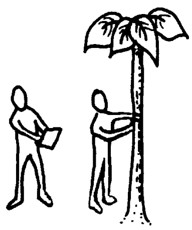
1 Introduce participatory inventory to the villagers
2 Determine the inventory purpose
3 Determine the inventory objectives
4 Select the inventory team and work dates

II Planning the inventory work



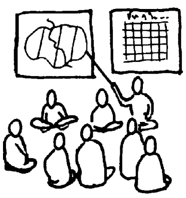
5 Assemble equipment unavailable in the village
6 Prepare the planning map
7 Use the planning map to plan the inventory
8 Plan the measurement of plants and site
9 Design the data form
10 Organise the work in the forest

III Inventory work in the forest



11 Train the inventory team
12 Locate the starting point in the forest
13 Conduct the inventory work
14 Check the inventory work
15 Collect botanical specimens

IV Presenting the results of the inventory



16 Prepare the final map(s)
17 Compile data and make calculations
18 Prepare the final report
19 Present the results to the villagers and plan follow up

Objectives

After reading this chapter, you will be able to complete the following tasks:

19.1. Prepare a general village meeting to present the inventory results to the villagers and facilitate a discussion of follow up activities, and

19.2. Facilitate the general village meeting.

Skills/information required

The skills or information that you will require include:

- *Appendix A*. Planning and facilitating village meetings.
- *Appendix E*. Further information and analyses needed to achieve some inventory purposes.

Materials required

- Large size paper, broad nib marker pens, drawing pins, final maps, other materials for preparing visual displays (optional), lighting, food and drink.

Introduction

At the end of the participatory inventory, the inventory team should hold a final village meeting to present the results of the inventory back to the villagers. This meeting, like the final report, should remind the villagers of the inventory purpose and objectives, and summarise the methods used and results obtained. It should also give the villagers the chance to discuss and plan any activities to follow on from the inventory. This chapter describes how to prepare and hold this final village meeting.

19.1. Prepare a general village meeting to present the inventory results to the villagers and facilitate a discussion of follow up activities

To prepare for the general village meeting, you should:[1]

- *Plan the general structure of the meeting.* Suggestions for meeting structure are provided below.
- *Prepare visual displays of the inventory purpose, objectives, methods and results.* Some, such as a display of the inventory purpose, might already have been prepared for earlier meetings. Others, such as tables of the inventory results, should be written on large sheets of paper so that everyone can see them.
- *Divide the points to be covered in the presentation amongst the members of the inventory team.* Most of the presentation, if not all, should be made by the villagers rather than outsiders. Villagers may be better able to explain the results in terms that the other villagers will understand. Presenting the results at the final village meeting will give them more confidence to explain the results by themselves to other people later.

19.2. Facilitate a general village meeting

This section suggests one possible structure for the final village meeting.[2]

19.2.1. Introduction

The facilitators or villagers should introduce the meeting by reminding the villagers of:

- What participatory inventory is,
- Who initiated the inventory,
- Who participated in the inventory,
- What the inventory purpose is, and
- What the inventory objectives are.

19.2.2. Summarise the methods used

In this part of the meeting the facilitators or villagers can briefly describe the methods used in the forest, by:

- Explaining the sampling design and why it was used (show a map of the inventory lines, if one has been made), and
- Explaining how the inventory work was done.

---

[1] *Appendix A contains general information on how to prepare for village meetings.*

[2] *Appendix A contains information on how to facilitate village meetings.*

19.2.3. Summarise the results obtained

Tables of the results

The inventory results should be presented to the village in the form of tables of resource density and quantity. These tables should be written on large sheets of paper so that all can see them.

Map of the results

The inventory results can also be presented to the villagers in the form of a forest resources map, if one has been made. The link between the tables and the map should be made clear (i.e. the map provides an illustration of the results in the tables). If the meeting place is large and there are many people taking part in the meeting it will be difficult for people to see the map. The people explaining the map might have to walk around with it, or pass the map around.

Summary of results

The main results of the inventory should be summarised, and the implication of these results discussed. For example, the implication of one set of results might be that one watershed is more rich in locally important resources than another watershed. The implication of another set of results might be that one resource was more affected by a development activity (i.e. selective logging) than another resource.

19.2.4. Facilitate discussion of follow up activities

Ask the villagers to discuss the next steps that should be taken as follow up to the inventory. The remainder of this section describes some of the topics that could be discussed:

Evaluate whether the inventory objectives were met

The villagers should evaluate whether or not the inventory objectives have been met, and the course of action to take if they were not. For example:

- If the inventory area was not completed within the constraints of time and other resources allotted for the inventory, the villagers may need to decide whether or not to invest more resources in finishing the inventory area.
- If the precision of the final estimates falls short of the precision that was set in the objectives, the villagers may need to decide whether or not to collect more data (by randomly or systematically placing more inventory lines throughout the inventory area).

Discuss information storage and security

The villagers should discuss information storage and security. Issues include:

- *Where to store the original data collected from the field* (i.e. the completed data forms). The data forms should be numbered clearly, ordered correctly, and stored in a safe, dry place. The data should be kept so that they can be used as a reference if someone wants to make further calculations or check how the results were obtained. The data should be stored securely because they represent a lot of work which would be very costly to redo.
- *Where to store copies of the data*. It is wise to take the precaution of copying the data at least once in case one set of data is lost (see *Box 19.1* for advice on copying data). Store the sets of data in different places to ensure that one set survives. At least one set of data should be stored in the village. If an extra set is stored outside the village, it should be done so with the permission of the villagers.

Box 19.1. Copying data

There are two choices for copying data. These are:

- Photocopying the original data forms, which ensures that an exact copy is made, and
- Transferring the data to another form or a computer database. This often results in errors being made during the transfer. If for some reason you must transfer the data, ask a different person to check the data at least once in order to minimise errors.

- *Where to store the botanical specimens*. If there are more than one set of each botanical specimen, the villagers may want to keep one set of botanical specimens as back up to their inventory report, and take or send the other set away for identification. Any specimens preserved in alcohol will need to be dried for long term storage.[3] As with the original data, the specimens should be stored in a safe, dry place.
- *Where to store the original maps*. The original copies of the final maps are best stored flat. Failing that, they should be stored rolled up in a map roll. You should try to avoid folding them as this can cause distortion or wear along the folds. As with the original data, the original copies of the final maps should be stored in a safe, dry place.
- *Who will be given copies of the final report and maps*. Some reports may be meant for a limited audience. Others may be available for all who are interested. The villagers should make arrangements for distributing the report to the desired audience.

Decide how to use the inventory results

One of the most important decisions the villagers will need to make is how to use the inventory results in order to achieve the purpose.

- For some purposes, the results can be directly used to achieve the inventory purpose (i.e. present results to a government office to negotiate for access rights to an area of forest).
- For other purposes, further information must be gathered and analysed in combination with the inventory results (i.e. a productivity study must be conducted before an economic evaluation of key forest products can be made).

The villagers should decide what the appropriate follow up steps should be and plan who will take these steps, and where, when and how will these steps be taken.[4]

Evaluate their experience of participatory inventory

If members of the inventory team or the village as a whole plan to conduct further inventories, it is be a good idea to evaluate their experience of a participatory inventory in order to see how it could be improved.

[3] *Chapter 15 describes how to press and dry botanical specimens.*

[4] *Appendix E discusses the further information gathering and analyses that may be needed for some inventory purposes.*

Ask all the people who have been involved in the inventory for their opinions on all aspects of the inventory, including:

- *The inventory method.* This might be discussed in stages such as initial decision-making by the villagers, planning the inventory, conducting the inventory work in the forest, and presenting the results. The villagers should evaluate what was done well and what could be improved.
- *The impact of the inventory.* Did the inventory address the villagers' issues and concerns? How could have been done to better address them?
- *The participation of the villagers.* Were the villagers happy with their level of involvement? Should it have been decreased or increased, and how?

Appendices

A

Planning and Facilitating Village Meetings

Objectives

By the end of this appendix, you should be able to do the following:

A.1. Describe two types of village meetings and when to use them in participatory inventory,

A.2. Plan village meetings, and

A.3. Facilitate village meetings.

Introduction

Village meetings are meetings in which the villagers play a central role. These meetings are a very important part of participatory inventory. Village meetings provide a means of communication between the people who are proposing or conducting an inventory (whether they be outsiders or villagers) and the rest of the village. They also give villagers a means for making important decisions about the inventory.

A.1. Two types of village meetings and when to use them in participatory inventory

Two types of village meetings used in participatory inventory include:

- General village meetings involving the entire village, and
- Small group meetings held by distinct groups in the village. Gender, age, ethnic group or social status may define these groups.

A.1.1. General village meetings

It is usually easier to organise one general village meeting than a number of small group meetings. General village meetings are therefore a more efficient means of communicating information to the villagers. General village meetings are recommended for:

- Introducing participatory inventory to the villagers (*Chapter 1*), and
- Presenting the results to the villagers (*Chapter 19*).

General village meetings are also essential for decision making, when the entire village agrees about inventory plans. General village meetings are recommended for:

- Asking the villagers to decide whether they want an inventory (*Chapter 1*),
- Determining the inventory purpose (*Chapter 2*),
- Making the final decisions on the inventory objectives (*Chapter 3*),
- Selecting the inventory team and work dates (*Chapter 4*), and
- Planning the follow up activities to an inventory (*Chapter 19*).

It is not necessary to have a separate village meeting for each of the uses described above. One meeting may combine several of these uses.

A.1.2. Small group meetings

Small group meetings provide better opportunities for discussion than general village meetings. This is because distinct groups within the village may find it easier to offer information or suggestions if their meetings are held separately from other, possibly more dominant, groups. Also, all groups will have important information to offer because each group uses the forest in different ways. For example, the resources and forest areas that are important for the women in a village may differ from those that are important for the men.

Small group meetings are therefore recommended for:

- Discussing the inventory objectives (*Chapter 3*).

The best way to divide the village into small groups varies from village to village. *Example A.1* describes how some villages were divided into small groups. In all cases, the aim is to identify the main groups that have a unique perspective in matters to do with the village's forest and its resources.

Example A.1. Ways in which villages can be divided into small groups

Some experiences from past participatory inventories include:

- A village which was divided into an older men's group, a younger men's group and a women's group,
- A village consisting of people from two smaller villages, which had been combined together in one location several decades ago but which still used different forest areas. These people were divided into four groups, consisting of a men's group and a women's group from each smaller village, and
- A village consisting of two ethnic groups between whom there was some tension over forest ownership and use. Village representatives and facilitators decided it might promote conflict to separate these ethnic groups into different meetings. Therefore the village was divided into an older men's group, an older women's group and a youths' group.

A.2. Planning village meetings

Villagers will have a protocol for village meetings. The team initiating the inventory should find out who in the village are usually responsible for planning these meetings and work with them. Some important considerations include:

- When to have the meetings,
- Where to have the meetings,
- Who to invite and how to invite them,
- The assignment of roles during the meetings, and
- The content of the meetings.

A.2.1. When to have village meetings

It is important to plan village meetings for a time of week and day that is most convenient for the largest number of people.

The best time for general village meetings may not be the same as the best time for small group meetings. For example, it may be usual for a village to hold the general village meeting in the evening. However, the women's group might find the middle of the day a better time for their small group meeting.

A.2.2. Where to have village meetings

General village meetings should be located in a place which is large enough to include all the people from the village. Usually there is a place in the village that is specifically designed for village meetings. Other good locations include schools or a suitable place outdoors (weather permitting!). You must ask the relevant people for permission to use these places.

Small group meetings will have fewer people and can take place in smaller, more informal settings. These meetings should be relatively secluded, so that people who are not part of that particular small group are not wandering in and out.

In both types of meetings, everybody attending should be able to see the people facilitating the meeting and any posters or other media that they are using. In some cases, the meeting place will need to be lit with one or several lamps. People should also be able to hear the facilitators clearly.

Seating arrangements that are not hierarchical help to encourage the participation of all villagers. One way of doing this is to arrange the seating so that everyone sits at the same level. At the same time, seating arrangements should try to fit in with the existing village protocol. For example, women may traditionally be seated on a different side of the meeting place from the men.

A.2.3. Who to invite to village meetings

As mentioned previously everybody in the village should be invited to attend the village meetings. This includes old and young, men and women, and rich and poor. There is usually a traditional system for informing people of village meetings, such as announcements made in church, the mosque, or over loudspeakers. There may also be a system for summoning villagers just before the meetings, such as the beating of a gong or bell. Members of the team initiating the inventory can also contribute by walking around the village and inviting villagers in person.

A.2.4. Assigning roles during village meetings

The meeting organisers will need to assign people to a number of important roles in advance of the meeting. These roles will be performed during the meeting and include:

- ***Facilitators***. These people present information at the meeting and assist villagers with decision making. Their tasks are described in more detail in the following section about facilitating village meetings.
- ***Recorders***. During discussion and decision making, these people write the suggestions of the villagers on a large sheet of paper.
- ***Interpreters***. If the facilitators are from outside the village and cannot speak the local language then interpreters may be needed.
- ***Note-takers***. These people record the details of the meeting, which can be referred to later when writing up the final report.
- ***General assistants***. These people can help with setting up and taking down chairs, blackboards, lights or sound systems in the meeting place and making and serving any refreshments.

Some people may have more than one role during the course of the meeting.

A.2.5. Planning the content of village meetings

It is important for the content of village meetings to be planned before the meeting. Some general elements to a village meeting are discussed below:

- There is usually a local protocol for running village meetings. For example, the village chief may be responsible for making an introductory or closing speech. There may be someone else who makes an opening or closing prayer and another person who reads out the agenda of the meeting.
- At or near the beginning of each meeting there should be an introduction to the meeting, explaining what the purpose of the meeting is and how it will be run.
- During the main part of the meeting, the facilitators will either be making a presentation to the villagers, facilitating discussion and decision making by the villagers or doing a combination of the two. General guidelines for the above functions of a facilitator are

discussed in the next section. Specific suggestions for the structure, content and presentation of each of the meetings recommended for participatory inventory are described in the relevant chapters.

- At the end of the meeting, it is good to have a summing up of the major points or decisions that have been made.

As a general rule, meetings should not be longer than three hours, including discussion and question time, because people have limits to their ability to concentrate. If the meeting is anticipated to be as long as three hours, a pause in the middle should be provided. Refreshments, such as coffee and biscuits, are a good way of providing a break and ensuring a relaxed atmosphere.

A.3. Facilitating village meetings

A facilitator plays an essential role in ensuring a village meeting runs smoothly and effectively. This section describes what qualities to look for when choosing facilitators, and the two main functions of facilitators, which are to:

- Make presentations to the villagers, and
- Facilitate decision making by the villagers.

A.3.1. What to look for when choosing facilitators

When choosing facilitators a number of qualities should be looked for, as outlined in *Table A.1*.

Table A.1. Qualities to look for in a facilitator.

A good facilitator:	*A poor facilitator:*
✓ Is a good communicator who is able to present new ideas in a clear and simple manner,	✗ Is a poor communicator,
✓ Is neutral when presiding over decision making,	✗ Has a hidden agenda and tries to influence decision making,
✓ Is trusted,	✗ Is not trusted,
✓ Is informal and relaxed,	✗ Is formal and inflexible,
✓ Respects everybody's views equally,	✗ Favours one individual or group over others,
✓ Encourages participation by all members of the group,	✗ Does not encourage participation by all members of the group,
✓ Looks for consensus,	✗ Does not look for consensus,
✓ Is a good listener,	✗ Does not listen to the points being made,
✓ Summarises people's points accurately and fairly, and	✗ Allows his or her summaries to be influenced by personal bias,
✓ Is good at keeping the discussion to the planned time limits, ensuring that the meeting is run efficiently.	✗ Does not control the length of discussions, resulting in an inefficient meeting.

Choosing women or men

If only men or only women are chosen as facilitators there is a chance that the villagers of the opposite gender might be alienated from the process. In small group meetings it is important that the facilitator is male for men's groups and female for women's groups.

Choosing outsiders or insiders

If the facilitators are from inside the village they are more likely to:

- Have credibility within the village if they are well known and respected,
- Speak the local language and so be able to communicate with all the people in the village,
- Understand the best way to communicate new ideas to villagers using examples they can directly relate to, and
- Have a good understanding of local issues and problems.

If the facilitators are from outside the village they are more likely to:

- Have a novelty value which might interest people and cause them initially to participate in greater numbers, and
- Have different and varied experiences to offer to the discussions.

Choosing the right balance of facilitators

It is usually best to have a team of facilitators rather than just one facilitator. For one thing, it can be exhausting for one person to facilitate an entire meeting. For another, teams of facilitators often cause a meeting to be more lively and entertaining. Also, having more than one facilitator means that the meetings will not be overly influenced by the biases of one person.

If possible, include a mix of outsiders (if there are any), insiders, men and women on the facilitating team, as this means the advantages of each are combined in one team. This will have the added advantage of fostering collaboration between an outside party, if there is one, and the villagers. It is still possible to have a successful meeting when the facilitators are all from either inside or outside the village or of the same gender. In the end, success will depend mainly on the enthusiasm and commitment of the people involved.

A.3.2. Making presentations to the villagers

One important function of a facilitator is to make presentations to the villagers. These may be used to introduce participatory inventory to the villagers or to inform the villagers of the results of an inventory.

Presentations should be prepared in advance. The team organising the meeting should plan the points that they would like to make, the order in which they would like to make them, who will be making each point (if there is more than one facilitator) and how to best present each point. There are a number of ways in which the facilitators can make their presentation of each important point more relevant and understandable to the villagers, including:

- Using examples from the villagers' own lives that the villagers will be able to relate to,
- Using visual displays such as pictures, diagrams, maps, or tables that make it easy for the facilitators to explain and for villagers to understand a point,
- Using short dramas or demonstrations which are fun to watch but contain important information, and

- Planning ways in which the presentation of a point can involve interaction with the villagers. The more interactive the presentation of a particular point, the more likely it is that people will remember it.
- Using photos, slides or videos of previous participatory inventories in other villages.
- Bringing a villager who has been involved in a previous participatory inventory to explain it to the villagers.

Throughout the meetings, facilitators need to interact with the villagers and ask for and accept any contributions in the form of questions or comments that the villagers might have about what is being explained. Members of the village who have a good grasp of what has been explained can be called upon to help to explain certain concepts to villagers.

A.3.3. Facilitating decision making by the villagers

This manual recommends that decisions be made by consensus. In consensus decision making, everybody who is involved must ultimately agree to go along with the decision. The majority cannot force a decision on a minority if the latter remain opposed to it. Consensus decision making is crucial to any truly participatory activity, as without it people will feel that they do not have an equal voice.

When facilitating consensus decision making, the facilitator must attempt to balance fairness with efficiency. Frustration will result if people feel some opinions have been given a greater weight than others, but it will also result if too much of the meeting time is spent on repetitive or overly lengthy discussion.

Fairness in decision making should be achieved if:

- The facilitators themselves are neutral and do not take sides,
- The quieter participants have their say and are not interrupted,
- The vociferous participants do not overly dominate the meeting,
- The people who disagree with a decision have the opportunity to express their feelings, and
- The decisions made are ultimately acceptable to all.

Ensuring the efficiency of a particular meeting is very much up to the discretion of the facilitator. The facilitator must decide how important an issue is compared to the time being taken to discuss it. A meeting can be run more efficiently if:

- the facilitator has forewarned the participants at the beginning of the meeting of the decisions that will need to be made and the time that will be allotted to each decision,
- all important contributions from the participants are summarised by the facilitator and written up somewhere visible in order that people do not repeat themselves,
- once a decision has been made, it is written down, and the facilitator moves on promptly to the next subject of the meeting.

B

Gathering Information About the Village

Objectives

By the end of this appendix, you should be able to do the following:

B.1. Decide what information you need to gather about the village, and

B.2. Gather this information using Participatory Rural Appraisal (PRA) techniques.

Introduction

This appendix suggests some useful information for an outsider to know about a village and its interaction with the forest. This information will help an outsider to facilitate decision making at village meetings. This appendix also lists a number of Participatory Rural Appraisal (PRA) techniques that can be used to obtain this information. In addition to gathering background information, some of these PRA techniques can be used to assist the villagers with decision making during village meetings.

B.1. Decide what information you need to gather about the village

If you are an outsider who is unfamiliar with a village, and if you will be facilitating meetings in which villagers will be determining the purpose and objectives of the inventory,[1] you will want to invest some time in gathering background information about the village, its forest, and its forest resources. This information will help you to be a more effective facilitator, as you understand more of the issues under discussion or the terms being used. This information may be important for explaining to outsiders the reason why particular inventory purposes and objectives were chosen. Thus you may also want to document this background information for use in the final inventory report.[2]

The type of background information that you will need depends upon the reason why the inventory has been initiated and how much you already know about the village. The sections below list some information that might be useful to gather about:

- The village,
- The forest, and
- The forest resources.

Read through these sections, and use the ideas presented to assemble a list of your own.

B.1.1. Useful information about the village

- The total number of people or households in the village,
- The existing social groups within the village, which might be based on gender, age, ethnic group or social status (based on custom, education or income),
- The people who are specialists in:
  - The history and traditions of the village, and
  - The forest (i.e. healers who use medicinal plants, business people who trade in forest products, people who make handicrafts, etc.),
- The main events in the history of the village (including the length of time families and individuals have been living in the village), and
- Some of the current issues or concerns in the village, particularly those to do with the village's forest and forest resources.

B.1.2. Useful information about the forest

- The main access routes to the forest.
- The distinct forest types present in the forest. These distinct forest types could be due to:
  - Non-human influences, such as altitude, soil type, and topography, or
  - Human influences, such as logging, agroforestry, swidden cultivation.
- The history of the village's forest (including how long people have been using it and under what systems of management).

---

1 *Chapters 2 and 3 describe how the villagers determined the inventory purpose and objectives.*

2 *Chapter 18 describes how to write the final inventory report.*

B.1.3. Useful information about the forest resources

Information about the types of forest resources that are important to the village, their products, and how these products are used, processed and sold

- The forest resources that are most important to the village,
- Whether each of these forest resources can be further divided into species or varieties,
- The forest products that are harvested from these resources (i.e. timber, fruit, resin, poles),
- The uses that these products have and whether these uses can be classified as:
    - Commercial (both within and outside the village),
    - Non-commercial, or
    - Cultural.
- Whether these forest products require processing, and if so when, where, how and by whom is this processing done,
- Whether these forest products are sold, and if so:
    - To whom they are sold,
    - What units are the forest products are sold in (e.g. rattan stems are sold in 4 m lengths),
    - If local units are used, how do these units convert to standard units, and
    - What are the conditions or limits for sale (e.g. poles of a certain species are sold only if they are between 3 and 10 centimetres diameter at breast height).

Information about the location and ecology of forest resources

- Where in the forest is the forest resource usually found (i.e. on ridges, by rivers),
- Why is the forest resource located there (i.e. is it because of human or non-human influence?),
- What is the life cycle of the resource (i.e. seed, seedling, sapling, tree), including the seasonality of its flowering and fruiting, and
- How is the resource changing over time, with respect to past, present and future quantities and qualities.

Information about the harvesting of forest products

- Who usually harvests the forest product (i.e. do all villagers harvest it, or only people of a certain age, gender or other grouping),
- When is the forest product usually collected (i.e. is there a defined season, or is the product collected often or seldom),
- How do the villagers determine whether a particular forest product is ready to be harvested (i.e. is this based on age, size, or some other condition (e.g. fruit size, flavour, ripeness, smell)),
- How do the villagers collect the forest product (i.e. what techniques or procedures are used),
- Which part of the plant is collected, and
- What quantities of the forest product are usually collected at one time.

B.2. Gather this information using Participatory Rural Appraisal (PRA) techniques

B.2.1. Principles of PRA

PRA techniques provide an efficient and flexible way of gathering information about a village. Although a variety of techniques are available, all are unified by a few basic principles, described in *Box B.1*.

Box B.1. Basic principles of PRA

Outsiders must take a learning role

Outsiders need to learn from and with local people. They need to find out and use the language and categories of local people and have an attitude of respect or appreciation for local people's knowledge. By adopting this attitude they will be able to develop a better relationship with the local people, from which all the involved parties will benefit.

Information should be cross-checked or triangulated

Any information obtained should be crosschecked by using a number of different perspectives or sources of information (e.g. different villager informants, different PRA techniques) in order to test its accuracy.

Rapid and progressive learning

Outsiders should not set themselves rigid procedures for applying PRA techniques. Instead they should use them in a manner that is flexible, exploratory, interactive and inventive.

Avoid bias

Inaccurate results, also known as bias, occur when one situation or perspective is preferred over another. For instance, a study that fails to include the perspective of women may be gender biased. Professional bias occurs when an individual is selective with information so the results reflect their own agenda, and seasonal bias occurs when a study does not take into account the seasonal change throughout the year. A study that obtains only the perspectives of the village leaders will have yet another form of bias.

Optimal ignorance and appropriate imprecision

Outsiders must have a clear objective of the type of information they will need for participatory inventory. It can be costly to find out more information than is needed, or to be excessively rigorous in the application of scientific methods. Often comparisons, information about broad trends and subjective ranking are all that are required.

Adapted from Freudenberger (1994) and Chambers and Guijt (1995)

B.2.2. How to do PRA

Timing

It is important that the timing of PRA activities is convenient for all participants, whether it is the time of year, the time of week or the time of day. PRA activities should not clash with important village activities.

Selection of informants

PRA activities in a village often begin by identifying key informants who can provide a general overview of the village. These key informants can be village leaders, village elders, school teachers, local merchants and government representatives. Protocol usually requires that village leaders are approached first. Often these key informants are well informed and easy to interview.

The interviewers should not limit themselves to interviewing only key informants. They should also try to interview the whole cross section of people living in the village, including: women, younger men, landless labourers and recent arrivals to the village in order to benefit from their knowledge and perceptions of the village. For participatory inventory, the interviewers must try to find forest specialists who can provide information about the forest and its resources. These forest specialists will not necessarily be among the richer, educated or more articulate members of a village community. In fact, often a village's forest specialists are people with little land and no livestock who rely more heavily on the forest as their primary source of subsistence.

Some communities may object to letting women take part in PRA activities, especially if the outsiders are all men. Men in the village might demean the women's contribution to a general PRA activity or attempt to disrupt PRA activities involving women. If possible, the outsider team should include at least one woman and PRA activities should be done with women in a place that is not too public.

Ensuring information is gathered efficiently

PRA activities should be well recorded and documented by the interviewers. If the activity uses drawings on the ground it is especially important that the information is recorded on paper before it is lost. To reduce duplication of effort all interviewers should share and discuss the information gathered during the day. This information can then be combined in a table or some other visual display for all to see. This can help to organise notes during the PRA activities and assist information sharing and further planning.

B.2.3. PRA techniques

A number of PRA techniques can be used to obtain information. These are described below. Deciding which technique to use depends upon the information that you desire. It is probably best to start by organising a semi-structured interview. You can then use other techniques in conjunction with the interview, if and when appropriate.

Semi-structured interviews (SSIs)

Interviews with villagers are one of the easiest and most efficient ways to gather information. However, formal interviews, which tend to have a carefully prepared sequence of questions, can be long, cumbersome and inflexible. They can also be intimidating for a villager and the quality of the information collected is often poor. For this reason interviews need to be more informal in appearance and flexible in execution. This style of interview is called a semi-structured interview or SSI.

Despite the appearance of being informal SSIs are carefully structured with a checklist of broad interview topics that act as a guide. It is vital that an interviewer listens carefully to what is being said, and challenges answers, asks for back up details, probes for increased depth and specification, and refers forward and back in time. The interviewer must also be observant and learn to pursue areas that are of interest to the informant. The success of a SSI will often depend on the rapport built up between the interviewer and informant, or group of informants. This rapport will largely depend on the way in which the interview begins and the skill of the interviewer. Some of the key considerations of an SSI are listed in *Box B.2*.

Box B.2. Dos and don'ts during semi-structured interviews

Do

- ✓ Choose the right time
- ✓ Interview small groups
- ✓ Introduce yourself
- ✓ Specify roles
- ✓ Be at the level of the villager
- ✓ Use the local language and try to make yourelf understandable
- ✓ Be sincere and genuine
- ✓ Have some knowledge of customs and tradition
- ✓ Be friendly
- ✓ Listen, ask open questions
- ✓ Ask one question at a time
- ✓ Go from general to particular
- ✓ Ask 'to the point' questions
- ✓ Ask for more answers to one question
- ✓ Give enough time for response
- ✓ Observe
- ✓ Thank the villager at the end

Don't

- ✗ Waste people's time
- ✗ Show distaste for local customs
- ✗ Make promises
- ✗ Be beaurocratic
- ✗ Ask leading questions
- ✗ Ask questions which are too personal
- ✗ Ask irrelevant questions
- ✗ Laugh at the villagers or what they say
- ✗ Repeat questions
- ✗ Interrupt
- ✗ Judge
- ✗ Criticise the villagers' answers

Adapted from Thompson et al. (1994)

Extensive note taking by the interviewer is not recommended during SSIs as it can draw the interviewer's attention away from the interview. It might also appear to be rude and disturb the informant. One solution is to use two interviewers, one who leads the interview and another who takes notes. Permission from the informant should be asked and the notetaker should not be too obvious during the interview. If the interviewer is alone, key notes can be taken of names, quantities, varieties, etc. and the full interview written up as soon as possible after the interview has ended, while the information is still fresh in the interviewer's mind.

Walks in the forest with forest experts

Walks in the forest with local forest experts will provide outsiders with the opportunity to discuss the forest and forest resources with villagers in a relaxed and informal environment.

During walks in the forest with experts much of the information required concerning the forest and its resources can be gathered by using semi-structured interviewing techniques. Informants can be asked to illustrate some of what they say about the forest using examples found during the walk. The walks provide the opportunity to view many of the forest resources first hand and obtain a fuller understanding of their appearance, ecology and management.

Participatory sketch map of the village

Making a sketch map of the village helps to orient a newly arrived outsider. It can provide background information about the population of the village and the existing social situation, as well as be used as a medium for further discussion of social and economic issues (see *Figure B.1)*.

A sketch map of the village can be drawn by a group of villagers or a single person. The technique of drawing a sketch map of the village is similar to that for drawing the participatory sketch map of a village's traditional lands.[3]

When making a sketch map, the facilitator should first encourage the group to begin with a central reference point in the village, for instance the school, meeting house or place of worship. From this point the relative location of other landmarks in the village can be added. If the village is small enough, even the individual houses and names of households could be added. The detail required from this map will depend on its use.

Figure B.1. A participatory sketch map of a village shows the location of important houses and features in a village.

[3] *Information about sketch mapping a village's traditional lands is described separately in Appendix C.*

Transects

Transects provide another perspective on land use, forest type and topography in a village area (see *Figure B.2*). Unlike a map, which provides a bird's eye view of a piece of land, a transect sketch illustrates a cross section of the land. The cross section will often pass through the village itself. Transects can be used to obtain information about the major land uses of the village (i.e. agricultural land, areas of primary and secondary forest, etc.) as well as important forest types differing in species composition, soil type and topography.

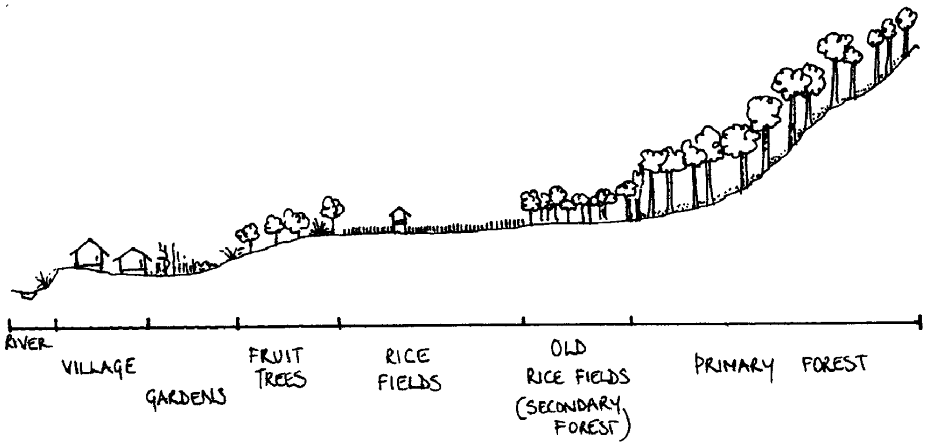


Figure B.2. A transect shows a cross section of the area around a village

A transect can be drawn by a member of the local community from a stationary position either in the village or sitting in a spot with good visibility of the area. Or, the transect can be drawn while travelling through the village land, either by foot or by another form of transport. Within each distinct land use zone or forest type the community member can list important information, such as the types of plants found, economic activities, or management problems.

Trend tables

Trend tables can be used to show and investigate the long term changes or history of a village and its forest. For instance, in the trend table shown in *Figure B.3*, there is a dramatic decline in the collection of rattan after the year 1989. On asking why this was the case it was learnt that the price of rattan fell sharply and it became no longer financially attractive to go to the forest to collect it.

YEAR	VILLAGE EVENT	VILLAGE POPULATION	MAJOR INCOME GENERATING ACTIVITIES	LEVEL OF COLLECTION		
				RATTAN	GAHARU	DURIAN
1995	FLOOD		GAHARU	* *	* * * * *	* * *
1990	ROAD		GAHARU / DURIAN	* *	* * * *	* * * *
1989	SLUMP IN RATTAN PRICE		GAHARU	*	* * *	*
1980	FLOOD		RATTAN	* * * * *	* *	*
1960	VILLAGE SET UP		RATTAN	* * * * *		*

Figure B.3. A trend table shows how a village and the area around it will change over time, it is a good opportunity for older villagers to explain the history of the village.

The information needed to create a trend table can be collected from interviews with individuals or small groups of the more elderly members of the community. A trend table can be drawn with a pen or pencil on a piece of paper or with a stick on a flat area of ground. The first column of the table should consist of significant past events in the village's history (for instance the time the village was founded, forest fires or other times of forest change). These events should be drawn on the paper in chronological order. The remaining columns should represent other variables, such as the village population level, the major income generating activities of the village, or the level of collection of specific forest resources. There is no need for accurate quantification of each variable, but stars drawn or stones placed in the relevant spaces in the table should show the general trends of these variables over time.

Seasonal calendars (or annual activity schedules)

Seasonal calendars can be used to determine events that occur on a seasonal basis (see *Figure B.4*). They can inform an outsider of the villagers' main activities throughout the year, such as when the villagers are most busy with their agricultural lands, either planting or harvesting, and when they are most likely to be collecting resources from the forest. They can also inform outsiders about the seasonal patterns of forest resources, such as their periods of flowering and fruiting.

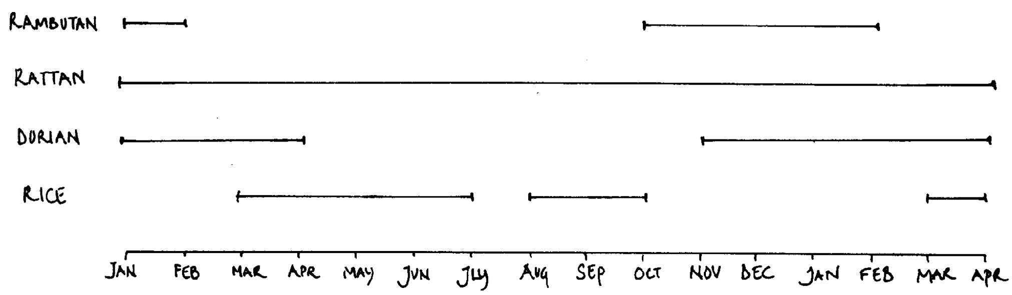


Figure B.4. Seasonal calendars be used to show when a tree or forest resource is in production as with rambutan, rattan and durian or when the villagers are busy farming as with rice.

Seasonal calendars can be either drawn on a large piece of paper or on the ground using twelve holes, or stones, to indicate the months of the year. Sometimes it is better to draw the calendar over fifteen to eighteen months in order to obtain complete cycles. Villagers can then indicate which activities they usually undertake during which months. This technique can also be used to illustrate the quantities of each individual resource that come from the forest over the year. This can be done by placing small stones or seeds next to the hole or stone indicating the specific month. The greater the number of small stones or seeds the larger the yield. Only one forest resource should be discussed at one time.

Scoring and ranking

Scoring and ranking are PRA techniques that can be used to determine the relative importance of different options. This can assist decision making in situations where not all of the options can be chosen. Scoring tends to be quicker and less painstaking than ranking, and may be appropriate for making the first shortlist from of an initial large list of options. Ranking is very time consuming if there are many options in question (i.e. more than 15), but it is the most reliable way of assessing the relative importance of the options, as all options are compared to all others using this method. With ranking you can produce a list where all options are ranked in order of importance. Thus ranking is recommended for making the final cut.

- *Scoring*. Scoring can be done on a large piece of paper or a flat, smooth area on the ground. The names of the options in question (for example, locally important forest resources) are either written on the paper or represented by a symbol or object on the ground (see *Figure B.5*). Village participants then judge the relative importance of each option by drawing stars (if on paper) or placing stones next to the names (if on the ground). The number of stars or stones allotted to each choice will reflect its importance in relation to the other options.

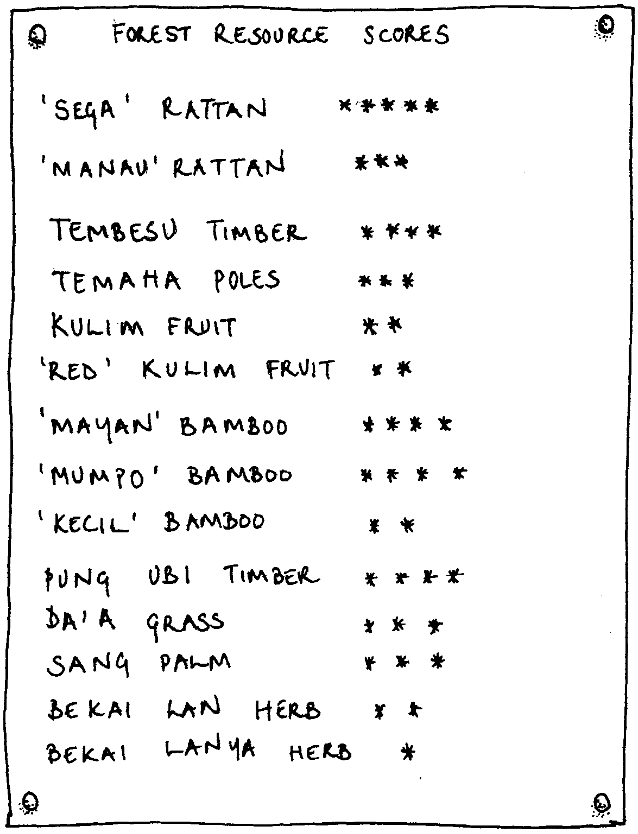


Figure B.5. Scoring is done to try to roughly determine the relative importance of forest resources. Each resource is awarded a number of stars from one to five (five being the most important).

- *Ranking*. Ranking can be done on a square table that has the same number of rows and columns as there are options to be ranked (see *Figure B.6*). This table can be drawn on a large piece of paper or on the ground. The name of the resources to be ranked should be written both along the top and side of the table. The full name of the resource can be shortened to a single letter, or number. Beginning with the resources in the first column and the second row, ask the group which of the two they consider to be more important. A quick way of determining how the group feels is by asking for a show of hands. The chosen resource is then written in the box in the table where the two compared resources converge. Continue with this comparison until all resources in the list have been compared with one another. Then, add up the number of times that each resource was considered more important. The most important resource appears the most number of times. Thus, this resource is ranked number 1, the resource that features second most is ranked number 2, and so on. The result of this process will be a list of the resources ranked by importance.

DURIAN	LANGSAT	RAMBUTAN	MATA KUCING	CEMPEDAK		TOTAL	RANK
	LGT	DRN	MK	DRN	DURIAN	2	3RD
		LGT	MK	LGT	LANGSAT	3	2ND
			MK	RBN	RAMBUTAN	1	4TH
				MK	MATA KUCING	4	1ST
					CEMPEDAK	0	5TH

Figure B.6. Ranking is another tool used to determine the relative importance of forest resources. If you are finding it difficult to decide which resources to include on the inventory ranking is a good system to decide which resource is more important than another.

C

Making a Sketch Map

Objectives

By the end of this appendix, you should be able to do the following:

C.1. Prepare to make a sketch map, and

C.2. Make a sketch map.

Introduction

Participatory sketch mapping is a process in which villagers draw maps of their village area from memory onto a blank piece of paper. Sketch maps are not as accurate as scale maps with respect to scale, orientation or location. For example, one common inaccuracy is for people to draw areas close to the village at a larger scale than more distant areas. However, a sketch map drawn by the villagers will contain far more detailed local information than a scale map made from aerial photographs or radar images. Villagers can often draw relatively correct locations of streams, ridges and footpaths, all features that may be difficult to interpret from aerial photographs or radar images. Villagers may also include information that is impossible for an outside survey team to know or interpret from aerial photographs or radar images, such as local names of places and details of local land uses.

Sketch maps may be used for the following steps of participatory inventory:

- *3. Determining the objectives*. The villagers will need to make decisions about inventory objectives, such as what area of forest will be included in the inventory area and how the inventory area might be subdivided into smaller areas or forest types. It is useful for the villagers to have a map as a focus for discussion and as a document on which to record their decisions. Sketch maps are often easier for villagers to understand and use than scale maps, especially if the villagers have participated in making the sketch maps but not the scale maps.[1]
- *6. Making the planning map*. Sketch maps can be used as a reference for adding information to a planning map, whether this planning map is produced by copying maps, photographs or images or by ground surveying. If the planning map is produced by ground surveying, sketch maps will provide the only available basis for planning the survey work.[2]

---

[1] *Chapter 3 describes how the villagers determine the objectives.*

[2] *Chapter 6 describes how to make the planning map.*

C.1. Prepare to make a sketch map

Preparing to make a sketch map involves the following considerations:

- *Who should make it*. The villagers whom you invite to make the sketch map should ideally be the people who know the forest well. Different groups within the village may know different areas better than others. For example, women may know the areas nearest to the village and young men may know the areas farthest from the village. Try to ensure that a representative from each of these groups is involved in sketch mapping.
- *Timing*. Making a sketch map can be a lengthy process. It might be good to divide the exercise into two sessions, or make arrangements for a break in the middle of the exercise.
- *Location*. Because there are often many people involved in sketch mapping it is important to be in a location where everybody can see the map and make contributions to it. For this reason it is often better to work in a large room. The map should be on the floor or pinned to a wall, rather than on a table where only a few people can be seated around it.
- *Equipment*. The equipment needed to make a sketch map includes 2-3 sheets of large size paper, pencils, pencil sharpeners, erasers, coloured fine nib pens and sticky tape or drawing pins.

C.2. Make a sketch map

C.2.1. Discuss the purpose of the sketch mapping activity

You should begin by discussing with the villagers why they are making a sketch map, as this will influence the information that they will want to put on the map. For example, the sketch map may be used to discuss and determine the inventory objectives, or to make the planning map. The sketch map may also be made for additional purposes that are not related to participatory inventory. After clarifying the purpose, everyone should discuss what information they will want to include on the map.

C.2.2. Getting started

Possibly the most difficult part of sketch mapping is getting the villagers to draw the first line on the paper. It is often best to begin with the location of the village itself or a prominent feature of the landscape, for example a river or road. This will act as a reference point from which the relative position of other features can be drawn. The villagers should also begin by using pencil because they will feel more confident to draw on the map if they know that mistakes can be erased.

C.2.3. Adding information

You should think carefully about the order in which the villagers should add information to the sketch map. It is often best to begin with features that are not difficult or controversial and include more sensitive or difficult information as the activity progresses.

It is often best to start a sketch map by drawing the location of the village, rivers, roads and ridges, and naming them. This provides a good framework to which other information can be added, such as the location of:

- Traditional boundaries of the village's land,
- Administrative boundaries,

- Agricultural lands,
- Types of agricultural land use,
- Forested lands,
- Types of forest or forest use,
- The location of specific forest resources, and
- Any other natural or man-made features.

An example of a sketch map is provided in *Figure C.1*.

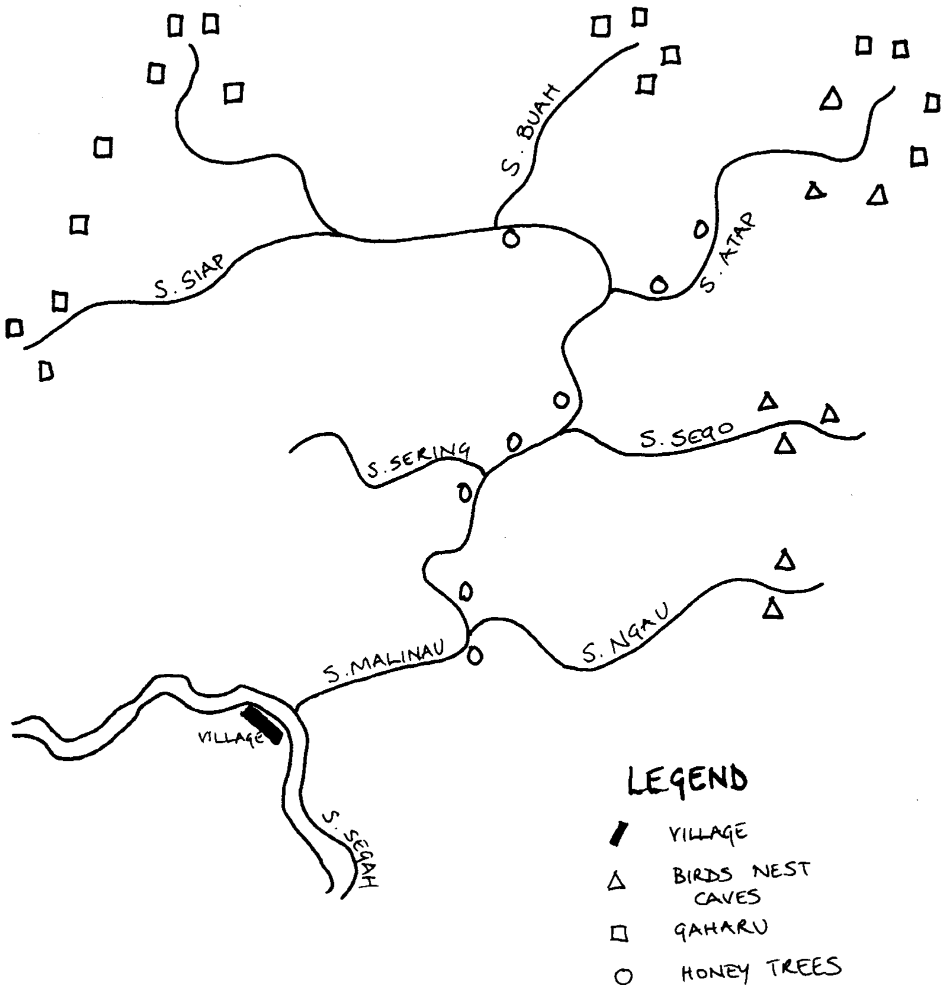


Figure C.1. This sketch map shows the location of the village, the local river system, and areas in the forest where there are concentrations of important forest resources, in this case birds' nest caves, gaharu and honey trees.

C.2.4. Choosing symbols and making a legend

All the features drawn on the map should be classified and each classification represented by a symbol. A symbol is a small diagram that is often drawn with coloured ink. This symbol is then explained in a legend. For example, rivers may be drawn with a solid blue line, ridges with a dotted black line and roads with a solid black line. Villages may be symbolised by a black circle.

D

Balancing Cost and Precision

Objectives

By the end of this appendix, you should be able to do the following:

D.1. Follow the general procedure for balancing cost and precision,

D.2. Make the approximations necessary for balancing cost and precision before the inventory work, and

D.3. (Optional) Make the reassessment necessary for balancing cost and precision after one week of inventory work.

Introduction

When planning an inventory, one of the important decisions that the villagers must make is about their objectives for cost and precision:

- The cost of an inventory is measured in terms of labour and time needed to finish an inventory. The units used are 'teams' and 'days'; for example, 3 teams (of 6 people per team) working for 20 days.[1]
- The precision of an inventory is commonly expressed in terms of the sampling error %. This is the ratio of the 90% confidence range to the estimated mean, expressed as a percentage. Thus an estimated mean of 5 trees per hectare with a 90% confidence range of ±1 trees per hectare will have a sampling error % of 20%.[2]

The aim in inventory is to have as high a precision as possible. A high level of precision is achievable, provided enough plots are established. However, the greater the number of plots, the higher the cost will be. This appendix describes a procedure for estimating whether the villagers' desired precision is compatible with the cost limits that they have set. It also discusses possible courses of action if these two objectives are not found to be compatible.

---

[1] *Chapter 3 defines the cost in more detail.*

[2] *Box 3.3 in Chapter 3 defines the precision in more detail.*

D.1. A general procedure for balancing cost and precision

The steps outlined below provide a general procedure for balancing cost and precision. You should follow this procedure at least once during the course of a participatory inventory, when you make approximations before the inventory work begins. If you feel reasonably confident about making calculations, you should follow this procedure a second time, when you make a reassessment after one week of inventory work. This second time is optional, but recommended, as discussed later.

1. Calculate the number of plots that can be made for the desired cost stated in the community's objectives.[3] These calculations are described in *Section D.2.1*, below, if you are making approximations before the inventory work, and *Section D.3.1*, below, if you are making a reassessment based on one week of inventory work.
2. Estimate what precision can be expected for this number of plots. The way to do this is described in *Section D.2.2* for approximations before the inventory and *Section D.3.2* for reassessment based on one week of inventory work. Note: This relationship between precision and number of plots is not valid for a sampling fraction greater than 5%. You should estimate the sampling fraction, and if it is higher than 5%, consult *Box D.1*.

Box D.1. Why is the precision related to the number of plots and not the sampling fraction?

The influence of the sampling fraction on the precision is assumed to be negligible when the sampling fraction is below 5% (i.e. when the total number of plots that you establish cover less than 5% of your inventory area). This manual has only included the precision calculations that are used when the sampling fraction is less than 5%, as low sampling fractions are almost always the case in forest inventories.

Dawkins (1971) says 'An experience that surprised most of us was the adequacy of information from low sampling fractions, even of very complex communities over large areas. In fact, sampling fraction is a parameter of little account, what matters is the number of independent sampling units (i.e. plots) available.'

However, if your sampling fraction is greater than 5%, it begins to have a significant impact on the precision of your estimates, causing the precision to be higher than that which you will calculate using the equations provided in this appendix. A good rule of thumb is that it is quite likely that you will have an adequate precision if your total number of plots cover between 5% and 20% of the inventory area. Of course, there is no problem with covering more than 20%, even covering as much as 100% (i.e. 100% enumeration), if it can be done for an acceptable cost.

3. Compare the precision estimated in the above step to the desired precision stated in the community's objectives.[4] Note that a precision (sampling error %) of 10% is more precise or greater than a precision (sampling error %) of 20%, even though the number 10 is less than the number 20:

[3] *Chapter 3 describes how the villagers determine the desired cost.*

[4] *Chapter 3 describes how the villagers determine the desired precision.*

- *If the estimated precision is the same as the desired precision*, then the community's cost and precision objectives are compatible at the calculated number of plots.
- *If the estimated precision is greater than the desired precision*, then the community's cost and precision objectives are compatible at the calculated number of plots. However, this result means that fewer plots are needed and hence the cost could be lowered to achieve the desired precision. Reduce the cost of the inventory (i.e. planning for fewer team days), and begin again at step 1 in order to estimate whether this reduced cost can still achieve the desired precision.
- *If the estimated precision is less than the desired precision*, then the community's cost and precision objectives are not compatible. In this case the community must reconsider their objectives. The options for changing the objectives include:
  a) Maintaining cost limits and hence the number of plots, and accepting a lower precision than that which was desired,
  b) Increasing the cost limits by increasing the number of work days, or
  c) Increasing the cost limits by increasing the number of inventory teams.

An illustration of these options is provided in *Example D.1*.

If you are considering these options prior to conducting the inventory work, then you should write them up on a large piece of paper and present them at the general village meeting held to make decisions about the objectives. The community as a whole can then decide which option they would prefer. If you are considering these options after one week of inventory work, you will have to decide whether the villagers should be consulted again, or whether you and the inventory team should decide by yourselves which option is preferable. If you choose to increase the cost limits in order to establish more plots, then you will have to recalculate the location on the planning map of all inventory lines which have not yet been enumerated.[5]

Example D.1. Balancing precision and cost

In Pohon Besar village, the villagers decided that a cost of 45 team days (3 teams and 15 days) was their preferred limit and a precision of 25% or greater was desirable. The inventory team found that the number of plots achievable for their specified cost (by approximation) was 900, and that this number of plots would only give a precision of 30-35% (by approximation). Thus the desired precision was not obtainable for the specified cost. The inventory team therefore presented the following choices back to the village:

- Maintain the time and labour limits and accept that the precision may be 30-35%,
- Increase the number of working days by 11 days while maintaining the same number of teams, making it possible to establish 1560 plots, which should result in a precision of approximately 25%, or
- Increase the number of teams to 5 while retaining the same number of days, making it possible to establish 1500 plots, which should result in a precision of approximately 25%.

[5] *Chapter 7 describes how to locate the inventory lines on the planning map.*

D.2. Make the approximations necessary for balancing cost and precision before the inventory work

Before starting the inventory work, it is important that you make some approximations that can help you make initial plans. You will want to approximate whether the cost and precision objectives set by the villagers are compatible (i.e. whether the desired precision can be achieved at the desired cost limits), and if you think that they are not, you will want to help the villagers to reconsider their options so that they can have objectives that are compatible.[6]

This section provides a method for making these approximations. As you have not yet gathered any inventory data from your area, your approximations are based on the results of two participatory inventories conducted in East Kalimantan and Jambi provinces. In these inventories, 13 to 15 different forest resources, both timber and non-timber, were enumerated in inventory areas that were a mixture of primary forest and old secondary forest. The more the conditions of your inventory differ from these conditions, the less relevant these approximations are likely to be for your situation, and the more important it becomes that you make a reassessment after completing one week of inventory work, as described in the next section..

D.2.1. Approximation of the number of plots that can be made for a given cost

To approximate the number of plots that can be made for a given cost, lessons can be learned from two participatory inventories conducted in East Kalimantan and Jambi provinces. It was found that the number of plots completed in one team day varied with the type of terrain in which the teams were working, such that:

- An average of 20 plots (10 x 50 metres in size) could be completed if the topography was steep, and
- An average of 30 plots (10 x 50 metres in size) could be completed if the topography was flat.

Thus, with some idea of the terrain that you will be working in, you can estimate how many plots can be completed for a given cost. This is illustrated in *Example D.2*.

The desired cost is stated in terms of the total number of team days available for conducting the inventory work. However, not all of these team days are available for making and enumerating plots.[7] For example, if the inventory teams have to camp in the forest, all teams will spend two days in setting up each camp at the beginning and taking it down at the end. Furthermore, all teams will use approximately one out of every ten days for checking the plots that have already been set up. Those team days not spent in making and enumerating plots must be subtracted from the total number of team days.

---

[6] *Chapter 3 discusses how to facilitate decision making by villagers about the cost and precision.*

[7] *Chapter 10 discusses how the days tend to be allocated when planning an overall work schedule.*

Example D.2. Approximating the number of plots from a given cost

In an inventory conducted in Pohon Besar village, there were 23 days available for conducting the inventory. With an estimated 6 days to be used for moving camp and 2 days for checks, this meant that there were 15 (23-6-2 = 15) days available for inventory work. These 15 days were multiplied by the 3 inventory work teams, making 45 team days. Since the forests around Pohon Besar village were almost all on very steep terrain, these 45 team days were multiplied by 20 plots per day. Thus it was approximated that 15 working days x 3 inventory work teams x 20 plots per working day per inventory team = 900 plots of size 10 metres x 50 metres could be completed under the given cost constraints.

D.2.2. Approximation of the precision that can be obtained from a given number of plots

Data obtained from two participatory inventories conducted in East Kalimantan and Jambi were used to calculate the number of plots necessary for specified levels of precision. These are listed in *Table D.1*, below. The precision that should be obtained for a given number of plots can be approximated from this table, as illustrated in *Example D.3*.

Table D.1. The number of plots (of size 10 x 50 metres) necessary to obtain specified levels of precision (for a resource with a CV% of 600%: see Note)

Number of plots	9756	4336	2439	1561	1084	796	610
Precision *(Sampling error %)*	10%	15%	20%	25%	30%	35%	40%

Note: To obtain the values listed in this table, the coefficients of variation (CV%) of all the resources in both inventories were calculated (See *Section D.3.2 (Step 1)* for an explanation of CV%). All resources that had CV%'s greater than 600% were disregarded, as these resources, which amounted to 6 out of the total of 29 resources, were either extremely clustered in distribution or very rare. Data from the most variable of the remaining resources, a resource that had a CV% of 600%, were used to obtain the above values.

Example D.3. Approximating the precision for a given number of plots

In Pohon Besar village, the inventory team approximated that a total of 900 plots could be enumerated under the desired cost limits. Using *Table D.1*, the inventory team approximated that the precision or sampling error % that could be expected for all but the most rare or uneven resources would be approximately 30-35%.

D.3. (Optional) Make the calculations necessary for balancing cost and precision after one week of inventory work

The approximations described above may be very inaccurate if your inventory differs greatly from the two inventories described above. This is because:

- Each inventory differs in the number of plots that can be established for a given cost (i.e. a given number of team days). This relationship will depend upon the number of resources being enumerated, how experienced the inventory teams are, the topography of the inventory area and the weather conditions.
- Each inventory differs in the number of plots that will be needed for a desired precision, as this will depend upon how variable the resources are (i.e. how unevenly the resources are distributed over the inventory area).

For this reason it is recommended that after your first week of work in the field, you use the data you have just collected to reassess whether the planned number of plots is still likely to achieve your cost and precision objectives.[8] These calculations are complicated and for this reason this step is optional, although recommended.

D.3.1. Reassessment after one week of inventory work of the number of plots that can be made for a given cost

A more accurate idea of how many plots can be completed per day can be obtained by conducting the inventory for a week, and then assessing how many plots are being completed, on average, per team per day, as illustrated in *Example D.4*. The inventory planners should keep in mind that the teams are still learning in the first few days, and may well improve their speed later in the inventory.

Example D.4. Reassessing the number of plots for a given cost

Pohon Besar village had a given cost of 45 team days (15 working days and 3 teams). After 4 days of inventory work, the 3 teams were found to complete an average of 22 plots per team per day (264 plots). Thus in the 11 working days that remained, the number of plots that could still be completed were 11 days multiplied by 3 teams multiplied by 22 plots per team per day. This made 726 plots of size 10 x 50 metres. Since 264 plots were already completed (4 days x 3 teams x 22 plots), this made a total of 990 plots that were likely to be completed within the given cost constraints of time and labour..

D.3.2. Reassessment after one week of inventory work of the precision obtainable from a given number of plots

This section describes a way of estimating the precision (expressed as the sampling error %) that can be obtained for a planned number of plots. These calculations can be made after one week of work in the field, using data from only a small proportion of the planned number of plots. The procedure to follow in making this reassessment is as follows:

8 *Chapter 10 recommends reassessing the cost and precision objectives after one week of inventory work.*

Step 1. Select the resource upon which to base the calculation of precision

It is not necessary to calculate the precision of every resource in the inventory. You must select one resource, and use its data to calculate the precision. The selection of the resource to use for calculating the precision may be based on either its relative importance or variability. The importance of a resource is determined subjectively. However, the variability of a resource, in other words how unevenly it is distributed across the inventory area, is expressed mathematically as the 'coefficient of variation' or the CV%. If you decide to base your selection of resource upon its variability, the procedure for calculating the CV% of the resources in question will be described later, in Step 3.

In selecting your resource, you may choose from the following options:

- *The most important resource*. In this case, the resource with the highest priority is selected and the other resources ignored. This may or may not result in an unacceptably low precision for the remaining resources.
- *The mean variability*. Calculate the CV% for each resource, then calculate the mean of all of CV%'s. Use this mean variability in your calculation of precision. This means that all of the resources, on average, will have the calculated precision. The problem with this method is that for some of the resources the resulting precision may be unacceptably low.
- *The most variable resource*. Calculate the CV% for each resource, then choose the resource with the highest CV%. This means that the remaining resources will have a precision higher than that calculated for this resource. The problem with this is that the number of plots needed to obtain the desired precision for this very variable resource may be so high that the cost is not affordable.
- *The most variable resource once the most rare and uneven resources have been eliminated*. Choose a group of resources from the overall list of resource, by using some criterion of variability (e.g. by eliminating all resources for which fewer than 5 plants were counted). From this smaller group, choose the resource with the highest coefficient of variation. The disadvantage is that some resources may be excluded which, although rare, are very important and for which an adequate precision is wanted.

An example of how to select the resource upon which to base the reassessment is provided in *Example D.5*.

Example D.5. Selecting the resource upon which to base the reassessment

After the first week in the field, the villagers of Pohon Besar village used the data that they had collected to calculate the CV% of each of the five resources that they were enumerating in their inventory. These CV%'s ranged from 167% to 603%. The inventory team decided to use the resource with the highest CV%, which was the 'seka' rattan with a CV% of 603%, as the basis for their reassessment.

Step 2. Compile the inventory data for the selected resource

Next, the inventory data that have been collected for the selected resource should be compiled on a compilation form, as described in *Chapter 17*.

Step 3. Use Calculation Form D.1 to calculate the CV% and the precision for the selected resource

Calculation Form D.1 at the end of this appendix provides a structure for calculating the precision (or sampling error %) that can be obtained for a given number of plots. *Chapter 17* provides some general guidelines for using calculation forms. To use the calculation form, complete the steps on the form as follows:

1, 2, 3, 4, 5 and 6. Complete Steps 1 to 6 of *Calculation Form D.1.* These are identical to steps 1 to 6 of *Calculation Form 2*, which have already been described in *Chapter 17*. Write these values in the spaces provided in steps 1 to 6 of *Calculation Form D.1*.

Calculating the CV%

7. Calculate the degrees of freedom, symbolised by *df,* by subtracting 1 from the number of plots that have been established in the first week of inventory work (n). Write the result in the space provided in step 7 of *Calculation Form D.1*. To continue *Examples D.4* and *D.5*, if 264 plots have been established after 4 days, the degrees of freedom is 264 minus 1, or 263. Thus:

   7. Degrees of freedom: $n - 1$, $df = 263$

8. Consult a Student's 't' table[9] to find the appropriate 't' value, symbolised by t. An acceptable probability level to use is 0.1 or 90%, although 0.05 or 95% is even better. The degrees of freedom (df) that is used to look up the t value in the table is equal to the number of plots minus 1 ($n - 1$). The 't' value that you obtain from the table using this probability level and degrees of freedom should be written in the space provided in step 8. To use the above example, the number of plots is 264, meaning that there are 263 degrees of freedom. At a probability level of 0.1 (90%), the appropriate t value in the table in *Appendix J* is 1.65. Thus:

   8. Student's t at P = <u>0.1</u>: $t = 1.65$

9. Calculate the variance, symbolised by Vy, by dividing the "sum of squared deviations from the mean," SSy, by the degrees of freedom, df. Write the result in the space provided in step 9. As an example, the "sum of squared deviations from the mean," which is 38,249, is divided by the degrees of freedom, which is 263. The result is a variance of 145.4. Thus:

   9. Variance: $\frac{SSy}{df}$, $Vy = 145.4$

10. Calculate the standard deviation, symbolised by SDy, by calculating the square root of the variance. Write this value in the space provided in step 10. To get the square root of a value a mathematical operation is made which is the opposite of squaring a value. For instance, if the number 3 squared is 9, then the square root of the number 9 is 3. This calculation is usually written as $\sqrt{9}$. The best way of making this calculation is by using a calculator. Press the '9' button on the calculator, then the '√' button; the number '3' should appear on the calculator's screen. In the example, the square root of the variance, $\sqrt{145.4}$, is 12.06. Thus the standard deviation is:

    10. Standard deviation: $\sqrt{Vy}$, $SDy = 12.06$

[9] *Appendix J contains a t-table and explains what it is and how to use it.*

11. Calculate the coefficient of variation %, symbolised by *CV%*, by dividing the standard deviation, SDy, by the estimated mean, $\bar{y}$, and multiplying the result by 100. Write this answer in the space provided in step 11. Using the example, 12.06 divided by 2.00 and multiplied by 100 is 603%. Thus,

    11. Coefficient of variation %: $100 \times \frac{SDy}{\bar{y}}$, $CV\% = 603\%$

Calculating the precision (sampling error %) obtainable for a given number of plots

12. The planned number of plots for the entire inventory is symbolised by N. The planned number of plots is not the same as the number of plots which have been established in the first week of work, which is symbolised by n. You should determine this value from the cost limits set by the villagers, as described in *Section D.3.1*. Write this value in the space provided in step 12. In this example, the villagers have decided that they can establish a maximum of 990 plots. Thus:

    12. Total number of plots obtainable for a given cost: $N = 990$

13. The sampling error % that is likely to be obtained for the planned number of plots is symbolised by E%. Calculate this by multiplying the coefficient of variation, *CV*%, by the student's t value, and dividing the result by the square root of the planned number of plots, N. Write this answer in the space provided in step 13. Using the example, 603 multiplied by 1.65 and divided by $\sqrt{990}$ is 31.6. Thus:

    13. Sampling error % obtainable for total number of plots: $\frac{CV\% \times t}{\sqrt{N}}$, $E\% = 31.6\%$

Calculation Form D.1

Form for calculating the precision (sampling error %) which is obtainable for a given number of plots

Resource: ______________________________

1. Sum of the number of plants in all plots: $\Sigma y =$ _____
2. Number of plots: $n =$ _____
3. Mean in units of number of plants per plot: $\frac{\Sigma y}{n}$, $\bar{y} =$ _____

4. Sum of the squared number of plants in all plots: $\Sigma(y^2) =$ _____
5. Correction for mean: $\frac{(\Sigma y)^2}{n} =$ _____
6. Sum of squared deviations from the mean: $\Sigma(y^2) - \frac{(\Sigma y)^2}{n}$, $SSy =$ _____

Calculating the CV%

7. Degrees of freedom: $n - 1$, $df =$ _____
8. Student's t at P = ______ $t =$ _____
9. Variance: $\frac{SSy}{df}$, $Vy =$ _____
10. Standard deviation: $\sqrt{Vy}$, $SDy =$ _____
11. Coefficient of variation %: $100 \times \frac{SDy}{\bar{y}}$, $CV\% =$ _____

Calculating the precision (sampling error%) obtainable for a given number of plots

12. Total number of plots obtainable for a given cost: $N =$ _____
13. Sampling error % obtainable for total number of plots: $\frac{CV\% \times t}{\sqrt{N}}$, $E\% =$ _____

E

Information and Analyses Needed for Some Inventory Purposes

Objectives

By the end of this appendix, you should be able to do the following:

E.1. Describe the information and analyses needed for Purposes 1 to 8.[1]

Introduction

Some of the inventory purposes mentioned in this manual can be achieved using the results of the inventory alone.[1] Other purposes cannot be achieved without additional information, some of which can be gathered in studies described in this manual (i.e. productivity studies, recurrent inventories), and some of which must come from outside sources or from studies not described in this manual (i.e. studies of market prices for forest products). Also, for some purposes the analyses that need to be performed are very simple, and for others the analyses are quite complex and beyond the scope of this manual. This appendix outlines the information and analyses that are likely to be needed for some inventory purposes, in order to assist you to:

- Determine, in advance of the inventory, whether you and your inventory team have the resources or capacity to achieve the purpose (i.e. will you be able to gather all of the necessary information and perform all the necessary analyses), and
- Plan and conduct the follow up activities (i.e. further information gathering and analyses) necessary to achieve your inventory purpose.

Many inventory purposes other than those mentioned in the manual may be possible. If your inventory purpose differs from the ones listed in this appendix, it may still help to refer to this appendix to obtain some idea of the information or analyses that may be needed.

---

[1] *Box 1.1 of Chapter 1 describes some possible purposes for conducting an inventory.*

E.1. Information and analyses needed for some inventory purposes

PURPOSE 1. Negotiate for tenure or access to an area of forest by showing which areas are most important to the villagers in terms of the relative density or quantity of forest resources

Information needed from the inventory

- You will need to determine the density and/or quantity of forest resources in each of the smaller areas within the inventory area. If you are estimating quantity, you will also need to map these smaller areas and calculate their size.

Information needed from further studies described in this manual

- None

Information needed from outside sources or further studies not described in this manual

- None

Analyses needed

- You will need to compare smaller areas within the overall inventory area, and rank them in order of resource density or resource quantity. The best way to display these results may be with an inventory results map.[2]
- You will need to decide whether you want to compare the relative density (i.e. the average number of plants in one hectare) or quantity (i.e. the total number of plants) of resources in the smaller areas within the inventory area. The resource density of an area is an important factor in determining the area's importance to a village, but so is the resource quantity which, unlike density, is influenced by the area's size. For example, the villagers may want to show that an area is relatively important to the village because it is dense in certain resources, or because, as it happens to be one of the larger areas near the village, it supplies a large proportion of the overall resource quantity.

Follow up activities needed

- The next action may be for the villagers to decide how to use the inventory results as part of their negotiation strategy.

[2] *Chapter 16 explains how to display relative resource densities or quantities on a map.*

PURPOSE 2. Negotiate for tenure or access to the forest by estimating the minimum area of forest required to maintain a sufficient supply of forest products to the village

Information needed from the inventory

- You will need to determine the density of productive individuals of the forest resources (divided into any age, size, sex or condition categories that may have an influence on their productivity) in each of the distinct forest types in the inventory area. You will also need to map the distinct forest types in the inventory area, and calculate their size.

Information needed from further studies described in this manual

- You will need to conduct a productivity study, which looks at the productivity of different ages, sizes, sexes or conditions of forest resources in different forest types. The productivity study will tell you the approximate quantity of each type of forest product you may expect to harvest in an average year from the inventory area.[3]

Information needed from outside sources or further studies not described in this manual

- You must find out how much of each type of forest product the villagers need in an average year. You may need to consider possible future changes in demand due to changing population levels. This manual does not discuss how to gather this type of information.

Analyses needed

- Compare the amount of each type of forest product that is produced within the inventory area during an average year to the amount that is required by the villagers, to determine whether the inventory area will be able to provide a sufficient supply.
- If the inventory area cannot provide a sufficient supply of forest products to the village, a larger inventory area will be needed to supply the average annual needs.
- If the inventory area provides more than a sufficient supply of forest products, a reduced inventory area will be needed to supply the average annual needs.

Follow up activities needed

- Once the villagers have determined the minimum area that can supply a sufficient amount of forest products for their needs, the next action may be to decide how to present the inventory results as part of their negotiation strategy.

[3] *Appendix M describes how to plan, conduct and analyse a productivity study.*

PURPOSE 3. Predict the impact of a development project on the quantity of forest resources (and possibly their products)

Information needed from the inventory

- You will need to determine the quantity of the forest resources in the area that will be affected by the development project.
- (Optional) If you are quantifying the forest products as well as the forest resources, you will need to determine the density of productive individuals of the forest resources (divided into any age, size, sex or condition categories that may have an influence on their productivity) in each of the distinct forest types in the area that will be affected by the development project. You will also need to map the distinct forest types in the area, and calculate their size.

Information needed from further studies described in this manual

- (Optional) If you are quantifying the forest products as well as the forest resources, you will need to conduct a productivity study, which looks at the productivity of different ages, sizes, sexes or conditions of forest resources in different forest types. The productivity study will tell you the approximate quantity of each type of forest product you may expect to harvest in an average year from the area that will be affected by the development project.[4]

Information needed from outside sources or further studies not described in this manual

- You may need a map that tells you what area will be affected by the development project, unless you can predict the area that will be affected from boundary markers in the forest.

Analyses needed

- No further analyses will be needed for this inventory purpose.

Follow up activities needed

- The next action may be for the villagers to decide how to present the inventory results as part of discussions about the development project.

[4] *Appendix M describes how to plan, conduct and analyse a productivity study.*

PURPOSE 4. Assess the actual impact of a development project on the quantity of forest resources (and possibly their products)

Information needed from the inventory

- You will need to determine the density and quantity of the forest resources in the area that is likely to be affected by the development project.
- (Optional) If you are quantifying the forest products as well as the forest resources, you will need to determine the density of productive individuals of the forest resources (divided into any age, size, sex or condition categories that may have an influence on their productivity) in each of the distinct forest types in the area that will be affected by the development project. You will also need to map the distinct forest types in the area, and calculate their size.

Information needed from further studies described in this manual

- If the development project causes the forest to be completely cleared (i.e. for plantations, transmigration), you will need to map the area that has been cleared.[5]
- If the development project affects but does not completely clear the forest (i.e. logging), you will need to conduct a second inventory, after the development activity, of the same plots that were enumerated in the first inventory, in order to assess its actual impact.[6]
- (Optional) If you are quantifying the forest products as well as the forest resources, you will need to conduct a productivity study, which looks at the productivity of different ages, sizes, sexes or conditions of forest resources in different forest types. The productivity study will tell you the approximate quantity of each type of forest product you may expect to harvest in an average year from the area that will be affected by the development project.[7]

Information needed from outside sources or further studies not described in this manual

- None

Analyses needed

- If the development project completely clears the forest, you will need to calculate the size of the area that has been cleared. Use this information to estimate how many of the forest resources, or possibly their products, have been lost.
- If the development project affects but does not completely clear the forest, you will need to assess its impact by comparing the results of the second inventory with those of the first.

Follow up activities needed

- The next action may be for the villagers to decide how to present the inventory results as part of discussions about the development project.

---

[5] *Chapter 6 describes how to map an area.*

[6] *Appendix L describes how to mark plots more permanently, so they can be found again..*

[7] *Appendix M describes how to plan, conduct and analyse a productivity study.*

PURPOSE 5. Conduct an economic evaluation of the forest products in an area

Information needed from the inventory

- You will need to determine the density of productive individuals of the forest resources (divided into any age, size, sex or condition categories that may have an influence on their productivity) in each of the distinct forest types in the inventory area. You will also need to map the distinct forest types in the inventory area, and calculate their size.

Information needed from further studies described in this manual

- You will need to conduct a productivity study, which looks at the productivity of different ages, sizes, sexes or conditions of forest resources in different forest types. The productivity study will tell you the approximate quantity of each type of forest product you may expect to harvest in an average year from the inventory area.[7]

Information needed from outside sources or further studies not described in this manual

- You will need to find out the market prices of the forest products. This manual does not discuss how to gather this type of information.

Analyses needed

- You will need to conduct an economic evaluation of forest products. This manual does not discuss how to do the necessary analyses.

Follow up activities needed

- The next step will be for the villagers to think of how to present the results of the economic evaluation to the people making decisions about the area.

PURPOSE 6. Plan the location of forest management zones, based on relative resource density and environmental information.

Information needed from the inventory

- The villagers may want to specify in advance some environmental criteria upon which to base the zonation of their forest (e.g. angle of the slope, soil type). Or, they may wish to directly assess the distinct forest types that are in the inventory area at present.
- You will need to determine the density of forest resources in each of the areas which have the environmental criteria specified above (and/or the distinct forest types). You will also need to map these areas (and/or distinct forest types).

Information needed from further studies described in this manual

- You may want to map the environmental information in more detail.[8]

Information needed from outside sources or further studies not described in this manual

- None

Analyses needed

- None

Follow up activities needed

- The next action will be for the villagers to use the inventory results to plan the location of forest management zones, and some simple regulations for managing them.

---

[8] *Chapter 6 describes how to make a map.*

PURPOSE 7. Plan a sustainable level of harvesting for specific forest resources

Information needed from the inventory

- You will need to determine the density of all individuals of the forest resources (divided into any age, size, sex or condition categories that may have an influence on their productivity) in each of the distinct forest types in the inventory area. You will also need to map the distinct forest types in the inventory area, and calculate their size.

Information needed from further studies described in this manual

- You will need to conduct a productivity study, which looks at the productivity of different ages, sizes, sexes or conditions of forest resources in different forest types. The productivity study will tell you the approximate quantity of each type of forest product you may expect to harvest in an average year from the inventory area.[9]
- You will need to conduct a regeneration study. You should also plan to repeat this study every one to five years.[10]

Information needed from outside sources or further studies not described in this manual

- None

Analyses needed

- This manual discusses a very simple way to plan the harvesting level, using a method described by Peters (1996) as 'successive approximation'.[10] This method cannot immediately predict a sustainable level of harvesting. Instead, it involves monitoring the impact of exploitation on the resource population and adjusting the level of harvesting accordingly.
- Another method described by Peters (1996) involves the use of matrix models and computer simulations. This method is more complicated and time consuming, but it can be used to predict a sustainable harvesting level after a relatively short period of study, compared to the 'successive approximation' method. You should refer to Peters' manual for further information on how to use this method of analysis.

Follow up activities needed

- The villagers will need to implement, monitor and if necessary modify their plans for harvesting rotation.

PURPOSE 8. Plan forest management by combining Purposes 6 and 7.

This purpose will need the information and analyses of both Purposes 6 and 7.

---

9 *Appendix M describes how to plan, conduct and analyse a productivity study.*

10 *Appendix L describes how to plan, conduct and analyse regeneration studies.*

F

Five Features of Maps

Objectives

By the end of this appendix, you should be able to do the following:

F.1. Describe and use the scale,
F.2. Describe the orientation,
F.3. Describe the grid reference and co-ordinates,
F.4. Describe the legend, and
F.5. Describe the date.

Introduction

This appendix discusses five features common to maps:

- *Scale*, which shows the relationship between the distance drawn on the map and the distance on the ground,
- *Orientation*, which shows the direction of north,
- *Grid reference and co-ordinates*, which describe where the mapped area is located on the globe,
- *Legend*, which explains what the symbols used on the map mean, and
- *Date*, which states when the map was created.

F.1. Scale

Scale is the term used to describe the relationship between a distance between two points on a map and the same distance on the ground. On a 'large scale' map it is possible to see an area in much greater detail than on a 'small scale' map. If you need to make a planning map, as described in *Chapter 6*, you will have to select the scale that is best for showing your whole inventory area.

There are two ways in which scale is usually expressed on a map. These are by:

- Fraction scale, and
- Graph scale.

F.1.1. Fraction scale

Scale is most commonly expressed on a map as a fraction scale. Some examples of fraction scales are:

- 1:5 000,
- 1:10 000, or
- 1:250 000.

The number to the left of the symbol ':' represents the distance on the map, and is usually the number 1. The number to the right of the symbol ':' represents the distance on the ground, and can be any of a range of numbers. The symbol ':' is used to say that the number on the left (in other words 1), when drawn on the map, 'represents' the number on the right, on the ground. The two numbers are always of the same unit (e.g. centimetres, millimetres, etc.).

For instance, if a map has a scale of 1:10 000, this means that one centimetre on the map represents 10 000 centimetres on the ground. As there are 100 centimetres in one metre, 10 000 centimetres on the ground is the same as 100 metres on the ground, so:

- A scale of 1 centimetre : 10 000 centimetres

is the same as:

- A scale of 1 centimetre: 100 metres.

Table F.1 can be used to express units of distance as millimetres, centimetres, metres or kilometres.

Table F.1. How to express units of area as millimetres, centimetres, metres or kilometres

	km	*m*	*cm*	*mm*
1 kilometre or km =	1	1000	1×10^5	1×10^6
1 metre or m =	0.001	1	100	1000
1 centimetre or cm =	1×10^{-5}	0.01	1	10
1 millimetre or mm =	1×10^{-6}	0.001	0.1	1

The fraction scale of a map can be used to calculate the distance on the ground from the distance on a map. A distance on the map must be measured in centimetres, using a ruler. This number in centimetres is then multiplied by the number to the right of the colon symbol to get the distance on the ground. The distance on a map can also be calculated from the distance on the ground using the fraction scale. A distance on the ground, expressed in centimetres rather than metres, must be divided by the number to the right of the colon symbol to get the distance on the map. *Example F.1* provides examples of how the fraction scale of a map may be used.

Example F.1. Using the map's fraction scale to calculate distances on the ground from distances on the map and vice versa

In the 1:25 000 scale map depicted in *Figure F.1*, the distance between the village and the bridge is 3 centimetres. Since this is 3 times 1 centimetre on the map, it therefore represents 3 times 25 000 centimetres on the ground. In other words, 3 centimetres on the map represents 75 000 centimetres (or 750 metres) on the ground.

If we begin with the distance on the ground the distance measured between the village and the bridge is 750 metres (or 75 000 centimetres) when measured on the ground. If this is divided by 25 000 centimetres the result is 3, thus this distance on the ground will be represented by 3 centimetres on the map.

F.1.2. Graph scale

Scale can also be expressed by a graph scale (see *Figure F.1*). This looks like a small ruler, usually printed in the margin of the map. The distances displayed on the graph scale represent the equivalent distance on the ground. Graph scales usually begin at 0, but some extend to the left of 0. When using graph scales, care should be taken to make sure that your measurements begin at 0. *Example F.2* provides examples of how the graph scale is used.

Example F.2. Using the map's graph scale to calculate distances on the ground from distances on the map and vice versa

In *Figure F.1*, the distance between the village and the bridge is 3 centimetres on the map. This 3 centimetre distance is measured with a ruler and this distance is compared with the graph scale. The graph scale will show that this distance on the map is equal to 750 metres on the ground.

If we begin with the distance on the ground, the distance between these two points is 750 metres when measured on the ground. The 750 metre point on the graph scale is 3 centimetres from the '0' mark, thus this is the distance on the map that is used to represent 750 metres on the ground.

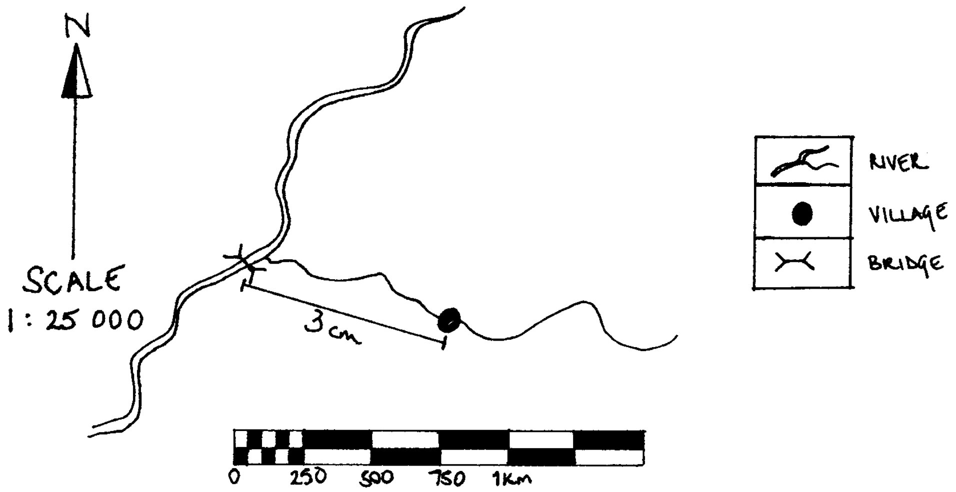


Figure F.1. A 1:25 000 map showing examples of fraction scale, graph scale, orientation (the north arrow) and symbols.

Graph scales are easy to make from fraction scales. If, for example, the fraction scale is 1:25 000 then 1 cm on the map is the same as 25 000 centimetres (250 metres) on the ground. A line should be drawn on the map with a ruler and marked with a tick every 1 cm. Next to each tick, the numbers '0 m', '250 m', '500 m', '750 m', and so on should be written.

Graph scales are easier to use if you are changing the scale of the map with a photocopy machine. If the size of a map is enlarged or reduced, the graph scale will change at the same rate and will therefore remain accurate. However, if the map only has a fraction scale then a new fraction scale must be calculated and written on the map after the map has been enlarged or reduced.

F.2. Orientation

The earth rotates on an axis with the North Pole at one end and the South Pole at the other. The location of the North Pole relative to any other point on the globe provides a standard reference for orientation. The convention for plotting orientation on a map is to have north pointing towards the top of the page (see *Figure F.1*).

There are really two north poles on the earth. These are:

- True north, which is located at a fixed point on the globe, and
- Magnetic north, which is located where the magnetic lines of force come together.

True north is close, but not exactly the same, as magnetic north (see *Figure F.2*). The north drawn on a map is usually true north, which does not move. However, a compass, which is an instrument used to determine orientation, points to magnetic north, which moves slightly every year.

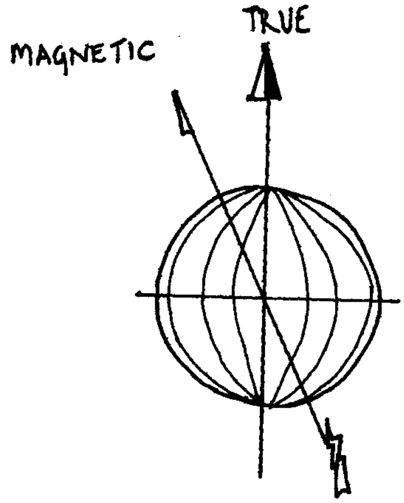


Figure F.2. True north and magnetic north are not the same. The difference between the two is called magnetic declination.

The angle between true north and magnetic north is called the magnetic declination. The declination varies from place to place, and can be either to the east or west. Most maps have a small diagram (see *Figure F.3*) which shows the difference between true north and magnetic north (in other words the magnetic declination). This is usually shown with two arrows the angle between them is expressed in degrees. The declination will be smaller the closer to the equator. In Indonesia the declination is less than 4° and can therefore be ignored in all but the most precise maps.

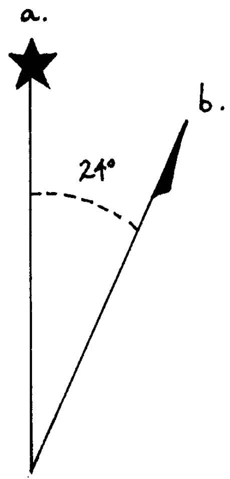


Figure F.3. Most accurate maps show the difference between true north a) and magnetic north b) using a small diagram to show the declination between the two bearings.

F.3. Grid reference and co-ordinates

A map's exact location on the earth is described using the co-ordinates of a grid reference. A grid reference is based on imaginary grid lines, some of which run horizontally from east to west around the globe and others which run vertically from north to south (see *Figure F.4*). The exact position of every point on the globe can be identified by knowing its position along these horizontal and vertical lines. This position is called its co-ordinates.

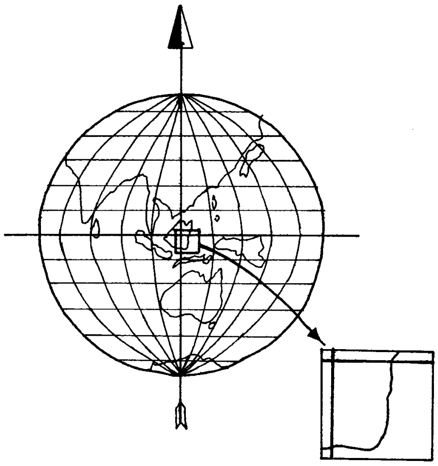


Figure F.4. Maps with latitude and longitude or UTM use a grid system to locate the exact position of every point on the globe.

There are several types of grid reference used. Among the most common are:

- Latitude and longitude, and
- Universal transverse mercator (or UTM).

F.3.1. The latitude and longitude

The most popular grid reference is latitude and longitude. Latitude refers to the horizontal east-west lines, and longitude to the vertical north-south lines. The lines of latitude and longitude are numbered in degrees, minutes and seconds. Degrees of latitude are measured 0° to 90° north and south from the equator, which is a line that travels around the globe exactly halfway between the north and south poles. Degrees of longitude are measured 0° to 180° east and west of the prime meridian that is a line that passes through Greenwich, England. Longitude lines are aligned with true north. Further subdivisions, measured in minutes and seconds, are numbered from 0 to 60. Every point on the planet can be identified by its co-ordinates where the latitude and longitude lines cross. An example of a point in Kalimantan might be a longitude of 117°45'10"E (117 degrees, 45 minutes and 15 seconds east of the meridian) and a latitude of 02°35'10"N (2 degrees, 35 minutes and 10 seconds north of the equator).

F.3.2. The universal transverse mercator (UTM)

An alternative, although not so common, grid is the Universal transverse mercator (UTM). A UTM grid, like a latitude and longitude grid, has lines running from north to south and east to west. However, the north lines on a UTM grid represent a third type of north called grid north. UTM uses a metric numbering system and works in sequences of 10's and 100's. Numbers in the margin are written as '10^{000}'. Because UTM uses a metric grid system it is less complicated to use than the latitude and longitude system.

Understanding the map grid system will help in ordering maps, aerial photographs and radar or satellite imagery from the organisations which distribute them, if the co-ordinates required can be determined for your inventory area.

F.4. Legend

The legend is used to explain the symbols on the map. Symbols are small diagrams, lines or shaded areas (see *Figure F.5*) used to represent natural and man-made features, such as buildings, boundaries, rivers, roads, swamps, forest resources and different types of land or forest use. Although the meaning of some symbols may be obvious, there will be others that are not. It is important to include all symbols and their meaning in a legend so that a person who was not involved with making the map can look at the legend and understand the information being displayed by the map.

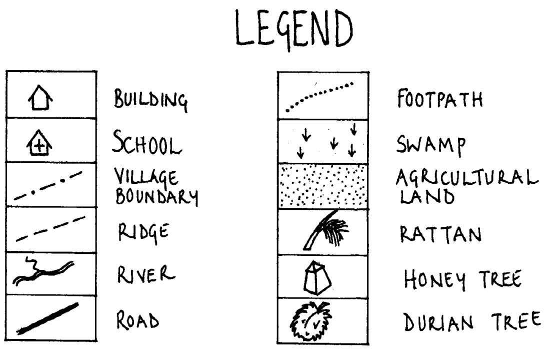


Figure F.5. Symbols are often used on maps to represent features on the ground. A legend is used to explain the meaning of these symbols.

The symbols shown on a map will vary greatly in appearance, depending primarily on the type of map. However, some symbols are standard. For example, a north arrow shows orientation. Also, major roads are usually depicted with solid lines, while smaller roads are shown with a dotted or dashed line.

Symbols drawn on maps are usually not drawn to scale. Roads and paths are usually given standard widths to match the type of track rather than their exact measurements. Rivers and streams are similarly standardised.

F.5. Date

Although some information on a map is unlikely to change, such as the location of a river or mountain, other information may be changing at a much more rapid rate, such as the pattern of land use around a village. The date at which the map was made should be written on the map to show at what time the information displayed on the map was current.

G

Scale Maps, Aerial Photographs and Radar Images

Objectives

By the end of this appendix, you should be able to do the following:

G.1. Explain what scale maps, aerial photographs and radar images are, and

G.2. Obtain all available scale maps, aerial photographs and radar images of your inventory area.

Introduction

Early in the planning stages of the inventory, you should try to obtain all available scale maps, aerial photographs and radar images that cover your inventory area. These maps, photographs and images will all provide you with valuable information about your area, which you will need for planning and conducting the inventory, and for calculating the final results. You may be lucky enough to find a scale map that you can use directly as a planning map. However, in most cases, you will have to copy, modify and build upon whatever maps, photographs and images you can find in order to make your own planning map, or failing that, make your map by ground surveying. This appendix explains what scale maps, aerial photographs and radar images are. It also describes how to try to obtain them.

G.1. What are scale maps, aerial photographs and radar images?

There are a number of different types of map and remote sensing imagery (this is a term used to describe photographs and images of the ground that have been taken from the air in a balloon, aeroplane or satellite). Each provides spatial information about an area, in other words, information about how an area's features are positioned in relation to one another. At the same time, each differs in the type of information that they display. This is partly due to the different technologies used to make them. It is also partly due to the purpose for which they were made, as the people making them will have made decisions about what information to include and what to leave out.

The remainder of this section describes some types of maps and remote sensing imagery, including:

- Scale maps,
- Aerial photographs, and
- Radar images.

The advantages and disadvantages of each for use in making a planning map are also discussed.

G.1.1. Scale maps

A scale map is any map that displays a scale.[1] Some important types of scale maps include:

- Land survey maps,
- Topographic maps, and
- Other scale maps.

Land survey maps

Land survey maps are produced by surveying an area of ground.[2] These maps provide information about the location of surveyed features such as rivers, roads, or ridges.

The advantage of using land survey maps is that they:

- Contain accurate information about the features that have been surveyed, such as rivers, roads and ridges.

The disadvantage of using land survey maps is that they:

- May not contain detailed information about an area (i.e. smaller streams or ridges), as surveying every feature in an area takes a lot of time.

Topographic maps

Topographic maps contain contour lines which give a three dimensional appearance to a map. These maps are copied from aerial photographs using special visual equipment that enables the person doing the copying to see the photographs in three dimensions. Other information can also be added to these maps.

---

[1] *Appendix F describes five important features of maps, including scale.*

[2] *Chapter 6 describes how to make a land survey map.*

The advantages of using topographic maps are that they:

- Contain information about the topography of an area, and
- Are understood and used by professional people (like foresters and other government planners).

The disadvantage of using topographic maps is that they:

- Require some training for non-professional people in how to understand and use them.

Other scale maps

Other scale maps are produced by copying information from aerial photographs, radar and satellite images.

The advantage of these maps is that they:

- Remove unnecessary information from the original photographs or images.

The disadvantages of these maps are that they:

- Rely on the original photograph or image being accurate, and
- Vary in accuracy depending upon the skill with which they are interpreted.

G.1.2. Aerial photographs

An aerial photograph is a coloured or a black and white photograph taken from a balloon or aeroplane. Because the photo is taken at a fixed distance above the ground it is possible to calculate the scale of the photograph. The plane will also be following a known bearing, often along the latitudinal or longitudinal grid lines, which means that the orientation and co-ordinates of the map are also known. Thus an aerial photograph will usually contain most of the basic features of a scale map. Like a radar image, described below, an aerial photograph displays the topography of the land as well as different land uses. It also shows some features which radar images do not, such as rock formations or rapids.

The advantage of using aerial photographs is that they:

- Give an accurate overall perspective of an area, including the topography and the location of rivers, ridges, different land uses and other natural and man-made features.

The disadvantages of using aerial photographs are that they:

- Are often difficult or expensive to obtain,
- May be out of date,
- Require some training in understanding and interpreting them, and
- May become stretched towards the edges because of the shape of the camera lens, although modern aerial photography equipment often compensates for this distortion.

G.1.3. Radar images

A radar image, or radar map as it is often called, shows a black and white image of the ground. As with an aerial photograph, a radar image is taken from an aeroplane. However, unlike an aerial photograph, a radar image is taken using radar wave equipment that can take these images even on cloudy days. A radar image has scale, orientation and co-ordinates, as does a scale map. Compared to an aerial photograph, the shape of the land is more obvious, but some man-made features are more difficult to determine because of the lack of colour.

The advantage of using radar images is that they:

- Give an accurate overall perspective of an area, including the topography and the location of rivers, ridges, different land uses and other natural and man-made features.

The disadvantages of using radar images are that they:

- Are often difficult or expensive to obtain,
- May be out of date,
- Require some training in understanding and interpreting them as features are often not obvious from the image, and
- Have areas of darkness or shadows, which have been missed due to the angle at which the radar equipment was set to take the image.

G.2. How to find scale maps, aerial photographs and radar images

Some sources of maps, photographs and images include:

- Government organisations,
- Forestry companies or other companies,
- Development agencies and projects,
- Universities, and
- Non-governmental organisations.

These are each described below.

G.2.1. Government

In Indonesia, a large number of government departments produce maps on the national, regional and district level. Some of these government bodies include:

- BAKOSURTANAL (the Co-ordinating Agency for Surveys and Mapping, Ministry of Research and Technology), based in Bogor, Java. BAKOSURTANAL produces a number of detailed, large scale topographic maps. These are available through order. Aerial photographs and radar images are also available, but you must first obtain security clearance.

  Address: BAKOSURTANAL, Jln Raya Jakarta, Bogor Km 46, #82062 - 67, Cibinong, Bogor.
- BAPPEDA (Agency for Planning Regional Development) will often have, or have access to, maps at the provincial (TK 1) and district (TK 2) level. BAPPEDA has good quality maps of some areas, but their coverage is not extensive.

  Address: A BAPPEDA office will usually be located in the provincial or district capital.
- JANTOP TNI-AD (the army mapping unit) also produces topographic maps.

  Address: JANTOP, Jln. Gunung Sahari 90, Jakarta Pusat, Jakarta, Java.

Scale maps, aerial photographs and radar images may also be available from other government agencies, including forestry, agricultural and transmigration departments at the national, regional and district level. However, they may not be willing to share this information.

In theory anybody can apply for maps, photographs or images through official government bodies. The procedure for applying is to write a letter to the government organisation, describing what type of map is required and how the map will be used. However, before applying for certain maps (usually maps or imagery that have been taken from an aeroplane) it will be necessary to apply for security clearance from:

- PUSURTA ABRI (the military centre for surveys and mapping)
  Address: Jl. Dr Wahidin I/II, Jakarta Pusat, Jakarta, Java

G.2.2. Forestry companies or other companies

If forestry companies are working in a specific area of forest they will usually have good quality, detailed maps of the area. Other companies working in the area, such as agribusinesses or mining companies, should also have maps. It might be worth trying to ask a local office to lend or give you a map.

G.2.3. Development agencies

If foreign development agencies, such as DFID, CIDA, USAID, EEC or GTZ, are working in your area, they may also have maps or know how to obtain them.

G.2.4. Universities

Geography, geology, forestry and agriculture departments in universities may also have maps or know how to obtain them. This is most likely if the department has being doing any work in the area for which the map is wanted.

G.2.5. Non governmental organisations

Small local non governmental organisations (NGOs) and larger national and international NGOs may also have maps or know how to obtain them. In Indonesia there is a national network for NGO's interested in mapping. They are:

- JKPP (Network for Participatory Mapping)
  Address: Jalan Citarum B XI/12, Bogor 16152, Java

H

Surveying Techniques

Objectives

By the end of this appendix, you should be able to do the following:

H.1. Measure horizontal distance, and

H.2. Determine direction with a compass.

Introduction

This appendix describes two important techniques used for ground surveying as well as for establishing inventory lines. These techniques are how to measure horizontal distance and how to determine direction using a compass.

H.1. Measuring horizontal distance

When you look at any map the distance between two points is measured as the horizontal distance. In other words, the distance between these two points is as if they were on level ground. If the ground between the two points is actually very hilly, the distance travelled walking up and down these hills between the two points will be much further than the horizontal distance between the same points (see *Figure H.1*). The distance that is walked along the ground is called the slope distance.

In participatory inventory the horizontal distance is used to measure all distances between points on the ground. This is because of the relationship between maps and inventories. Maps are used to plan inventories. Sometimes information gathered while conducting inventories is used to improve the maps. If horizontal distances are measured on the ground, rather than slope distances, they will correspond more consistently to the horizontal distances on the maps. Thus using horizontal distances on the ground makes inventories more accurate as well as better able to improve the content of the maps.

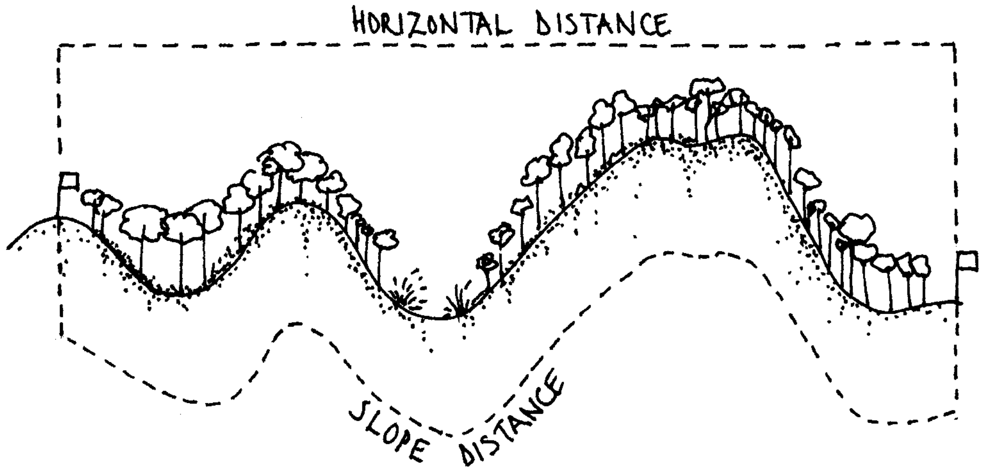


Figure H.1. During participatory inventory and mapping most measurements of distance use horizontal distance.

If the ground is level then the horizontal distance can be measured directly between two points, making sure that these points are an equal height from the ground. However, if there is a slope, there are two methods that can be used to measure horizontal distance:

- Measuring horizontal distance by holding the rope or tape level, or
- Determining horizontal distance from measurements of the angle of the slope and the slope distance.

H.1.1. Measuring horizontal distance by holding the rope or tape level

This method varies with the steepness of the slope:

- If the slope is not too steep, then the people at either end of the nylon rope or metre tape which is being used to measure the distance must hold it level by raising or lowering their end of the rope or tape (see *Figure H.2*).

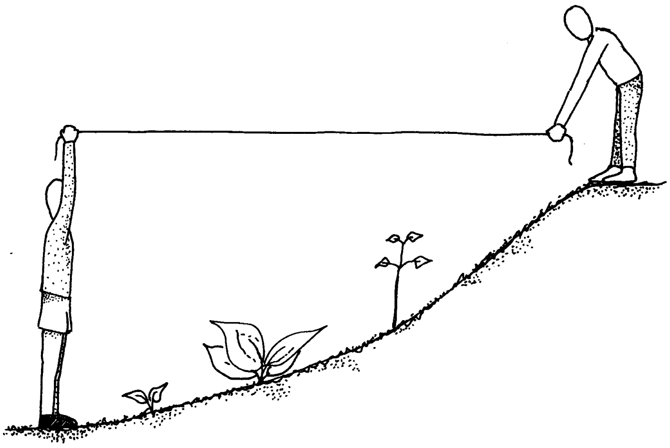


Figure H.2. **If a slope is not too steep, the horizontal distance can be measured by raising or lowering the end of the measuring rope until it is horizontal.**

- If the slope is very steep, and if you are establishing the inventory line1 in 10 metre subplot segments,[1] then step chaining may be necessary (see *Figure H.3*). In step chaining the 10 metre horizontal distance is broken into steps of smaller horizontal distances (two steps of five metres, or more steps of even smaller distances if the slope is very steep). The compass bearer and rope person measure horizontal distances over 'steps' at which it is still possible to hold the rope or tape measure level. A full subplot length has been measured when these smaller 'steps' of horizontal distance add together to a total length of 10 metres.

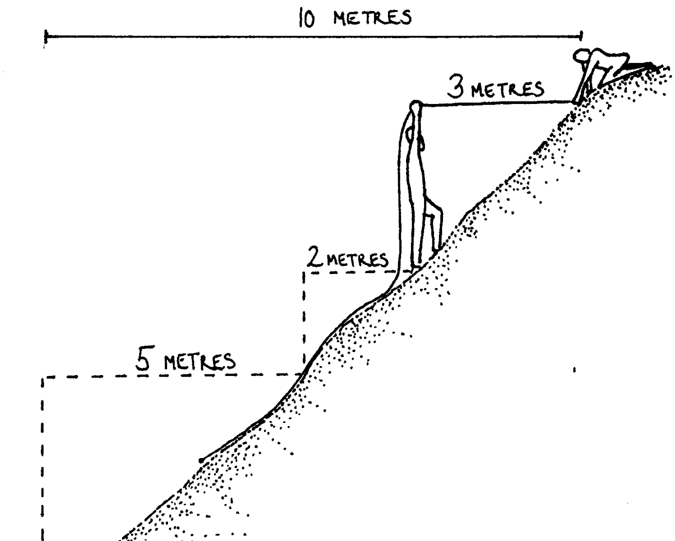


Figure H.3. **Step chaining is used to measure a horizontal distance in steep terrain.**

[1] *Chapter 13 discusses establishing the inventory line.*

H.1.2. Determining horizontal distance from measurements of the angle of the slope and the slope distance

The horizontal distance can also be determined from measurements of the angle of the slope and the slope distance. You must do this in two steps:

1. Measure the angle of the slope.
2. Measure the slope distance and look both measurements up in a slope table to determine the approximate horizontal distance.

Both of these steps are described below.

Measuring the angle of the slope

The angle of the slope is the incline angle of the slope plane from the horizontal plane (see *Figure H.4*). Some instruments do not measure the angle of the slope directly but measure the percentage of the slope instead. The percentage of the slope is the ratio of the vertical distance to the horizontal distance, expressed as a percentage. The percentage can be converted to the angle using the first two columns of *Table H.1* at the end of this appendix.

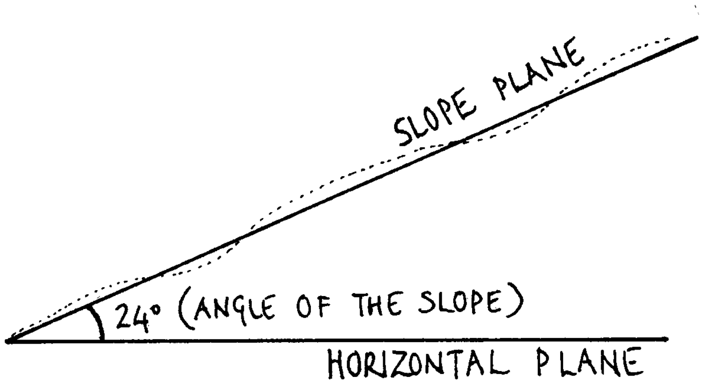


Figure H.4. The angle of the slope.

There are several instruments that can be used to measure the angle or percentage of the slope. These are described below:

- *Clinometer*. A clinometer has a dial that is similar in appearance to a compass, with degrees marked out along its rim. However, whereas the compass dial rotates on a horizontal plane, the clinometer dial rotates on a vertical plane (see *Figure H.5*). The clinometer user looks through a viewing hole and sights on an object further up or down the slope. This object should be at the same height from the ground as the clinometer (it helps to use points at identical heights on two sighting sticks for this). Often both the angle and the percentage of the slope can be read from a clinometer dial.

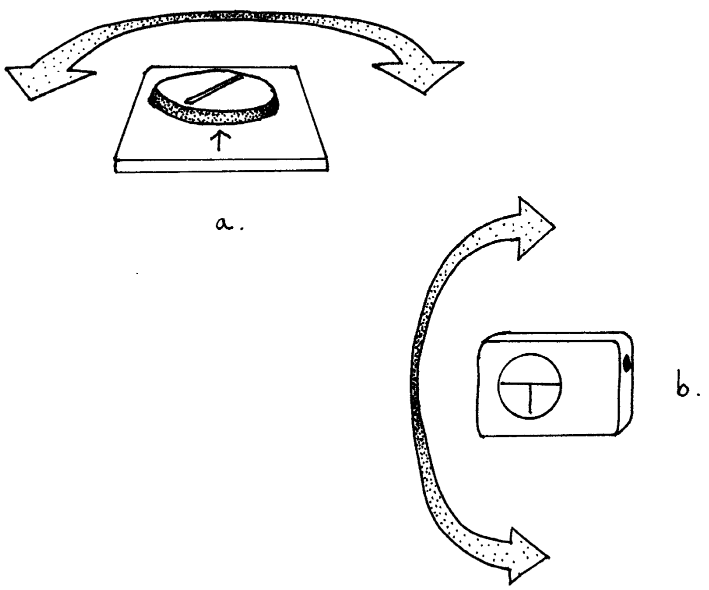


Figure H.5. A compass dial a) rotates on a horizontal plane whereas a clinometer dial b) rotates on a vertical plane.

- *Compass with slope needle*. Some compasses have a slope needle set into them that act the same as a clinometer. To read a slope needle the user holds the compass on its side (see *Figure H.6*) so that the long edge of the compass base plate follows the angle of the slope. The angle of the slope can then be read from the dial.

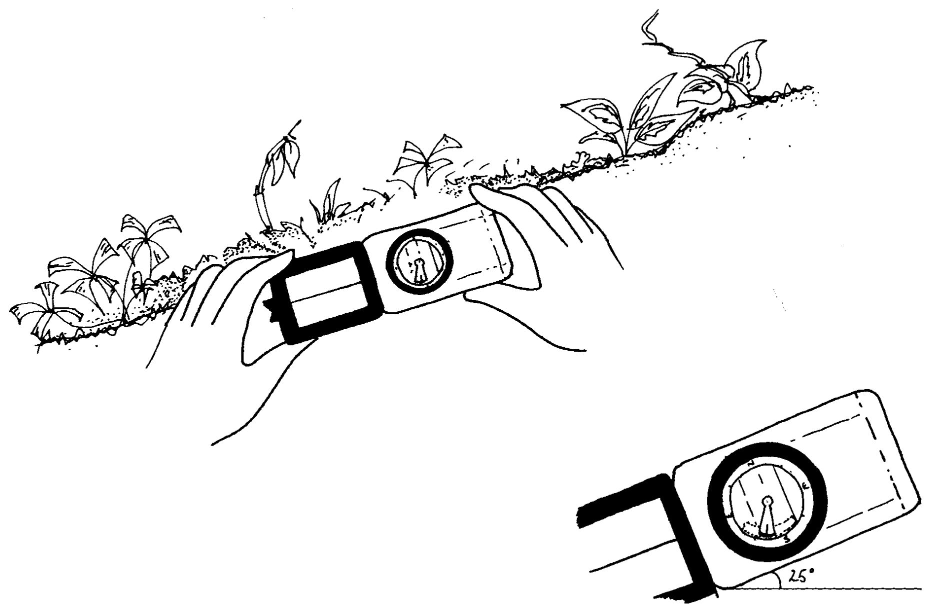


Figure H.6. Some compasses have a slope needle that can be used for measuring the angle of a slope.

- *Homemade slope measuring tool*. To make this tool, cut out a piece of cardboard in the shape of a quarter of a circle. Using a protractor, draw marks representing 0° to 90° on its rim (see *Figure H.7*). This tool should then be held at eye level in a vertical position, with the 90 mark facing upwards. This vertical position can be estimated by lining the tool up against an erect tree. While keeping the tool in this position, read the angle of the slope.

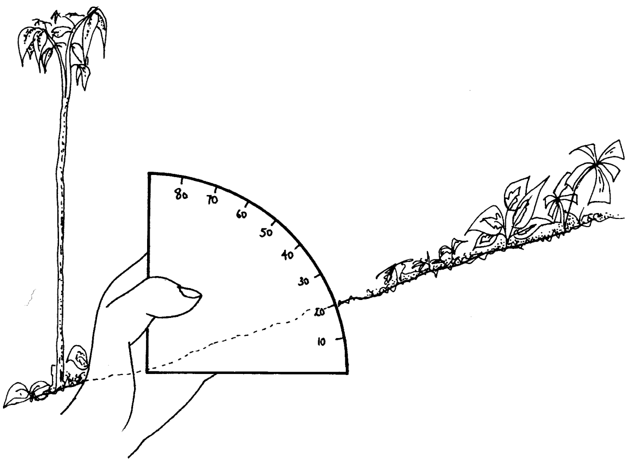


Figure H.7. A tool made from cardboard can also be used to measure the angle of a slope.

Consulting a slope table

After determining the angle of the slope, you should look it up in one of two slope tables at the end of this appendix (*Tables H.1 and H.2*). The table to use will depend upon whether you are ground surveying or establishing an inventory line:

- *If you are making a map by ground surveying*, you will need to use *Table H.1*. When making a traverse from point A to point B, measure the slope distance as well as the angle of the slope.[2] Look up the intersection of these two measurements in *Table H.1* to determine the horizontal distance between point A and point B. You will notice that *Table H.1* only gives you horizontal distances for slope distances that are between 10 to 50 metres and are some multiple of two (e.g. 10, 12, 14, ..., 50). If your slope distance is some other value, you can still estimate the horizontal distance corresponding to it by following these steps:

  1. Find the slope distance in *Table H.1* that is closest to your slope distance value.
  2. Find the horizontal distance that corresponds to this slope distance and your angle of the slope.
  3. Subtract the horizontal distance found in step 2 from the slope distance found in step 1 to find the correction used.
  4. Subtract that same correction from your slope distance value to obtain the horizontal distance that corresponds to your slope distance value.

An example is given in *Example H.1.*

[2] *Chapter 6 describes making a map by ground surveying.*

[3] *Chapter 13 describes establishing the inventory line.*

Example H.1.	**Determining the horizontal distance that corresponds to a slope distance not found in Table H.1.**

A survey team measured a slope distance of 36.4 metres and an angle of the slope of 23 degrees. They determined the horizontal distance as follows:

1. The slope distance in *Table H.1* that was closest to their slope distance was 36 m.
2. The horizontal distance that corresponded to 36 metres in *Table H.1* (at 23 degrees) was 33.1 metres.
3. The correction was 36 - 33.1 = 2.9 metres.
4. The horizontal distance that corresponds to the team's slope distance was therefore 36.4 - 2.9 = 33.5 metres.

- *If you are establishing an inventory line in 10 metre subplot segments,*[3] you will need to use *Table H.2*. Establish a subplot segment of approximately 10 metres and measure the angle of the slope. Look up this reading in the field in *Table H.2* to determine the slope distance. The compass person and the rope person should then measure out this exact distance between subplot markers in order to obtain a horizontal distance of 10 metres.

H.2. Measuring direction with a compass

H.2.1. What is a compass?

A compass is a tool that provides a quick and accurate means of determining where north is. This has several uses. It enables the person using the compass:

- To move accurately in any direction that he or she has selected from a map (this is called following a bearing), and
- To determine the direction of other features in relation to his or her own position (this is called taking a bearing to a feature).

Both of these skills will be explained later.

A compass works by means of a magnetised 'needle', which is a small, thin strip of metal balanced inside an oil filled capsule (see *Figure H.8*). The needle is free to rotate on a pin in response to the Earth's magnetism. This means that it always points to the magnetic north. The oil filled capsule is mounted on a base plate on which the compass user can rotate it. The capsule will usually have an orientating arrow and parallel lines marked on the bottom side, below the needle.

[4] *Chapter 5 discusses the type of compass that you will need for participatory inventory.*

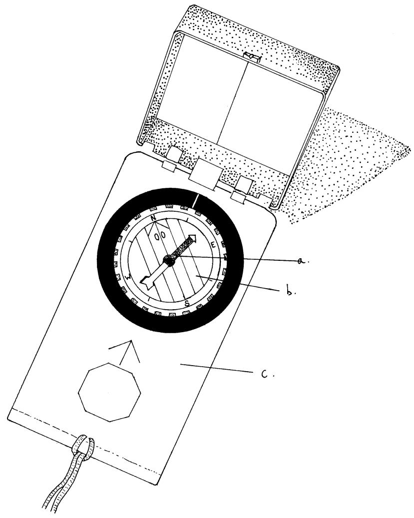


Figure H.8. A mirror hand held compass, with a) a magnetised needle, which is balanced inside b) an oil filled capsule, which is mounted on c) a base plate.

The outer rim of the capsule is called the compass dial, and is marked with a series of numbers representing degrees (*Figure H.9*). These go from 0° (north) clockwise past 90° (east), 180° (south), 270° (west), and back to 0° again (which is also 360°). Smaller ticks mark every 2 or 5 degrees.

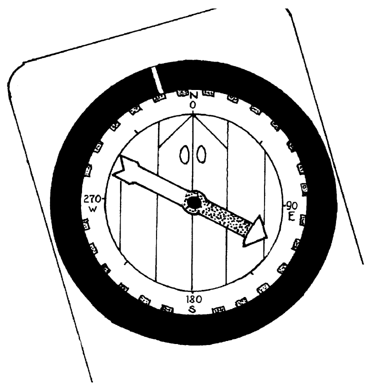


Figure H.9. The outer rim of the compass dial is marked with a series of numbers representing degrees. North is represented by 0°, east by 90°, south by 180° and west by 270°.

You may have a compass which is different from the compasses depicted in the figures. There are many different types of compasses, but the basic principles behind how they work is the same.[4]

H.2.2. Holding the compass

Some general guidelines for holding a compass are as follows:

- The base plate must be held level so that the magnetic needle can turn freely. Special care needs to be taken when sighting up or down a slope, as the compass user is more likely to hold the compass at an angle.
- Because a compass works using the earth's magnetism it is very sensitive to other magnets and metal objects. The compass should be kept at least three metres away from parangs,

wire fences, or vehicles. The people using the compass should not have a parang either in their hands or on their bodies. Special care needs to be taken with strong magnets (for instance radio speakers) because they can actually damage the compass if they come too close.

- The compass user should always try to hold the compass in the same hand and in as close to the same position as is practical each time. He or she should also look through the compass with the same eye. This will standardise the bearings, or directions, taken with the compass by that user.

The way to hold a compass will also depend upon the type of compass being used, as described below.

Simple hand held compasses

This compass is usually held at stomach height and close to the body so that you can look down onto the compass. This position helps to ensure that the compass is held level and that the true relationship of the needle to the markings on the capsule is seen.

While holding the compass in this position, you must imagine a line extending exactly straight out from the sighting line on the compass (see *Figure H.10*). You will use this extended sighting line to follow a bearing or take a bearing on some feature.

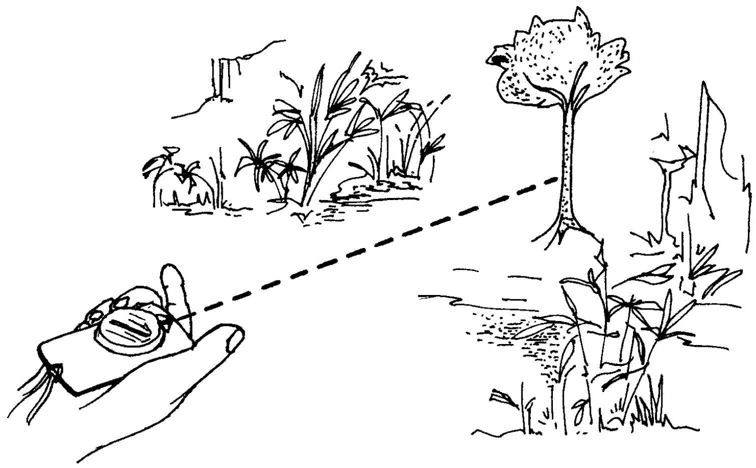


Figure H.10. When using a compass to take or follow a bearing you must imagine a line extending directly forward from the sighting arrow of the compass.

Mirror hand held compasses

This compass should be held at arm's length and at eye level (*Figure H.11*). With a mirror compass, the bearing is followed or taken by reading the reflection of the compass dial in the mirror and not the compass dial itself. You should adjust the angle of the cover of the compass, in which the mirror is housed, so that the reflection of the top of the compass dial can be seen clearly in the mirror (see *Figure H.12*). When sighting up or down a hill, you can raise or lower the angle of the mirror in order to see better up or down the slope.

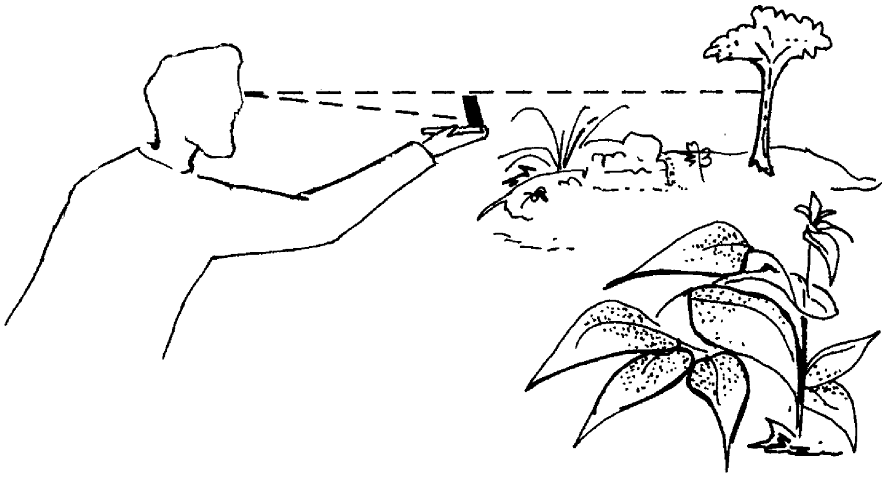


Figure H.11. A mirror compass should be held at arms length and at eye level.

Look through the 'v' shaped sight found on top of the cover of the compass, as you would look through the sights of a gun. The line from your eye through the sight is called the sighting line. This will be used to follow or take a bearing.

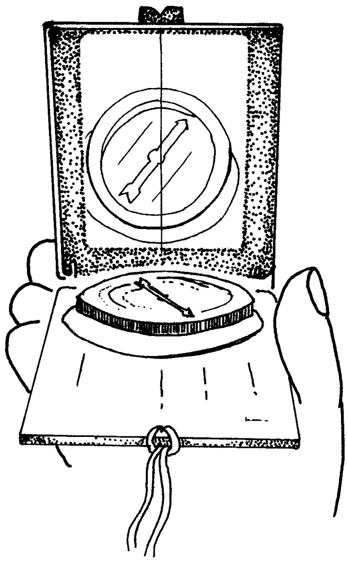


Figure H.12. When taking a bearing with or following a bearing with a mirror compass, you should hold the compass at eye level and read the bearing in the mirror's reflection.

H.2.3. Using a compass

Taking a bearing from a map

It is possible to determine the direction, or bearing, from one point on a map to another using a compass (or protractor) and a map. The steps required are described below:

1. Draw a line in pencil on the map, between the two points of interest.
2. Place the compass on the map so that the long edge of the base plate lies along the pencil line (*Figure H.13*). If using a protractor, place it so that the centre point of the protractor lies on the pencil line.
3. Keeping the compass in this position, turn the dial so that the meridian lines in the centre of the dial are exactly parallel with any meridian lines (north-south) on the map (see *Figure H.13*). If the map has no meridian lines make a meridian line with a ruler and pencil, by drawing a line across the map parallel with the north arrow. The magnetic needle plays no part during this process of aligning the meridian lines. If using a protractor, rotate it on the map (keeping its centre point on the drawn line) until the axis from the 0° point to the 180° point on the rim of the protractor is parallel to any meridian lines on the map.
4. Look for and write down the degree reading found on the outer rim of the compass dial or protractor that is aligned with the line drawn in pencil. If your inventory work team will be walking from point A to B in the field, make sure the bearing read on the map is from the perspective of point A to B and not from point B to A. If you have read the bearing from B to A, you can calculate the opposite bearing from A to B as described below.

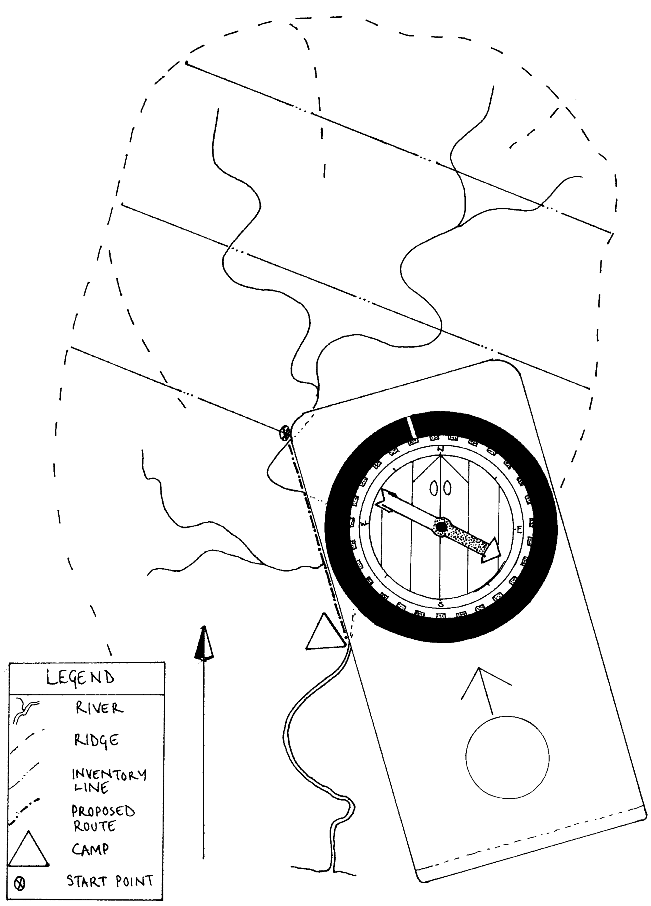


Figure H.13. A compass can be used to take a bearing from a map.

Calculating the opposite or perpendicular bearings of a bearing

Once a bearing has been taken from a map, it is often useful to calculate the opposite and perpendicular directions of this bearing. This is because, for example:

- Two teams might decide to walk to the same starting point and work in opposite directions along an inventory line, or
- A team might need to walk in a direction that is at right angles (i.e. perpendicular) to another line.

These bearings can be worked out by understanding their relationship to the original bearing of a line. One direction is opposite to another if there is a 180° difference between the two bearings. To use a simple example, the opposite of the north bearing, or 0°, is the south bearing, or 180°.

The mathematics of adding and subtracting 180° complicated by the fact that if the result is higher than 360° it begins again at 0°. Thus determining the opposite direction of the original bearing will depend upon what the original bearing is:

- If the original bearing is less than (or equal to) 180°, add 180° to the bearing, and
- If the original bearing is greater than (or equal to) 180°, subtract 180° from the bearing.

Bearings at right angles to the original bearing are 90° more than and 90° less than the original bearing. Thus the line at right angles to the north-south line should have the east bearing, or 90°, or its opposite direction the west bearing, or 270°.

As with determining the opposite bearing, determining the perpendicular directions of the original bearing will depend upon what the original bearing is:

- If the original bearing is greater than or equal to 90°, add 90° and 270° to the bearing,
- If the original bearing is between 90° and 270°, add 90° to the bearing and subtract 90° from the bearing, and
- if the original bearing is greater than or equal to 270°, subtract 90° and 270° from the bearing.

An example is provided in *Example H.2*.

Example H.2. Calculating the opposite and perpendicular directions of the original bearing

In this example the original bearing is 210°:

Opposite direction: As the original bearing is greater than 180°, the opposite direction must be calculated by subtracting 180° from 210°, which gives a result of 30°.

Perpendicular directions: As the original bearing is between 90° and 270°, the perpendicular directions must be calculated by adding 90° to 210°, which gives a result of 300°, and subtracting 90° from 210°, which gives a result of 120°.

Following a bearing in the field

Following a bearing in the field means that the compass user walks a straight line in the field using the compass to keep to a predetermined direction. During participatory inventory, inventory teams follow bearings in the forest that they have previously determined from a map.

To follow a bearing, you should rotate the compass dial until the desired degree reading is aligned against the indicator mark at the top of the compass. *Figure H.14* shows a compass dial that has been rotated to follow a bearing of 80°. Hold the compass in the correct position and pivot yourself and the compass together until the orientating arrow is lined up with the magnetic needle and the north-pointing end of the needle is between the orientating marks. The sighting line, or the sight on top of the cover of the compass, should now face in the desired direction or bearing.

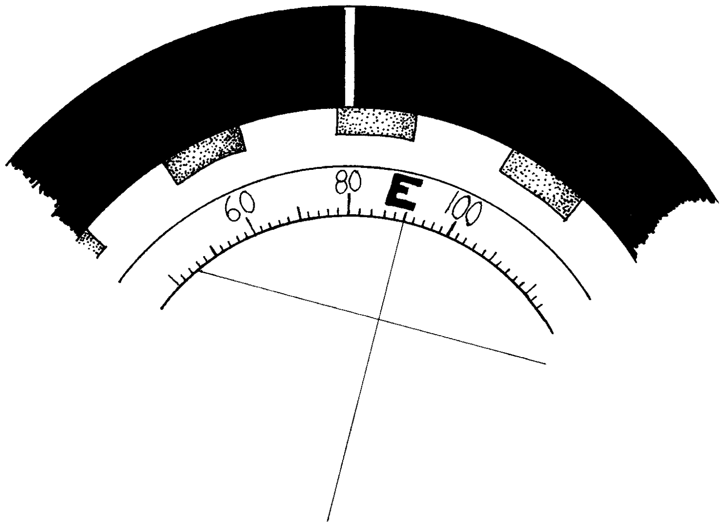


Figure H.14. The compass dial must first be rotated to the desired bearing

When following a compass bearing in the field, it is often easiest to look for an object that is in line with the sighting line, then walk directly to that object, rather than try to walk while reading the compass continually. Sight on a distant object and a close object and keep them aligned when walking. To make it even easier to follow a bearing, another person can hold a sighting stick specifically for the purpose of helping you to take a bearing. You can direct this person to move the stick to the left or the right until it is properly aligned with the sighting line. Using a sighting stick is more accurate but takes more time.

Taking a bearing of a feature in the field

Sometimes the compass is used to take a bearing from the point where the compass bearer is standing to another feature. This method is used a lot when making a map. To sight on a feature, you must hold the compass in the correct way and point it directly at the feature. This feature may be a natural feature such as a mountain, or a sighting stick such as is used when surveying. Align the compass dial with the magnetic needle such that the north-pointing end of the needle is between the orientating marks. Read the number on the outer rim of the compass dial that is aligned with the indicator mark. This is the bearing from the compass to the feature.

Table H.1. Slope table for determining horizontal distance when making a map by ground surveying

		Slope distance (metres)									
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*	*26*	*28*
% of slope	*Angle of slope*	*Horizontal distance (metres)*									
2	1	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
3	2	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
5	3	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
7	4	10.0	12.0	14.0	16.0	18.0	20.0	21.9	23.9	25.9	27.9
9	5	10.0	12.0	13.9	15.9	17.9	19.9	21.9	23.9	25.9	27.9
11	6	9.9	11.9	13.9	15.9	17.9	19.9	21.9	23.9	25.9	27.8
12	7	9.9	11.9	13.9	15.9	17.9	19.9	21.8	23.8	25.8	27.8
14	8	9.9	11.9	13.9	15.8	17.8	19.8	21.8	23.8	25.7	27.7
16	9	9.9	11.9	13.8	15.8	17.8	19.8	21.7	23.7	25.7	27.7
18	10	9.8	11.8	13.8	15.8	17.7	19.7	21.7	23.6	25.6	27.6
19	11	9.8	11.8	13.7	15.7	17.7	19.6	21.6	23.6	25.5	27.5
21	12	9.8	11.7	13.7	15.7	17.6	19.6	21.5	23.5	25.4	27.4
23	13	9.7	11.7	13.6	15.6	17.5	19.5	21.4	23.4	25.3	27.3
25	14	9.7	11.6	13.6	15.5	17.5	19.4	21.3	23.3	25.2	27.2
27	15	9.7	11.6	13.5	15.5	17.4	19.3	21.3	23.2	25.1	27.0
29	16	9.6	11.5	13.5	15.4	17.3	19.2	21.1	23.1	25.0	26.9
31	17	9.6	11.5	13.4	15.3	17.2	19.1	21.0	23.0	24.9	26.8
32	18	9.5	11.4	13.3	15.2	17.1	19.0	20.9	22.8	24.7	26.6
34	19	9.5	11.3	13.2	15.1	17.0	18.9	20.8	22.7	24.6	26.5
36	20	9.4	11.3	13.2	15.0	16.9	18.8	20.7	22.6	24.4	26.3
38	21	9.3	11.2	13.1	14.9	16.8	18.7	20.5	22.4	24.3	26.1
40	22	9.3	11.1	13.0	14.8	16.7	18.5	20.4	22.3	24.1	26.0
42	23	9.2	11.0	12.9	14.7	16.6	18.4	20.3	22.1	23.9	25.8
45	24	9.1	11.0	12.8	14.6	16.4	18.3	20.1	21.9	23.8	25.6
47	25	9.1	10.9	12.7	14.5	16.3	18.1	19.9	21.8	23.6	25.4
49	26	9.0	10.8	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2
51	27	8.9	10.7	12.5	14.3	16.0	17.8	19.6	21.4	23.2	24.9
53	28	8.8	10.6	12.4	14.1	15.9	17.7	19.4	21.2	23.0	24.7
55	29	8.7	10.5	12.2	14.0	15.7	17.5	19.2	21.0	22.7	24.5
58	30	8.7	10.4	12.1	13.9	15.6	17.3	19.1	20.8	22.5	24.2
60	31	8.6	10.3	12.0	13.7	15.4	17.1	18.9	20.6	22.3	24.0
62	32	8.5	10.2	11.9	13.6	15.3	17.0	18.7	20.4	22.0	23.7
65	33	8.4	10.1	11.7	13.4	15.1	16.8	18.5	20.1	21.8	23.5
67	34	8.3	9.9	11.6	13.3	14.9	16.6	18.2	19.9	21.6	23.2
70	35	8.2	9.8	11.5	13.1	14.7	16.4	18.0	19.7	21.3	22.9
73	36	8.1	9.7	11.3	12.9	14.6	16.2	17.8	19.4	21.0	22.7
75	37	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4
78	38	7.9	9.5	11.0	12.6	14.2	15.8	17.3	18.9	20.5	22.1
81	39	7.8	9.3	10.9	12.4	14.0	15.5	17.1	18.7	20.2	21.8
84	40	7.7	9.2	10.7	12.3	13.8	15.3	16.9	18.4	19.9	21.4
87	41	7.5	9.1	10.6	12.1	13.6	15.1	16.6	18.1	19.6	21.1
90	42	7.4	8.9	10.4	11.9	13.4	14.9	16.3	17.8	19.3	20.8
93	43	7.3	8.8	10.2	11.7	13.2	14.6	16.1	17.6	19.0	20.5
97	44	7.2	8.6	10.1	11.5	12.9	14.4	15.8	17.3	18.7	20.1
100	45	7.1	8.5	9.9	11.3	12.7	14.1	15.6	17.0	18.4	19.8
104	46	6.9	8.3	9.7	11.1	12.5	13.9	15.3	16.7	18.1	19.5
107	47	6.8	8.2	9.5	10.9	12.3	13.6	15.0	16.4	17.7	19.1
111	48	6.7	8.0	9.4	10.7	12.0	13.4	14.7	16.1	17.4	18.7
115	49	6.6	7.9	9.2	10.5	11.8	13.1	14.4	15.7	17.1	18.4

Table H.1. *Continued*

		Slope distance (metres)										
		30	*32*	*34*	*36*	*38*	*40*	*42*	*44*	*46*	*48*	*50*
% of slope	*Angle of slope*	*Horizontal distance (metres)*										
2	1	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0	46.0	48.0	50.0
3	2	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0	46.0	48.0	50.0
5	3	30.0	32.0	34.0	36.0	37.9	39.9	41.9	43.9	45.9	47.9	49.9
7	4	29.9	31.9	33.9	35.9	37.9	39.9	41.9	43.9	45.9	47.9	49.9
9	5	29.9	31.9	33.9	35.9	37.9	39.8	41.8	43.8	45.8	47.8	49.8
11	6	29.8	31.8	33.8	35.8	37.8	39.8	41.8	43.8	45.7	47.7	49.7
12	7	29.8	31.8	33.7	35.7	37.7	39.7	41.7	43.7	45.7	47.6	49.6
14	8	29.7	31.7	33.7	35.6	37.6	39.6	41.6	43.6	45.6	47.5	49.5
16	9	29.6	31.6	33.6	35.6	37.5	39.5	41.5	43.5	45.4	47.4	49.4
18	10	29.5	31.5	33.5	35.5	37.4	39.4	41.4	43.3	45.3	47.3	49.2
19	11	29.4	31.4	33.4	35.3	37.3	39.3	41.2	43.2	45.2	47.1	49.1
21	12	29.3	31.3	33.3	35.2	37.2	39.1	41.1	43.0	45.0	47.0	48.9
23	13	29.2	31.2	33.1	35.1	37.0	39.0	40.9	42.9	44.8	46.8	48.7
25	14	29.1	31.0	33.0	34.9	36.9	38.8	40.8	42.7	44.6	46.6	48.5
27	15	29.0	30.9	32.8	34.8	36.7	38.6	40.6	42.5	44.4	46.4	48.3
29	16	28.8	30.8	32.7	34.6	36.5	38.5	40.4	42.3	44.2	46.1	48.1
31	17	28.7	30.6	32.5	34.4	36.3	38.3	40.2	42.1	44.0	45.9	47.8
32	18	28.5	30.4	32.3	34.2	36.1	38.0	39.9	41.8	43.7	45.7	47.6
34	19	28.4	30.3	32.1	34.0	35.9	37.8	39.7	41.6	43.5	45.4	47.3
36	20	28.2	30.1	31.9	33.8	35.7	37.6	39.5	41.3	43.2	45.1	47.0
38	21	28.0	29.9	31.7	33.6	35.5	37.3	39.2	41.1	42.9	44.8	46.7
40	22	27.8	29.7	31.5	33.4	35.2	37.1	38.9	40.8	42.7	44.5	46.4
42	23	27.6	29.5	31.3	33.1	35.0	36.8	38.7	40.5	42.3	44.2	46.0
45	24	27.4	29.2	31.1	32.9	34.7	36.5	38.4	40.2	42.0	43.9	45.7
47	25	27.2	29.0	30.8	32.6	34.4	36.3	38.1	39.9	41.7	43.5	45.3
49	26	27.0	28.8	30.6	32.4	34.2	36.0	37.7	39.5	41.3	43.1	44.9
51	27	26.7	28.5	30.3	32.1	33.9	35.6	37.4	39.2	41.0	42.8	44.6
53	28	26.5	28.3	30.0	31.8	33.6	35.3	37.1	38.8	40.6	42.4	44.1
55	29	26.2	28.0	29.7	31.5	33.2	35.0	36.7	38.5	40.2	42.0	43.7
58	30	26.0	27.7	29.4	31.2	32.9	34.6	36.4	38.1	39.8	41.6	43.3
60	31	25.7	27.4	29.1	30.9	32.6	34.3	36.0	37.7	39.4	41.1	42.9
62	32	25.4	27.1	28.8	30.5	32.2	33.9	35.6	37.3	39.0	40.7	42.4
65	33	25.2	26.8	28.5	30.2	31.9	33.5	35.2	36.9	38.6	40.3	41.9
67	34	24.9	26.5	28.2	29.8	31.5	33.2	34.8	36.5	38.1	39.8	41.5
70	35	24.6	26.2	27.9	29.5	31.1	32.8	34.4	36.0	37.7	39.3	41.0
73	36	24.3	25.9	27.5	29.1	30.7	32.4	34.0	35.6	37.2	38.8	40.5
75	37	24.0	25.6	27.2	28.8	30.3	31.9	33.5	35.1	36.7	38.3	39.9
78	38	23.6	25.2	26.8	28.4	29.9	31.5	33.1	34.7	36.2	37.8	39.4
81	39	23.3	24.9	26.4	28.0	29.5	31.1	32.6	34.2	35.7	37.3	38.9
84	40	23.0	24.5	26.0	27.6	29.1	30.6	32.2	33.7	35.2	36.8	38.3
87	41	22.6	24.2	25.7	27.2	28.7	30.2	31.7	33.2	34.7	36.2	37.7
90	42	22.3	23.8	25.3	26.8	28.2	29.7	31.2	32.7	34.2	35.7	37.2
93	43	21.9	23.4	24.9	26.3	27.8	29.3	30.7	32.2	33.6	35.1	36.6
97	44	21.6	23.0	24.5	25.9	27.3	28.8	30.2	31.7	33.1	34.5	36.0
100	45	21.2	22.6	24.0	25.5	26.9	28.3	29.7	31.1	32.5	33.9	35.4
104	46	20.8	22.2	23.6	25.0	26.4	27.8	29.2	30.6	32.0	33.3	34.7
107	47	20.5	21.8	23.2	24.6	25.9	27.3	28.6	30.0	31.4	32.7	34.1
111	48	20.1	21.4	22.8	24.1	25.4	26.8	28.1	29.4	30.8	32.1	33.5
115	49	19.7	21.0	22.3	23.6	24.9	26.2	27.6	28.9	30.2	31.5	32.8

Table H.2. Slope table for determining the slope distance to measure on the ground for a horizontal distance of 10 metres

Percentage (%) of slope	*Angle of slope*	*Slope distance*
2	1	10.00
3	2	10.01
5	3	10.01
7	4	10.02
9	5	10.04
11	6	10.06
12	7	10.08
14	8	10.10
16	9	10.12
18	10	10.15
19	11	10.19
21	12	10.22
23	13	10.26
25	14	10.31
27	15	10.35
29	16	10.40
31	17	10.46
32	18	10.51
34	19	10.58
36	20	10.64
38	21	10.71
40	22	10.79
42	23	10.86
45	24	10.95
47	25	11.03
49	26	11.13
51	27	11.22
53	28	11.33
55	29	11.43
58	30	11.55
60	31	11.67
62	32	11.79
65	33	11.92
67	34	12.06
70	35	12.21
73	36	12.36
75	37	12.52
78	38	12.69
81	39	12.87
84	40	13.05
87	41	13.25
90	42	13.46
93	43	13.67
97	44	13.90
100	45	14.14
104	46	14.40
107	47	14.66
111	48	14.94
115	49	15.24

I

Why We Have Chosen to Sample with Inventory Lines

Objectives

By the end of this appendix, you should be able to do the following:

- I.1. Explain why we chose systematic strip sampling (i.e. sampling with inventory lines),
- I.2. Explain why we chose our inventory line orientation, and
- I.3. Explain why we chose our plot size.

Introduction

The sampling design is the way we select where to locate the plots in the inventory area. If we choose to quantify a given resource in an inventory area by sampling, we are faced with a number of choices for sampling design. However, in this manual you will be limited to one sampling design. Inventory experts call this sampling design 'systematic strip sampling'. Another way of describing it is as sampling with inventory lines which are spaced evenly across the inventory area. This appendix explains why we selected this sampling design from all of the choices that are available, based on considerations of simplicity, accuracy and cost efficiency.[1]

Although this sampling design is appropriate to many situations, there may be times when other sampling designs are more simple, accurate or cost efficient. You should feel free to use these other sampling designs if you are familiar with sampling theory or if you have been advised to do so by someone who is familiar with sampling theory. If neither of the above are true, however, it is best that you use the sampling design recommended here.

---

[1] *The Introduction to this manual defines simplicity, accuracy and cost efficiency.*

I.1. Why we chose systematic strip sampling (i.e. sampling with inventory lines)

There are a variety of ways in which an inventory can be accomplished. You may count every individual plant in the forest, a method which is called 100% enumeration. This method is likely to be costly, as it will usually take a considerable amount of time. For this reason, inventory of forest resources is more commonly done using a method called sampling. This involves counting only some of the plants and using this information to estimate the total quantity of plants in the entire forest. The way in which the plants are sampled is by using small areas of land with clearly defined borders, called plots. These plots are established across the forest and only the plants that fall within the plots are counted.

Sampling will only provide accurate estimates of quantity if the plots that are marked out are good representatives of the entire inventory area. For example, if all the plots are set up in a steep rocky area, and if this type of forest only occurs in a small proportion of the inventory area, then the estimate of resource quantity obtained from these plots will be far from the true resource quantity for the inventory area. Thus, the way in which you decide where to locate the plots is very important. *Figure I.1* shows a decision tree that illustrates some of the standard choices that are made when deciding how to locate plots. These choices include:

- Objective versus subjective sampling,
- Systematic versus random sampling, and
- Systematic strip sampling versus other systematic sampling designs.

Each of these are described in more detail below.

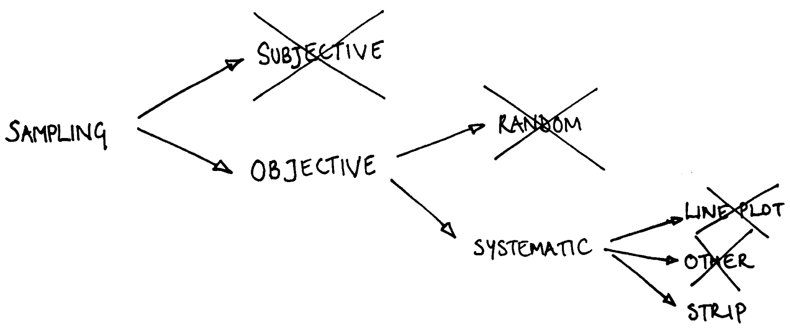


Figure I.1. There are many choices when planning a sampling design for an inventory. Here are the decision-making steps used to arrive at systematic strip sampling.

I.1.1. Objective versus subjective sampling

Plots can be located by:

- Subjective sampling, where the inventory planners choose the locations of the plots themselves, and
- Objective sampling, where the inventory planners select the location of the plots using a mathematical system.

The problem with subjective sampling is that the personal preferences of the inventory planners may influence the plot locations, even if they do not intend to have such an influence. This is an unacceptable way to sample, as it leads to inaccurate inventory results. An inventory that uses subjective sampling will therefore have very low credibility. This is illustrated by three examples in *Figure I.2*:

- In *Figure I.2a*, the inventory planners wanted to show that there are many trees of a certain species in the inventory area. Thus, they put plots (in the form of inventory lines) in areas where they knew there are a lot of trees of this species. This resulted in an overestimation of quantity.
- In *Figure I.2b*, the inventory planners wanted to show that there are very few trees of a certain species in the inventory area. Thus, they put plots (in the form of inventory lines) in areas where they knew there are few trees of this species. This resulted in an underestimation of quantity.
- In *Figure I.2c*, the inventory planners were feeling lazy and did not want to travel too far from the forest camp. Thus they put most of the plots (in the form of inventory lines) near the camp. In this example, the forest resources that they were counting had been heavily harvested near the camp. Thus, this resulted in an underestimation of quantity.

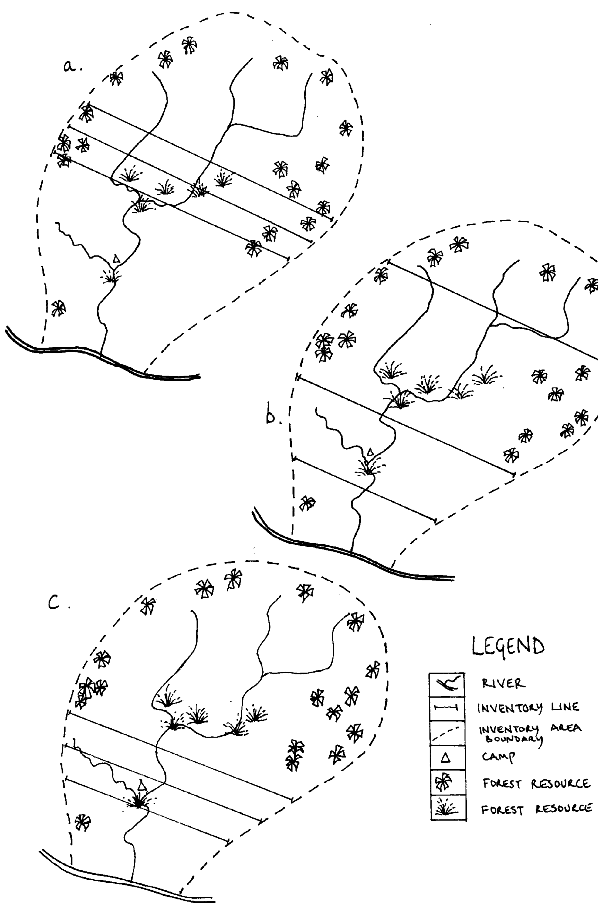


Figure I.2. Three examples of subjective sampling, where lines are purposively placed: a) where there is a large amount of the resource of interest, b) where there is a small amount of the resource of interest, and c) to be conveniently close to camp. Subjective sampling is always inaccurate and an inventory done by subjective sampling will have a very low credibility.

With objective sampling, it is not possible for the inventory planner to influence the result, and therefore this is always the preferred method of sampling.

I.1.2. Systematic versus random sampling

Two types of objective sampling are commonly used. These are:

- Random sampling, where the choice of plot location is left to chance. This method of sampling is used to deal a hand of playing cards, when the pack of cards is shuffled and the cards dealt out without being looked at. Plots that have been randomly sampled will tend to have an irregular distribution, as illustrated in *Figure I.3a*.
- Systematic sampling, where the choice of plot location is made by randomly selecting a starting point, and locating the remaining plots at set distances from this point, in accordance with a selected pattern. This pattern is regular and repeating, much like a regularly printed batik pattern. Plots that have been systematically sampled will have a regular distribution, as illustrated in *Figure I.3b*.

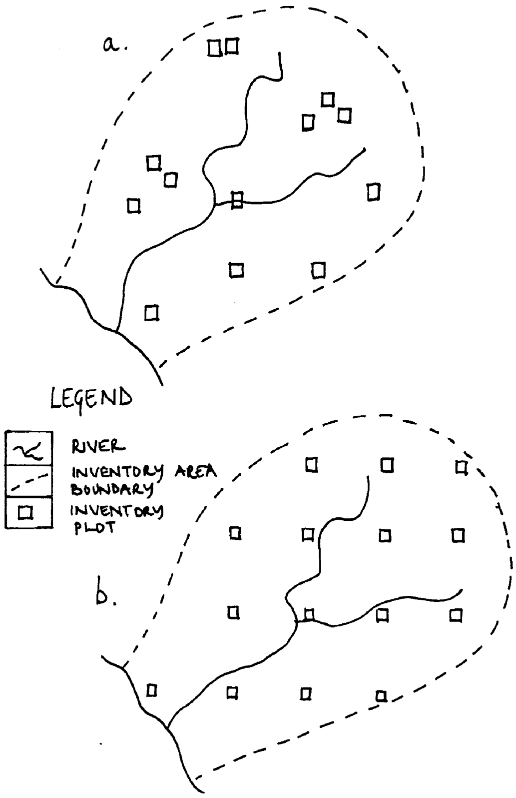


Figure I.3. Two types of objective sampling: a) random sampling and b) systematic sampling.

The disadvantage of systematic sampling is that it can lead to an inaccurate result if the pattern of sampling is somehow similar to a pattern in the distribution of the plants being counted in the inventory. For example, in *Figure I.4*, systematically sampling the plots results in the sample mostly being taken on hilltops, resulting in under-representation of the river valleys and slopes.

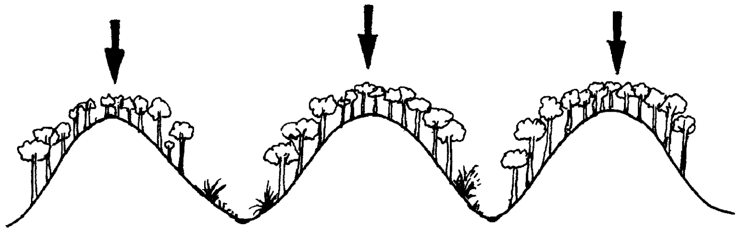


Figure I.4. When using systematic sampling plots can sometimes not be representative of a forest area because the pattern of plot distribution may by chance be similar to the pattern of plant distribution.

The advantage of systematic sampling is that it is a simple and cost efficient method to use in the field. With this method of sampling, inventory teams usually find it easier to locate the plots in the forest, and it takes less time to walk between plots. Furthermore, it is an easier method to use when inventory work is to be combined with mapping. This is because the forest area is covered evenly by an inventory team using systematic sampling, whereas it might be covered more intensively in some areas and less intensively in others if random sampling were used. Despite the risk of inaccuracy mentioned above, systematic sampling has many points in its favour and is the method recommended in this manual.

I.1.3. Systematic strip sampling versus other systematic sampling designs

A number of regular patterns are commonly used for systematic sampling. Some of these are illustrated in *Figure I.5*. This manual recommends one well-known pattern called 'strip sampling'. In strip sampling, the plots are placed end to end in lines, the location of the first line is selected randomly and there should be an equal distance between all of the lines in any given area.[2]

[2] *Chapter 7 explains how to choose the position of the first line and the distance between lines.*

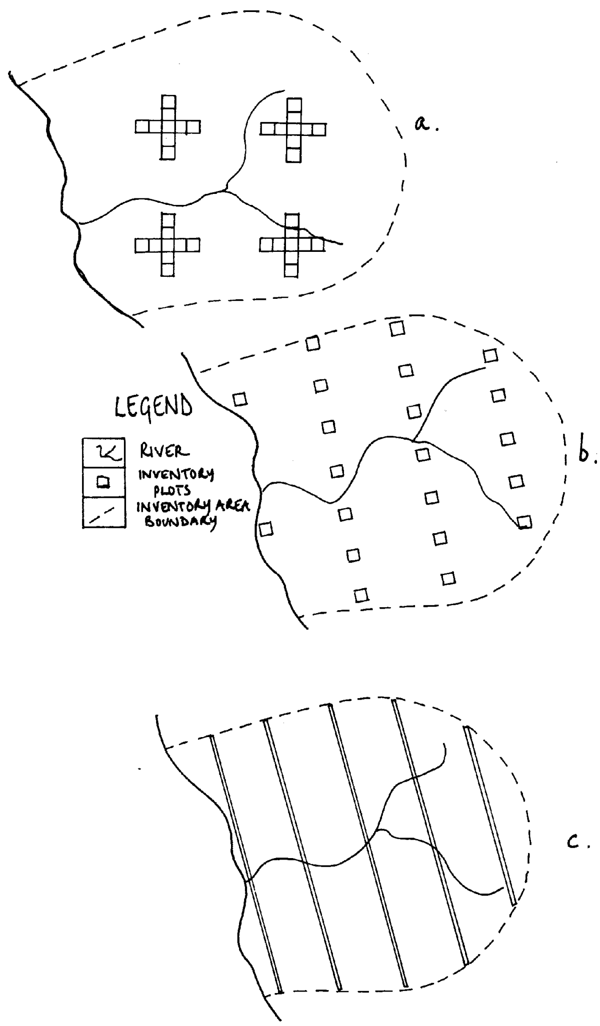


Figure I.5. Commonly used forms of systematic sampling include a) cluster sampling, b) line plot sampling, and c) strip sampling.

Strip sampling works well with the recommended method for plot establishment and enumeration described in *Box I.1*. The advantage of using strip sampling with this method is that the inventory team can gather information continuously while walking along the line, rather than intermittently, as they would with other systematic patterns. Thus more information is gathered for approximately the same amount of time, making it more cost efficient than other methods.

Box I.1. The method used to establish and enumerate plots along the inventory line

In this manual, the recommended way of establishing and enumerating plots is to establish a line down the centre of the theoretical plot, and count only those plants which are equal to or less than a specified distance to the left or right of that line.[3] Thus the plot boundaries are theoretical rather than actually marked out. The disadvantage of this method is that inaccuracies in enumerating the plants that lie close to the border of the plot can arise if the enumerators are not very careful about measuring the distance from the centre line. The advantage of this method is that plots can be established and enumerated at a slow walking pace, which is much quicker than staking out all four borders of the plot.

I.2. Why we chose our inventory line orientation

In systematic strip sampling, the inventory lines are all parallel within a given area. There are two considerations influencing the orientation of inventory lines within a given area, in other words, the direction in which all of the inventory lines run.[4] These are that the orientation of the lines:

- Cover the maximum variation in vegetation, and
- Maximise the number of lines in the area.

Both considerations are discussed below.

I.2.1. Covering maximum variation in vegetation

Inventory lines are most cost efficient if they are oriented so that they cover the maximum variation in vegetation. Plots with this orientation cover more variation within them than between them, compared to plots with other orientations. This means that you will need to establish fewer plots to obtain the same level of precision.

The topography of the land is often the main source of variation in vegetation. This is particularly true in steeper areas, and less important in flatter ones. Some resources mainly grow by the river whereas others will be most commonly found on a ridge. Inventory lines that run from the river to the ridge (see *Figure 7.2b*) are therefore more likely to cover all forest resources whose distributions are linked to topography than inventory lines that run parallel to the river and ridge (see *Figure 7.2a*). Thus often the best orientation for inventory lines in any given watershed is one in which the lines cut at right angles the general direction of the main river.

The level of human disturbance can be another source of variation in vegetation. Some resources may be more heavily harvested near the village or the main roads from a village, and less so as the distance from the village increases. If so, the best orientation for inventory lines will be one in which they:

- Travel from the village outwards, or
- Cut at right angles the general direction of a main road.

---

3 *Chapter 1 (Figure 1.5) illustrates how the plots and subplots are established along the inventory line.*

4 *Chapter 7 describes how to orient the inventory lines on the planning map.*

I.2.2. Maximise the number of lines

Inventory lines should be placed so as to maximise the number of lines in the area. This is done by drawing the lines so that they are perpendicular (i.e. at right angles) to the long axis of the inventory area. This results in many short lines (see *Figure 7.3b*) instead of fewer long lines (see *Figure 7.3a*). This is preferable because there is an assumption in sampling that the plots are spread randomly around the inventory area, whereas in actual fact they have been placed end to end in lines. This means that they are clustered in the lines with larger gaps then expected between the clusters. Increasing the number of lines distributes the plots across the area a little more evenly.

I.3. Why we chose our plot size

A number of plot widths and lengths are possible in inventory. However, this manual recommends a plot width of 10 metres and a plot length of 50 metres. The size of such a plot is 500 m^2 (0.05 ha). Plot width and plot length are discussed in turn in the sections below.

I.3.1. Plot width

Plots can be a variety of widths. However, a 10 metre width is recommended as field experience has shown that this width is the most efficient using the plot establishment method recommended in this manual, where the plot boundary is 5 metres to the left and right of the central line. If plot boundaries are further than 5 metres from the central line it is difficult for the enumerators to see all of the plants when walking roughly in the middle between the central line and the theoretical edge of the plot.

I.3.2. Plot length

Field experience has found that 10 metres lengths make convenient distances to split the central line into. This is a good length for staking out the poles that make the line, and for dividing up the data that is recorded while walking along the line.

However, with systematic strip sampling, plots of 10 metres length are not appropriate for calculating the precision of estimates of resource quantity. This is because such a high number of small plots distorts the calculation of precision. We therefore want the plots to be as long as possible. However there is a practical limit to how long they can be. With very long plots it becomes very difficult to determine when to cut them off before or after boundaries, or how to assign them to different subdivisions. Thus a practical limit to plot length has been set at 50 metres.

J

The Student's t-Table and How to Use It

Objectives

By the end of this appendix, you should be able to do the following:

J.1. Explain what the Student's *t*-table is, and

J.2. Use the Student's *t*-table to obtain a t value.

Introduction

This appendix contains the Student's *t*-table, which must be used to look up the *t* value appropriate for your needs. This *t* value is then used to calculate the precision of an estimate of density or quantity. If you already have a background in statistics, the explanation below may help to remind you what the *t*-table is. However, you do not have to know what the *t*-table is in order to use it. If you wish, skip the explanation of what the *t*-table is, and read the instructions following it, which tell you how to use the *t*-table to obtain a *t* value.

J.1. What is the student's *t*-table?

When we estimate, for example, the density of bamboo plants from a sample of plots,[1] this estimate is made a lot more credible if we can obtain some indication of its reliability. The standard error of the estimate helps us to establish limits that suggest how close our estimate is to the true density of bamboo plants.[2] The distance between these limits is called the confidence range. For reasonably large samples (i.e. samples of over 30 plots) statisticians have found that, on an average of 2 out of 3 times, the true value is within one standard error of the estimated value. *Box J.1* discusses the assumption under which this finding holds true.

> **Box J.1. Assumption of independent selection of plots**
>
> To calculate the way in which the estimates from a number of samples are distributed about the true value (i.e. the distances between the true and estimated values), statisticians use simple random sampling. In other words, in their samples the selection of each plot is completely independent of the selection of all other plots. In this manual, we use systematic sampling. One of the disadvantages of this is that the selection of each plot is not independent; thus we can't be certain that there is not some bias, or error, in our estimates as a result.

To use an example, if the estimated density is 10 plants per plot and its standard error is 0.6 plants per plot, and if we take as given that the number of plots in our sample is over 30, we can assume that the true density is within the limits of 9.4 and 10.6 plants per plot (10 ± 0.6 plants per plot). In making such a statement over a number of inventories, we are likely to be right an average of 2 out of 3 times, and wrong 1 out of 3 times. This probability of being mistaken is called a 0.3 probability and these limits are called the 67% confidence limits.

However, this level of confidence is not very high, if we are likely to be mistaken 1 out of 3 times. To increase our confidence, we set confidence limits that are 2 (to be exact, 2.042) standard errors from the estimated value. In our example, this will mean that we assume the true density is within 8.8 and 11.2 plants per plot (10 ± (2.042 x 0.6)). This improves our chance of being mistaken to 1 in 20 times, a probability of 0.05. These limits are called the 95% confidence limits and are much more commonly used than the 67% limits. Other popular limits are 1.697 standard errors from the estimate, with a chance of being mistaken of 1 in 10 times (a probability of 0.1). These are the 90% confidence limits.

The Student's t value, symbolised by t, tells us how many standard errors from the estimated value our confidence limits should be. In the above examples, where the number of plots is assumed to be greater than 30, the t value is 1 for 67%, 1.697 for 90% and 2.042 for 95% confidence limits. These t values are arranged in a table called the Student's t table (see *Table J.1*), enabling you to select the appropriate t value for the probability that you desire.

The Student's t value also varies with the number of plots used to make the sample. The more plots that are used, the greater the reliability of the estimate; this is reflected by a decrease in the size of the t value and a corresponding decrease in the size of the confidence limits.

---

1 *The density is calculated in Step 3 of Calculation Form 2; see Chapter 17.*

2 *The standard error of the mean is calculated in Step 8 of Calculation Form 2; see Chapter 17.*

J.2. How to use the Student's *t*-table

The Student's *t* value to be used depends upon the probability level that you want and the number of plots used in your sample. To use the Student's *t*-table in *Table J.1*, select which probability level you want to use. We recommend that you use a probability of 0.1, as this is a standard choice of probability level. However, a probability of 0.05 is also standard and ensures an even higher level of confidence. Then, select the degrees of freedom or the *df* appropriate for your example. The *df* is equal to the number of plots in your sample, or *n*, minus one (i.e. $df = n - 1$). If your *df* is greater than 120, the maximum value listed for *df* in the *t*-table, look up your *t* value in the row headed by the infinity sign, ∞.

To use the bamboo example from *Chapter 17*, the number of plots or *n* is equal to 3. Thus the degrees of freedom or *df* is equal to 2. If you have decided to use a probability level of 0.1, your *t* value is therefore 2.92.

Table J.1. The Student's *t*-table

	Probability	
Degrees of freedom (df)	*0.1 (90%)*	*0.05 (95%)*
1	6.314	12.706
2	2.920	4.303
3	2.353	3.182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.782	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
17	1.740	2.110
18	1.734	2.101
19	1.729	2.093
20	1.725	2.086
21	1.721	2.080
22	1.717	2.074
23	1.714	2.069
24	1.711	2.064
25	1.708	2.060
26	1.706	2.056
27	1.703	2.052
28	1.701	2.048
29	1.699	2.045
30	1.697	2.042
40	1.684	2.021
60	1.671	2.000
120	1.658	1.980
∞	1.645	1.960

K

Measuring Plant Size

Objectives

By the end of this appendix, you should be able to do the following:

K.1. Measure the diameter at breast height of a tree or other plant, and

K.2. Measure or estimate the height of a tree or other plant.

Introduction

Sometimes you will want to measure plant size in an inventory. This appendix describes the standard procedures for measuring a tree's diameter at breast height and for measuring or estimating its height. These methods can be applied to other types of plants (e.g. climbers, palms, rattans).

K.1. Measuring the diameter at breast height

K.1.1. Measuring the diameter at breast height of normal trees

Finding breast height

Throughout the world the diameter of the trunk of a tree is measured at a standard height called the 'breast height'. It is called this because it originated as the height from the ground to the breast of the person making the measurement. However, this height varies between different people; on tall people it is higher than on smaller people (see *Figure K.1*). For this reason 'breast height' has been set at 1.3 metres so that all people will take the measurement at the same point on the tree. Everybody on the inventory team should determine the point on their body that is 1.3 metres from the ground. They should remember this point because this is the height at which they should measure the tree's diameter.

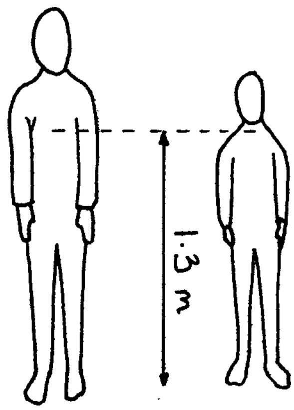


Figure K.1. Breast height differs a lot between different people, therefore a standard height of 1.3 metres is used to measure the diameter of a tree at breast height.

Measuring the diameter with a diameter tape

To measure the diameter at breast height or DBH of a tree, wrap a diameter tape[1] around a tree at breast height (see *Figure K.2*), making sure that you are standing with your feet at the same level as the base of the tree. To make the measurement as accurate as possible, you should:

- Hold the diameter tape level and not at an angle,
- Check that the diameter tape is not twisted or caught on any small branch or protrusion, and
- Cut away any vines, creepers, moss or old bark on the tree to ensure that the tape is held as close as possible to the tree.

[1] *Chapter 5 describes what a diameter tape is and how you can obtain or make one.*

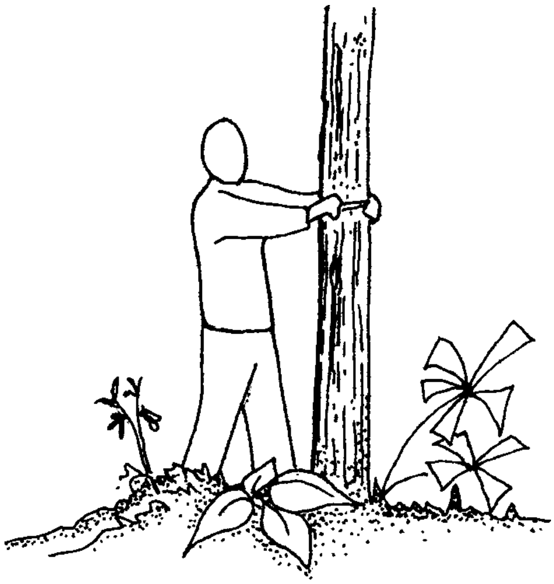


Figure K.2. A diameter tape is wrapped around the tree at breast height (1.3 metres from the ground), this measurement is called the diameter at breast height.

Pull the tape tight and overlap the zero mark on the tape, usually distinguishable by a metal clip or ring, above the rest of the tape (see *Figure K.3*). Remember that the zero mark does not always occur at the end of the tape. Read the number on the tape that aligns with the zero mark. This number is the DBH of the tree, in centimetres. Make sure that you are reading the tape correctly. A common mistake is to read '19.1', as shown in *Figure K.3*, as '20.1'.

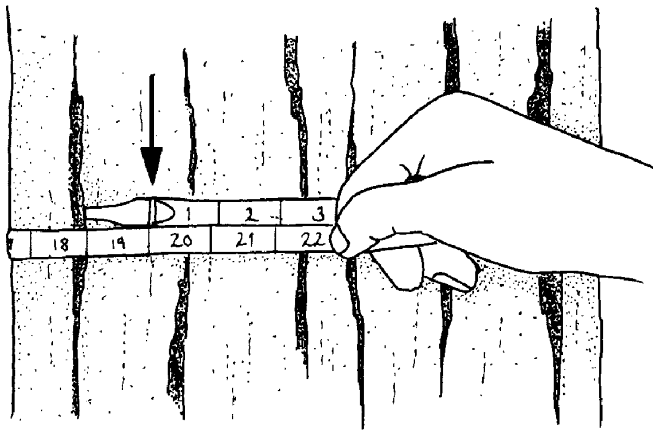


Figure K.3. The diameter of the tree is read off the diameter tape at the point where the tape end that has been wrapped around the tree aligns with the zero mark (this point is marked by the arrow in this figure).

K.1.2. Measuring the diameter at breast height of problem trees

Multiple stemmed, crooked or unusual trees

There are also standard procedures for measuring multiple stemmed, crooked or unusual trees. These types of 'problem tree' are illustrated in *Figure K.4*. When data from a multiple stemmed tree is included in the inventory it is important to note this in the data recording sheets.

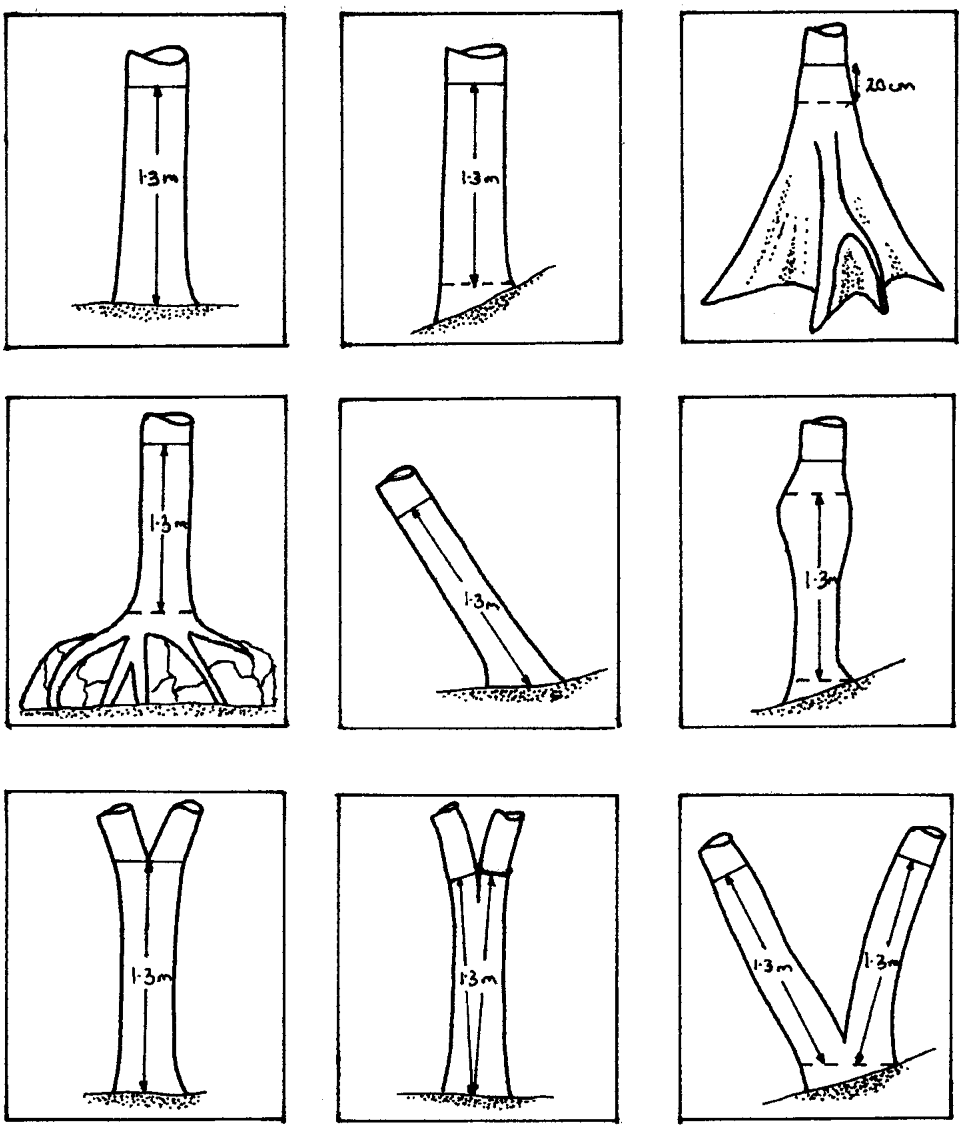


Figure K.4. Standard procedures for measuring the DBH of all unusual types of tree.

Buttressed trees

With buttressed trees, the diameter must be measured at a height of 20 centimetres above the buttresses. If it is difficult for the enumerator to climb to the height where the diameter should be measured, another method for determining the diameter can be used. In this method, two people hold either end of a metre tape (not a diameter tape) at the base of the trunk, so that each tape end is aligned with an imaginary line extending downwards vertically from the points on the trunk where the diameter should be measured (see *Figure K.5*). A third person, standing at a suitable distance from the tree, helps these two people to align their tape ends accurately. After the tape ends have been aligned, the distance between them can be read on the metre tape. This measurement should be considered an approximate measure of the diameter.

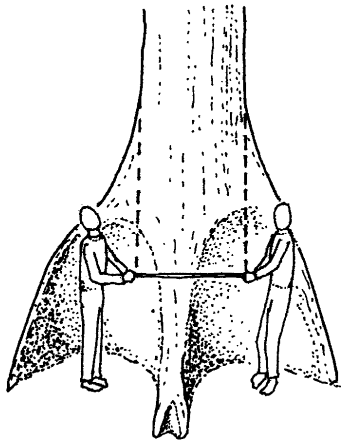


Figure K.5. One method for measuring the diameter of a buttressed tree is to line up two ends of a measuring tape at the points where an imaginary line marks the approximate diameter of the tree, 20 centimetres above its buttress.

Large trees

Sometimes a normal diameter tape will be too short to measure a very large tree. In such circumstances the enumerators can improvise with the 5 metre nylon rope that they are using to check whether a plant lies inside or outside a plot. The enumerators should wrap the 5 metre rope around the tree and mark the overlap point, as for a diameter tape. They then measure the length of rope that was wrapped around the tree, using the diameter tape. Because the diameter tape was too short in the first place the enumerators will need to measure the nylon rope in a number of stages. The total number of centimetres read in each stage must be added together to give the total diameter at breast height of the tree.

K.2. Measuring or estimating the height

The height of shorter trees can be measured directly. The height of other trees must be estimated with the aid of an instrument.

K.2.1. Measuring the height

The height of smaller trees (3 metres or less) can be quickly and easily measured using a height pole. A height pole is a straight rod around 3 metres high, with 10 centimetre intervals marked along its length. It is a simple tool to make and can easily be manufactured in a village. The only tools required are:

- A straight stick or piece of plastic tubing,
- A metre tape, to measure accurately the marks on the stick, and
- Brightly coloured sticky tape, a permanent pen or a knife to mark the 10 centimetre intervals.

The pole can be made longer than 3 metres, but, unless it is telescopic or can be broken down into smaller lengths and then reassembled, it will be difficult to transport through the forest.

The enumerator must hold the pole next to the tree, as close as possible to the stem of the tree to minimise error (see *Figure K.6*). He or she reads the height of the tree from the pole and records it on the data form.

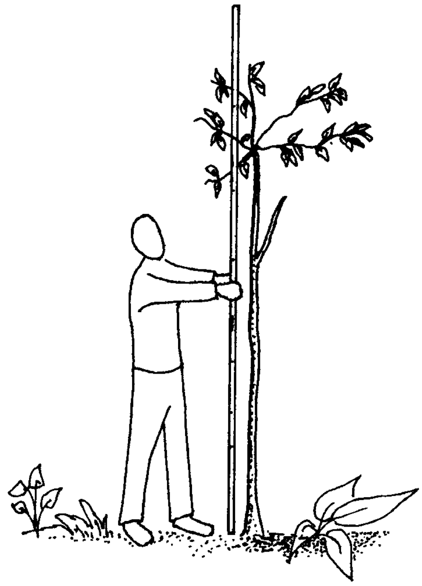


Figure K.6. When gauging the height of smaller trees using a measuring pole you must hole the pole vertical and as close as possible to the stem of the tree being measured.

For trees taller than 3 metres the one way of measuring their height is by climbing them and measuring them with a metre tape. However, climbing is not normally recommended because it is time consuming.

K.2.2. Estimating the height

Philip (1994) describes two ways of estimating tree height using the following instruments:

- A ruler (or stick with inches marked out on it) and a 3 metre height pole, or
- A clinometer.

Both methods require the enumerator to see the top and bottom of the tree from a distance. This is often not possible in closed canopy forest.

Estimating height with a ruler and a height pole

In this method, one person places a 3 metre height pole (described in the previous section) upright against the tree to be measured. Another person moves as far away from the tree as he or she can go while still being able to see the top and the bottom of the tree. The second person holds the ruler vertically in his or her fist and moves it towards and away from his or her eye, until the point is reached at which the bottom of the ruler is aligned with the bottom of the 3 metre pole (and tree) and the 3 inch mark on the ruler is aligned with the 3 metre mark at the top of the 3 metre pole (see *Figure K.7*). In this position, 1 inch measured on the ruler is the same as 1 metre measured on the tree. Once the ruler is aligned, the person's arm should be held steady, and he or she should glance up to determine the reading on the ruler which is in line with the top of the tree. This reading, in inches, is converted to metres to provide an estimate of the height of the tree.

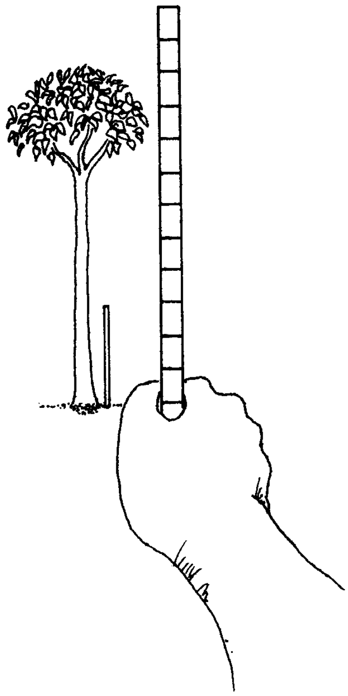


Figure K.7. From a distance a ruler is lined up against a pole of a known height. This calibrates the ruler and makes it possible to estimate the height of a tree.

Estimating height with a clinometer

The most common professionally used method of estimating a tree's height is by using a clinometer.[2] A clinometer measures the angles of the slopes from the clinometer user's eye to the top and bottom of a tree (see *Figure K.8*).

[2] *Chapter 5 describes how to obtain a clinometer.*

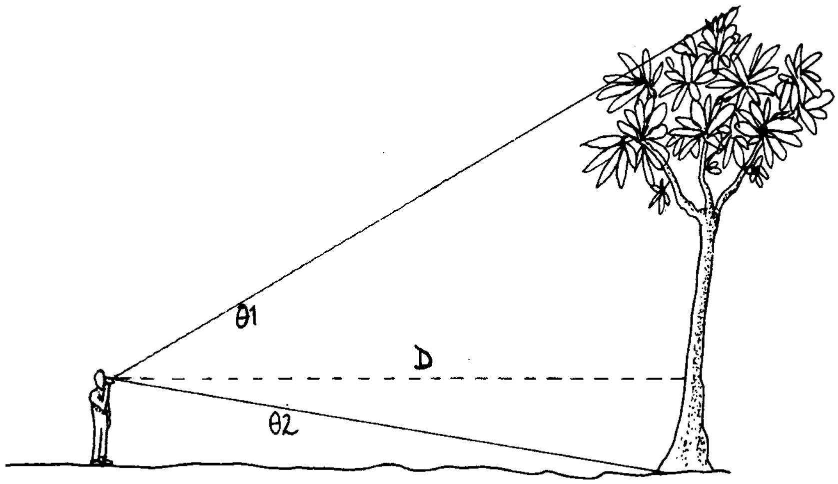


Figure K.8. A clinometer is used to calculate the height of a tree. You must use the instrument to know the angle to the top of the tree (θ_1) and the bottom (θ_2), you must also know the distance from the point where you are taking the measurement to the tree (*D*).

In this method, the person doing the measurement stands at a known distance from the tree, in a position where both the top and bottom of the tree are visible. The clinometer user aligns the cross hair seen through the sighting mechanism of the clinometer with the top of the tree. He or she then reads and records the number on the dial in the sighting mechanism that is aligned with the cross hair. This angle reading will be called θ_1. The cross hair is then aimed at the bottom part of the tree and the number also read and recorded. This angle will be called θ_2. On many clinometers the reading to the base of the tree will be a negative number. These two angle readings (called 'θ_1' and 'θ_2') and the horizontal distance from the observer's eye to the tree (called '*D*') are sufficient data from which to calculate the height of the tree. The distance '*D*' must be the horizontal distance from the observer to the tree, rather than the slope distance.[3]

The calculation used to estimate the height of the tree is as follows:

$$\text{Total tree height} = D\,(\tan\theta_1 + \tan\theta_2)$$

To make this calculation, a calculator which has the tan function key is needed. To obtain the value '$\tan\theta_1$', the angle should first be typed in and then the *tan* function key pressed. This is added to the value for '$\tan\theta_2$' and the sum is multiplied by the horizontal distance '*D*'.

[3] *Appendix H describes how to measure the horizontal distance.*

L

Planning, Conducting and Analysing Regeneration Studies

Objectives

By the end of this appendix, you should be able to do the following:

L.1. Plan the regeneration studies,
L.2. Conduct the regeneration studies, and
L.3. Analyse the regeneration studies.

Introduction

If the purpose of your inventory is to determine a sustainable level of harvesting for a specific resource or resources, then there is a relatively simple, inexpensive and straightforward method available for doing this. This method, called 'successive approximation', has been developed in Peters' (1996) manual. The 'successive approximation' method is based on the premise that the first sign that a plant population is being harvested at an unsustainable level is when the youngest age classes (e.g. seedlings and young saplings in tree species) begin to diminish in number. Harvesting regimes that kill reproductive adults, reduce the vigor of reproductive adults causing them to produce fewer flowers or seeds, or remove the seeds themselves may cause a decrease in densities of the very young age classes. This impact can be detected if the villagers periodically monitor the densities of these young age classes in a series of regeneration studies. If the impact is to cause a decrease in the density of these young plants, the intensity of harvest should be decreased until the population is more stable. This appendix explains how to plan, conduct and analyse regeneration studies in order to eventually reach a sustainable level of harvest though 'successive approximation'.

The disadvantage of 'successive approximation' is that it is reactive rather than proactive. In other words, it responds to signs that the population is being adversely affected by the intensity of harvest, and does not attempt to understand why the harvesting regime is affecting the population in this way. There are other methods for determining a sustainable level of harvesting that attempt to understand why and how a resource population changes over time. Using these methods, it is possible to determine a harvesting level that is likely to be sustainable before the adverse impacts of harvesting have the chance to take place. A combination of these methods, including the study of plant population dynamics (or plant demography), the use of matrix models, and the use of computer simulations, is described in Peters' (1996) manual. It is beyond the scope of this manual to describe these methods. However, it is recommended that you consult Peters' (1996) manual if you believe you are capable of conducting these more complex analyses.

L.1. Plan the regeneration studies

One of the first issues when planning the regeneration studies is to determine when to do the first study. This study may be done together with the inventory, or it may be done after the inventory. In theory, the younger age classes of the resources under study could be counted together with the older age classes in all of the plots along the inventory line. However, there are usually so many more young plants than old that the inventory would take much more time to complete.[1] It is recommended that only 0.4% (one twenty-fifth) of the area under inventory plots be used for regeneration studies. This means that the team conducting the regeneration study should sample the first of the five 10 x 10 metre subplots in a plot, and they should select one plot from every five 10 x 50 metre inventory plots along the line.

The planning team should attempt to estimate how many inventory subplots (or regeneration study plots) will be established, using either an estimation of (if the inventory has not been completed yet) or actual data on (if the inventory has been completed) the size of the area under inventory plots. In addition to the usual equipment required for the work along the inventory line, they should prepare to take to the forest a number of 1.5 metre stakes made of some durable material, such as painted hardwood stakes, metal stakes or PVC pipes. These stakes should be brightly marked so that they can be easily found one year later or more. The number of stakes required depends upon how many regeneration study plots are going to be established, as each plot will need four stakes. Other items of equipment to take to the forest are paint and paintbrushes or permanent markers for writing the plot numbers on the stakes. The team should also take the planning map to the forest, in order to mark it with the location of the regeneration study plots.

The planning team should also think about what age or size classes to use. *Chapter 8* has some suggestions for ways of identifying broad age classes for different types of plants. These may be broken down further into size classes. For example, the ‘seedlings’ age class recommended for trees in *Chapter 8* may be divided further into three height classes: 0-50 cm, 51-100 cm, 101-150 cm. The planning team should make sure that the data forms they prepare are suitable for recording the data. *Chapter 9* provides some guidance on how to prepare data forms.

Before going to the field the team that conducts the regeneration study should have some training in the use of the methods described in this appendix.

L.2. Conduct the regeneration studies

Once the regeneration study team has walked to the stake marking the beginning of the plot selected for the regeneration study, the team leader should mark its location on the planning map, and write a description of its location, relative to important local features (e.g. large trees, rocks), in a notebook. It may even help to take some bearings and measurements of distance from the starting point to these features. The aim is to make it easier to find the plot again in the future.

The regeneration study plot’s outer boundaries must be accurately marked out with rope, because the young plants that will be counted within them are likely to be small and numerous and it will be difficult to determine whether they are in the plot or not. This is unlike the inventory subplots, in which only the central line is marked out with rope. To mark out the outer bounda-

[1] *This is also true for smaller sized plants, as discussed in Chapter 13.*

ries of the plot, the compass person and rope person should follow these steps:

1. They should begin by turning 90 degrees to the right of the direction in which the inventory line is headed,[2] measuring out 5 metres of line from their starting point, and marking this first corner of the plot with one of the permanent stakes. The plot number should be clearly painted or marked on the stakes, as well as information indicating which corner the stake is marking, as this will make it easier to locate the other stakes at a later time. One end of the 50 metre rope that is normally used for marking the center line of the inventory plot should be tied to this stake.
2. The compass person and rope person should then turn 90 degrees left, so that their direction is the same as the direction of the inventory line. They should measure out 10 metres of line and mark the second corner of the plot with a numbered stake. The 50 metre rope should be wrapped around the stake, forming the first marked boundary of the plot.
3. The compass person and rope person will need to turn 90 degrees to the left twice more, in order to measure out two more 10 metre lines, and mark two further corners with stakes. They should also ensure that all four boundaries of the plot are delineated by the 50 metre rope.

This process is illustrated in *Figure L.1*.

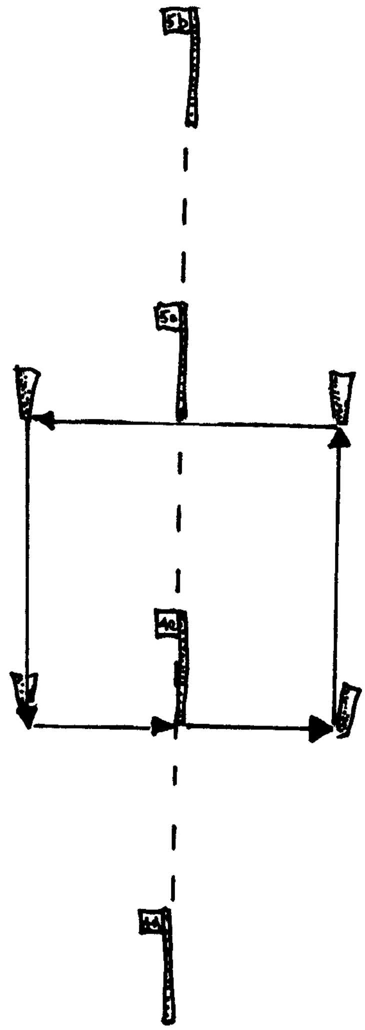


Figure L.1. Procedure for measuring and marking the regeneration study plot boundaries.

As these plots are meant to be permanent, it is important that disturbance be kept as low as possible, so that the team's activities do not influence the species composition and number of young plants observed in the plot in later years. This means that there should be no clearing of vegetation along or within the plot boundaries.

It may make it easier for the enumerators to count the younger plants if they work along 1 metre wide strips within the plot. To avoid counting the same plants twice they should temporarily mark the plants on the outer edge of these strips with notched twigs or string.

Within each plot the total number of plants in each age/size class of the resources species in question should be counted and recorded on the data form. Young plants are often bent over at the tip, and their height should be measured without attempting to straighten them. *Figure L.2* illustrates how a seedling's or sapling's height should be measured.

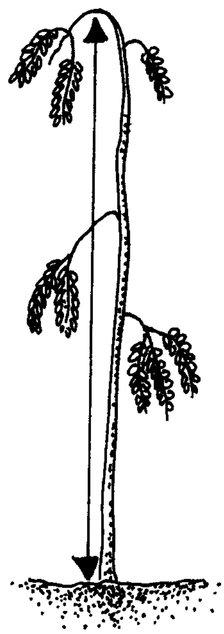


Figure L.2. Young plants are often bent at the tip. Their height should be measured without straightening them.

[2] *Appendix H describes how to calculate right or perpendicular angles (i.e. 90 degree turns) to a bearing.*

L.3. Analyse regeneration studies

Once the team has completed the first regeneration study, they should calculate the densities (and if desired, the precision of these densities) for each age/size class of each resource species in each forest type. It will not be necessary to calculate the quantities. These densities will be used as the 'threshold values' against which to evaluate the effects of harvesting.

In general, the regeneration study should be redone every five years, at the same season as the initial regeneration study, in order to monitor fluctuations in population. However, it is recommended that the regeneration study be repeated more frequently in the first three years, perhaps every year. This is because there is a risk that the threshold values established in the first regeneration study might be unusually high or low due to natural (i.e. non-human) causes such as a 'mast year' for fruiting. A comparison of the values of the first three years should establish more precise threshold values, possibly ones that are an average of the three years.

As long as densities measured in subsequent regeneration studies remain above these threshold values, there is a high likelihood that the current level of exploitation is sustainable. If they drop below the threshold values, however, the intensity of harvest should be reduced. By lowering or maybe even raising the harvest levels in response to the changes in the densities of younger plants, the level of recruitment of young plants should eventually approximate the threshold value established for that population.

M

Planning, Conducting and Analysing a Productivity Study

Objectives

By the end of this appendix, you should be able to do the following:

M.1. Plan a productivity study,

M.2. Conduct a productivity study,

M.3. Analyse the information from a productivity study, and

M.4. Apply a productivity study to a range of different products.

Introduction

You may need to conduct a productivity study as well as an inventory if you need to know what quantity of a particular timber or non-timber forest product is produced each year by a particular resource in a given area of forest. Measuring the quantity of a forest product can be time consuming and is sometimes destructive of the plant from which the product comes. For these reasons it is usually better to measure the products in a separate productivity study rather than during the inventory, although there may be exceptions for which it is more effective to measure the products throughout the inventory. In a productivity study, a smaller sample of plants of the chosen resource is selected from the total number of plants that have been counted in the inventory. The next step is to determine how much of the chosen product (e.g. fruit, resin, timber, leaves, etc.) is produced by this sample of plants in one year. This information, in addition to the information from the inventory about the total number of plants in the forest area, is used to estimate the quantity of product produced per year throughout the forest area. This appendix describes how to plan, conduct and analyse the information from such a productivity study. Many of the methods described here are adapted from those described in Peters' (1996) manual.

M.1. Plan a productivity study

Planning a productivity study involves the following steps:

1. Plan the inventory so that it collects relevant information for the productivity study,
2. Select plants from the inventory data for the productivity study, and
3. Plan how to measure the selected plants' annual productivity.

M.1.1. Plan the inventory so that it collects relevant information for the productivity study

The inventory will need to be conducted before the productivity study in order to have inventory data from which to select plants for the productivity study. This appendix should be read before planning both the inventory and the productivity study, so that the data collected during the inventory is appropriate for the productivity study.

Information that should be gathered during the inventory may include the:

- *Forest type.* The inventory team should discuss whether the inventory area consists of more than one distinct forest type. They should also discuss whether these forest types are likely to affect the quantity of plants found in a given area of forest (e.g. the number of trees per hectare) or the quantity of products produced by a given plant (e.g. the number of fruit per tree). If the forest type is believed to have a significant effect, the inventory team should note, for each inventory plot, the forest type that the plot is found in.
- *Plant size, age, sex or condition.* The inventory team should also discuss whether a plant's size, age, sex or condition is likely to influence the quantity of products produced by the plant. A plant's size almost always has an influence on productivity, and there are times when age, sex and condition are important as well. For example, both the size (in this case the diameter at breast height) and sex (because only the female trees produce fruit) of a tree are likely to influence the number of fruit a given durian tree produces. If any of these factors are believed to have an influence, the inventory team should note the relevant information on size, age, sex or condition for each plant of the resource species for which you want to measure annual productivity.

M.1.2. Select plants from the inventory data for the productivity study

This step involves the following sub-steps:

1. Obtain the inventory data on the resource species for which you wish to estimate the annual productivity, and use the data to determine the number of plants that were counted in each forest type (this may already have been done as part of the compilation and calculation of inventory results).
2. Divide all plants that were counted in each forest type into those size, age, sex or condition classes that are likely to have an important influence on plant productivity (as discussed in the previous section). If there are a continuous range of sizes, ages or conditions, determine discrete classes that are fairly broad so that there are not too many classes. Six is probably the maximum number desired. For example, trees of a continuous range of sizes and two sexes may be divided into the following size and sex classes: 20-39 cm dbh male, 20-39 cm dbh female, 40-59 cm dbh male, 40-59 cm dbh female, 60 and above cm dbh male, 60 and above cm dbh female. Only those classes that are productive are of interest. Thus in the above example, trees that were less than 20 cm dbh were not included because they were too small to be productive in this particular species.

3. Randomly select a predetermined number of plants from each forest type and size, age, sex and/or condition class. *Box 7.2* in *Chapter 7* describes methods for making a random selection. There should be at least three individual plants from each possible combination of forest type and size, age, sex and/or condition class. For example, if there are 2 forest types, 3 size categories and 2 sex categories, the total number of possible combinations is 2 x 3 x 2 = 12. Since there should be at least 3 plants from each possible combination, this means a total of 3 x 12 = 36 plants.

M.1.3. Plan how to measure the plants' annual productivity

You will next need to plan how to measure how much of the product of interest is produced every year by the plants you have selected for your study. This is something you will need to think carefully about, as there are many options, depending upon the purpose of the inventory and the nature of the resource plant and product. Some of the major questions you will need to consider are:

1. Do you want to measure the productivity at the time of one harvest or the annual productivity?
2. Do you want to measure the harvested annual productivity or the potential annual productivity?
3. What units and classes will you use to measure productivity?
4. When is the best time to conduct the productivity study?

These questions are described in more detail below. You should read them and think about how they apply to your own particular situation.

1. Do you want to measure the productivity at the time of one harvest or the annual productivity?

- The *productivity at the time of one harvest* is the quantity of a product that is gathered and measured (or counted) during one particular harvest.
- The *annual productivity* is the quantity of a product that a plant produces over the course of one year.

The productivity measured at the time of one harvest may or may not represent one year's worth of productivity. These two measurements of productivity may be identical if the product is harvested once a year and takes a year to recover to its pre-harvest levels (e.g. a fruit tree that has one seasonal harvest every year for a number of consecutive years). However, they may not be the same if the product is harvested more than once over the course of a year (e.g. the resin of a rubber tree), if the product takes more than a year to recover to pre-harvest levels (e.g. the beehives of the honey bee tree), or if the plant is more than one year old when it is destroyed at the time of harvest (e.g. a palm stem that is harvested after ten years of growth).

The use of annual productivity is recommended over productivity at time of harvest because it enables us to standardise the measurement of productivity. Otherwise, it is difficult to compare the productivities measured at different harvests or from different resources. For example, it is not very meaningful to compare the honey that is measured from one harvest of a honeybee tree with the rubber that is measured from one harvest of a rubber tree. This is because the honeybee tree is harvested only once every two or three years, whereas the rubber tree is harvested many times a year. Whether the purpose is to estimate the economic value of a forest or to determine a sustainable level of harvest, it is usually best to work with standardised, comparable measurements of annual productivity.

2. Do you want to measure the harvested annual productivity or the potential annual productivity?

- The *harvested annual productivity* is the quantity of a product harvested in one year from a given population of plants.
- The *potential annual productivity* is the greatest potential quantity of a given product that can be harvested in one year from a given population of plants.

The harvested annual productivity measures what is typically produced, as it may be that not all plants in an area are harvested in a given year, or not all plants are harvested to the same level. A number of factors may influence the level of harvest, such as the product's price, how much of the product is needed by the villagers, the time available for doing the harvesting (which depends upon the other activities the harvesters are involved with). The potential annual productivity measures what would be produced if all the plants were harvested as completely as possible.

The choice of which measurement to use will depend upon the purpose of the inventory. For example, a purpose such as determining the present economic value of a given area of forest for the local community might require a measurement of harvested annual productivity. A purpose such as estimating the minimum area of forest necessary to provide a sufficient supply of products to a village might require a measurement of potential annual productivity.

The ways to measure these two types of productivity are quite different from one another.

- To obtain the *harvested annual productivity*, you must measure or estimate the quantity of products that is actually collected by human harvesters from a given population of plants over the course of one year. The best way to make this measurement is not to conduct a productivity study as described in this appendix, but to interview harvesters and traders of the product in the village, and obtain either measurements or estimates of product quantity from them.[1] You will need to ask them how many people are involved in the harvest, and then make sure to select a sample of these people for interviews or else interview all of them. You will also need to know how many times a year these people make their harvests and the approximate quantity of the product obtained in each harvest. The harvesters or traders may already have a record of the quantities harvested. If not, you should measure the products yourself, or ask the harvesters or traders to measure these products as the harvest is brought in.
- To obtain the *potential annual productivity,* you must estimate the maximum quantity of products that can be harvested from a given population of plants over the course of one year. The method to use will depend upon whether the product is harvested in a manner that destroys the plant or not. For example, a durian tree is destroyed when its timber is harvested, whereas it is not affected by the harvesting of its fruit.
  - *If the product is harvested in a manner that destroys the plant*, then you should follow the procedure outlined in *Box M.1*.
  - *If the product is harvested without destroying the plant*, then you should follow the procedure outlined in *Box M.2.*

---

[1] *Appendix B describes how to gather information from villagers.*

Box M.1. How to estimate potential annual productivity for products whose harvest involves the destruction of the plant.

When a plant is destroyed at the time of a product's harvest, such as when a tree is cut down for its timber, the quantity of timber measured at the time of harvest represents not the productivity of the tree in the most recent year but rather the productivity resulting from many years of growth. To standardise this measurement of productivity at time of the harvest to a measurement of the potential annual productivity, we need instead to measure the quantity of the product that is produced by the living plant over a one year period. For example, in a timber tree we need to measure how much timber is grown over one year. In a tree destructively harvested for its roots we need to measure how much root biomass is produced over one year.

It is often difficult to estimate the potential annual productivity of destructively harvested plants. Peters (1996) recommends a 'two-step sampling scheme', described below. This scheme is only useful for plants in which there is a relationship between productivity and plant size.

1. During the first step of this procedure, a selected sample of plants are harvested, and the quantity of the harvest as well as the size of the plant are measured. Regression analysis is then used to test whether there is a relationship between the plant size and product quantity. If there is, the slope of the line can be used to predict the quantity of harvest for any plant, once its size is measured. This manual is not capable of discussing how to conduct regression analysis. You will need to consult a standard statistics manual to learn how to do this. If you do not know how to do a regression analysis, a cruder way of determining whether there is a relationship is to plot the relationship on graph paper. This is done by plotting some indicator of plant size (e.g. the diameter at breast height if a tree, the height if a palm)[2] on the x-axis and some indicator of product quantity (e.g. number of fruit, trunk volume) on the y-axis. A relationship might be visible, as shown in *Figure M.1a*. If no relationship is visible, as shown in *Figure M.1b*, then clearly this method cannot be used to predict potential annual productivity.
2. The second step is to determine the rate of production, or the rate at which the plant grows in size. To collect this information, a second sample of plants should be monitored to determine how much, on average, each size class increases in size over a one year period.
3. Combining the information from both steps provides an estimate of the potential annual productivity. For example, if the average root biomass of a 20 cm dbh tree is 3.0 kilograms (data from step 1) and the average root biomass of a 25 cm dbh tree is 3.5 kilograms (data from step 1), a 20 cm dbh tree growing at approximately 0.5 cm a year (data from step 2) would produce approximately $3.5 - 3.0 = 0.5$ kilograms of roots a year.

If necessary, or if people feel there is likely to be a relationship between plant size and productivity, the order of these steps can be reversed, with the growth study conducted first and these sample plants then harvested and analysed. This means that only one set of sample plants is needed.

---

[2] *Chapter 8 describes some good indicators of plant size for different types of plants.*

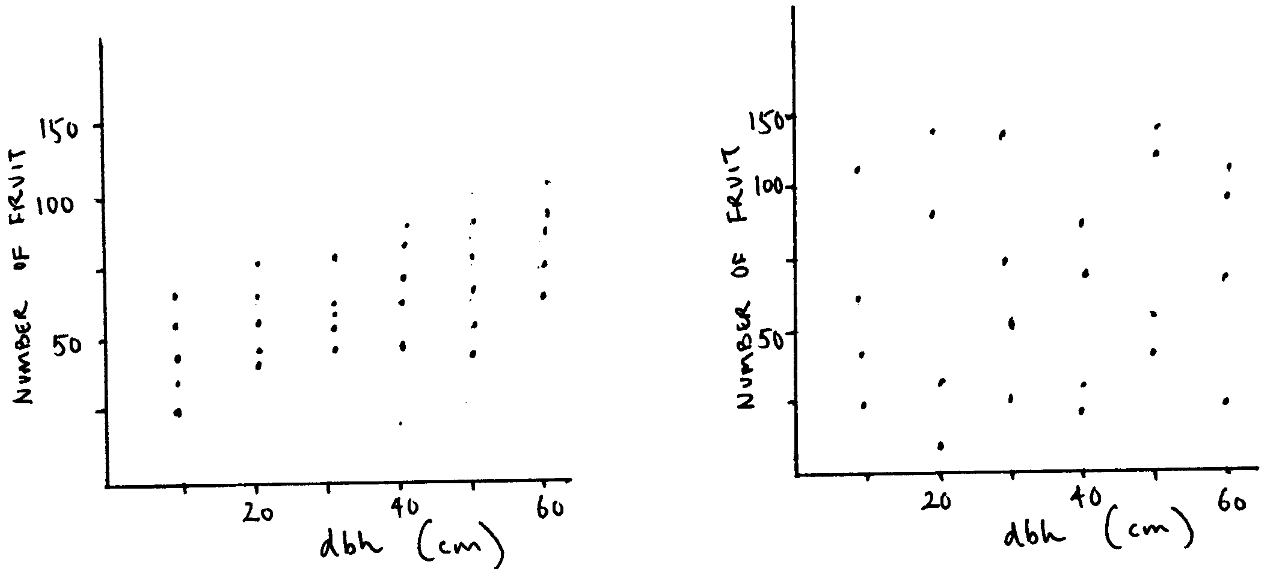


Figure M.1. If you do not know how to do a regression analysis, a cruder way of determining whether there is a relationship between plant size and productivity is to plot the relationship on graph paper. In this example, the plant size (dbh) is plotted on the x-axis and the product quantity (number of fruit) is plotted on the y-axis. There appears to be a strong relationship in Figure M.1a, but no clear relationship in Figure M.1b.

Box M.2. How to estimate potential annual productivity for products whose harvest does not involve the destruction of the plant.

If the product is harvested in a manner that does not destroy the plant, the potential annual productivity should be calculated by dividing the quantity of product collected in a harvest by the time taken for that quantity of product to replace itself.

There are some products for which it is possible and relevant to measure how long it takes for the plant to replace the quantity of the product that has been harvested from it. The types of products for which the recovery of the product can be measured include the bark, leaves, branches, honeybee hives and epiphytes found on the plant (and when palms, rattan and bamboo are clumped, the stems and shoots found in the clump). The general procedure outlined below applies to these types of products. In addition to this general procedure, *Section M.4* of this appendix offers some more specific suggestions for methods of measuring potential annual productivity of some of these types of products.

Sometimes it will not be possible to determine whether a product has recovered its pre-harvest quantity. For example, it is difficult to determine whether the resin or sap levels have recovered without possibly interfering with the recovery process while making the measurements. Or, it may not be relevant to measure the recovery of the product, if the product would have been shed by the plant anyway, whether harvested by people or not.

For example, the fruit, nuts or seeds of a plant are shed by the plant and it would be meaningless to measure a recovery period for them. If this is the case for your product, the general procedure outlined below should not be used. However, you may still wish to consult *Section M.4*, where some suggestions for measuring potential annual productivity are provided for specific products, including resins or saps, and fruit, nuts and seeds.

The general procedure for measuring potential annual productivity in products where the recovery can be measured is as follows:

1. Measure the quantity of product produced by the selected plant after it is harvested as completely as possible. Even though you are trying to determine maximum quantities, it is important to respect traditional ways of harvesting, as villagers are quite likely to have reasons for their practice (i.e. certain traditional ways of harvesting may prevent the death of the plant). For example, if the villagers prefer to leave a certain proportion of leaves on a shrub rather than strip it of all of its leaves, their preferred method should be used to harvest the shrub.
2. Measure the length of time it takes for the product to recover to its pre-harvest levels. You will need to discuss how to this is to be done with knowledgeable villagers. Often villagers know how long it takes for a product to be replaced, and time their harvests accordingly. If the recovery period is well known and agreed upon by all villagers, it may not even be necessary to test it in the field. If you all feel it necessary to test the recovery period in the field, however, villagers should be able to help you to plan the most appropriate time scale for checks in the field (i.e. whether the selected plants should be visited every week, month or year). Another issue to discuss with villagers is how to determine whether a product has fully recovered. Should it be done by counting numbers of the product, by measuring the product's size, or both? Are there qualitative indicators to be looked for as well?
3. Divide the value obtained from step 1 by the value obtained from step 2 to obtain the potential annual productivity.

It is best to measure the harvest level and length of time to recovery more than once. This is particularly true when the period of time between harvests is relatively short (i.e. there are a number of harvests in each year), to take account of seasonal variation. However, it is also a good idea to take account of variation between years.

3. What units and classes will you use to measure productivity?

There are often many choices for units to use to measure a product. Some are universally used units, others are local. For example, rattan stems can be measured in universally used units of weight (kilograms), volume (m^3) or length (metres). They also can be measured in local units equivalent to three times the span of a man's arms (or approximately 4 metres).

In addition to units, products are sometimes placed in classes that may be based on size, colour, shape, or other measurements of quality. These different classes may have different uses, be of differing quality for a specified use, or fetch different prices. For example, rattan stems are classified into grades 'A', 'B' and 'C'. This classification system is based on the stem's colour, diameter, length between internodes, and number of blemishes.

Choosing which unit to use to measure the product, and whether to classify the product, will depend upon the purpose of the inventory, the audience for whom the inventory results are intended, and the nature of the product. For example, there are many advantages to using volume (in cubic metres) as a measurement of timber, if the audience is the government, or other outsider agencies. However, if timber is to be assessed in terms of its use by villagers, it may be just as valid to measure it in terms of the number of planks produced from a log.

4. When is the best time to conduct the productivity study?

The most convenient time of year for the productivity study will usually be when the products are ready for harvesting, as it is easy to measure the products when they are harvested. However, within a given year, more than one period of data collection may be required. One reason may be that different products are ready for harvest at different times of the year. Another reason may be that the product is harvested over the course of several months (e.g. fruit on fruiting season), requiring repeated measurements to determine annual production. A final reason may be that the product is harvested in a way that causes the destruction of the product (e.g. leaves for wrapping food) or the entire plant (e.g. when the tree is cut down to obtain firewood). In this case the recovery rate of the product or the growth rate of the tree should be determined by making a series of measurements over a given period of time.

It is strongly recommended to measure productivity over several years, rather than just one year. This is because the amount of product produced every year can fluctuate widely, especially for fruit or nuts that are produced in large numbers in fruiting or 'mast' years (which occur every seven years or so), but are scarce at other times. Measuring productivity over several years will give you a more accurate idea of the average annual productivity. However, it is often not possible to conduct a productivity study over such an extended period of time.

M.2. Conduct the productivity study

To conduct the productivity study, you must:

1. Enter the inventory area and find the plants selected for the study,
2. Tag and number these selected plants with some form of durable marker (e.g. strips of brightly coloured plastic, metal tags, etc.)
3. Make the measurements of potential annual productivity as planned, whether once, twice or at regular intervals throughout the year. Record the productivity data in a notebook.

M.3. Analyse the productivity study

When you have finished collecting the data from the productivity study, group the data by forest type and by size, age, sex or condition class.

1. Create a table for each forest type, as shown in *Table M.1*. The first column should show the size, age, sex or condition classes of the resource species under study.
2. Obtain the data from the inventory and estimate the number of plants of each size, age, sex or condition class in each forest type in the entire inventory area. Place this information in the second column of each table.
3. Calculate the average potential annual productivity (the average quantity of product produced every year) of the sample trees from each size, age, sex or condition class in each forest type. Place this information in the third column of each table.

4. Multiply the number of individuals in each size, age, sex or condition class by the average potential annual productivity for that class to obtain the total quantity of the product produced for each class in each forest type. Place this information in the fourth column of each table.
5. Sum the total of all these classes to obtain the total quantity of product produced for each forest type. Sum the totals for the forest types to obtain a total for the entire inventory area.

Table M.1. Sample calculation of the total quantity of fruit produced by a shrub in a given inventory area (adapted from Peters (1996)). The inventory area has been divided into two forest types: a) fruit gardens and b) primary forest. The shrubs have been divided into six size (dbh) classes.

a. Fruit gardens

Size class (diameter at breast height (dbh))	*Number of shrubs*	*Average potential annual productivity for each class*	*Total number of fruit produced*
2.1-3.0	1800	6	108 000
3.1-5.0	910	481	437 710
5.1-7.0	200	758	151 600
7.1-9.0	60	1198	71 880
9.1-11.0	60	1896	113 760
11.1-13.0	20	3007	60 140
Subtotal for fruit gardens			845 890

b. Primary forest

Size class (diameter at breast height (dbh))	*Number of shrubs*	*Average potential annual productivity for each class*	*Total number of fruit produced*
2.1-3.0	1200	4	4 800
3.1-5.0	590	355	209 450
5.1-7.0	175	580	101 500
7.1-9.0	65	1120	72 800
9.1-11.0	60	1997	119 820
11.1-13.0	27	2994	80 838
Subtotal for primary forest			589 208
Total for village area			1 435 098

M.4. Apply a productivity study to a range of different products

This section describes a number of common products and gives some suggestions on how to measure their potential annual productivity. These products include:

- *Destructively harvested products:* Timber, gaharu
- *Destructively or non-destructively harvested products*: Stems/culms, shoots, firewood, bark, epiphytes
- *Non-destructively harvested products:* Leaves, honeybee hives, resin/sap, fruit/nuts/seeds.

M.4.1. Timber

Description. Timber comes from the trunks of trees. Some tree species have better quality timber than others. In villages it is used for building houses, boats and other items.

How to measure potential annual productivity. Timber is harvested destructively. To estimate the volume of timber produced by a tree in one year, estimate the volume of timber in the standing tree using one of the methods described in *Box M.3.* Return after one year to estimate the volume again. Subtract the earlier estimate from the later estimate.

If you are estimating the volume using Huber's formula (the first method described in *Box M.3*), it may be quite difficult to estimate the increase in volume accurately as the mid-diameter can only be estimated quite roughly. One way to increase the accuracy would be as follows. In the first year, estimate the volume by making estimates of mid-diameter and length, and also measure the diameter at breast height. After one year, return to measure the diameter at breast height a second time. Assume the increase in mid-diameter is the same as the increase in dbh and re-estimate the volume of timber for this increased mid-diameter. This assumption is made because using two accurate measurements of dbh is likely to be more accurate in detecting the growth in volume over one year than two rough estimates of the mid-diameter.

What units or classes are used. The standard way to measure timber is by measuring its volume. The volume is usually measured in cubic metres (abbreviated as m^3). Two ways of estimating the volume are described in *Box M.3.*

Box M.3. How to estimate the volume of timber in a tree

The volume of a tree can only be roughly estimated because a tree's shape is irregular both along and across the trunk. There are two possible methods for estimating the volume of a tree:

1. Estimating volume using Huber's formula

Estimation using this method can be done either while the tree is still standing, or after it has been felled and cut to a shorter length, called a log. The mathematical equation for measuring the volume is called Huber's formula:

$$\text{Volume} = (p\, L\, d^2_m)/4$$

In the above equation, p is 3.143, L is the length of the log or merchantable (timber) height of the tree,[3] and d_m is the mid-diameter or the diameter at the mid-point of the length of the log or tree (see *Figure M.2*). To use the equation, multiply 3.143 by the length of the log or tree, and then multiply this result by the mid-diameter of the log or tree (which has been squared, or in other words multiplied by itself). This must then be divided by 4 to obtain the volume.

The length of the log can be measured directly using a measuring tape if the tree has been felled. If the tree is still standing, it is best to estimate the timber or merchantable height using one of the methods described in *Appendix K*.

The mid-diameter is measured from a point in the middle of the length of the tree or log (as a tree's shape usually tapers toward the top, the diameter at breast height should not be used as it will result in an overestimate of the volume). It is easy enough to measure the mid-diameter of a tree or log that has been felled and lies horizontal (just use a diameter tape as described in *Appendix K*). However, it is more difficult with a tree that is still standing. One method is to measure it directly by climbing the tree to the mid-point. Another method is to estimate the mid-diameter using the same method as that used to estimate the above-buttress diameter of a buttressed tree (this method too is described in *Appendix K*).

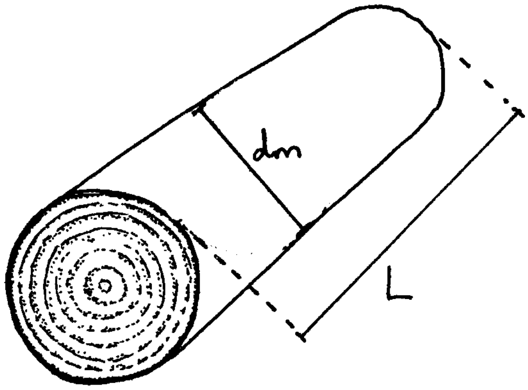
2. Estimating volume using a volume table

This method is much more accurate and convenient to use when the tree is still standing, compared to the method described above. It involves measuring the diameter at breast height (dbh) and then looking up the volume that corresponds to this dbh in a volume table. The volume tables have been created using data from real trees to establish a relationship between the volume and the dbh, in a manner similar to that used in *Box M.1* to determine a relationship between productivity and plant size. These tables have been established for specific commercial timber species in specific districts, thus you will have to make sure you are in the appropriate district, and that you are using the tables only for the species to which they refer. Usually these tables can be obtained from the local Forestry Department, or from the Forestry Faculty at the local university.

---

[3] *Figure 8.5 in Chapter 8 illustrates the merchantable or timber height of a tree.*

Figure M.2. To estimate the timber volume of a log using Huber's formula, you must measure both: *L*, the length of the log, and *d*, the diameter of the log at mid-point.



M.4.2. Gaharu

Description. Gaharu or aloes wood or is a special type of diseased wood found in a small, related group of tree species. It is used to produce a scented wood or essential oil that fetches an extremely high price in international markets. The cause and nature of the diseased wood is unclear. Some trees have the disease, whereas others do not, and the diseased trees are often clustered in distribution. Gaharu can be found in trees as small as 10 centimetres dbh, as well as in larger trees. It also occurs in both tree trunks and branches.

How to measure potential annual productivity. Gaharu is harvested destructively. Estimating the potential annual productivity of the diseased wood is very difficult due to our present lack of knowledge on the nature of the disease that causes it and its mechanisms for dispersal. Although there may be a relationship between productivity and size of the tree (simply because larger trees have the capacity for more diseased wood than smaller ones) it would not be a very precise one, because of the variability between trees in levels of diseased wood. Still it may be worth your time to examine the strength of this relationship in your inventory area.

What units or classes are used. Gaharu is sold by weight. Quality classes, based on the intensity of the disease in the wood, are also important.

M.4.3. Stems/Culms

Description. A stem in a young tree, a climber or a palm (such as a rattan) is called a culm in a bamboo. Whether stems or culms, they are mainly used for building materials or for splitting and weaving mats, baskets and other items.

How to measure potential annual productivity. Some plants that produce stems are clustered, whereas other plants are not clustered and produce only a single stem. The clustered plants are not usually destroyed when the stem is harvested, but the non-clustered plants are. In the clustered plants, the potential annual productivity can be estimated by harvesting the stems, and determining how long it takes for the cluster to replace them in quantity and size, as described in *Box M.2*. However, care has to be taken not to harvest all the stems if this is believed by villagers to lead to the death of the entire cluster. In the non-clustered plants, the potential annual productivity of a stem can usually be measured directly, by measuring the relationship between height (and sometimes also the diameter at breast height(dbh)) and productivity, as well as the change in height (and sometimes also the change in dbh) over the course of one year, as described in *Box M.1.*

What units or classes are used. Stems can be measured in units of height/length, volume or weight. There are often quality classes for stems as well.

M.4.4. Shoots

Description. Many types of plants produce shoots, whether trees, climbers, bamboo or palms. However, there are different definitions of what a shoot is, depending upon the type of plant. For example, the shoot of a tree or climber is the uppermost, growing part of a branch. Similarly, the shoot of a palm is the uppermost, growing part of the stem. However, the shoot of a bamboo is the young, stemless bud that has just sprouted from a clump. In all cases, shoots are most often eaten as a vegetable.

How to measure potential annual productivity. As with stems, some plants that produce shoots are clustered, whereas other plants are not clustered and can produce only a single shoot. The clustered plants are not usually destroyed when the shoot is harvested, but the non-clustered plants are. In the clustered plants, the potential annual productivity can be estimated by harvesting the shoots, and determining how long it takes for the cluster to replace them, as described in *Box M.2*. However, care has to be taken not to harvest all the shoots if this is believed by local people to lead to the death of the entire cluster. In the non-clustered plants, it will be difficult to measure the potential annual productivity, as described in *Box M.1*, because the shoot of a plant does not tend to increase in size with the size of the plant (i.e. its size tends to remain constant). Thus it would not be possible to measure its potential annual productivity as it is defined in this appendix.

What units or classes are used. Shoots may be measured by weight, or by the individual shoot or bundle of shoots.

M.4.5. Firewood

Description. People who use firewood for cooking are often selective of species and type of wood. For example, small dry sticks are used to make a very hot fire, whereas larger pieces are used to maintain heat. Thus firewood comes from the branches as well as sometimes from the trunks of trees.

How to measure potential annual productivity. Firewood can be both non-destructively and destructively harvested, depending upon whether only the branches are harvested, or the branches and the trunk. If firewood is harvested destructively, it is very likely that the amount of firewood in a tree is related to the dbh of the tree. To determine this relationship, a number of trees would need to be felled and the amount of firewood that can be collected from them determined (as described in *Box M.1*). If firewood is mostly harvested non-destructively, the time for it to recover on the tree can be determined by asking the villagers, or by observing its growth at regular intervals, to see how long it takes for the firewood to recover in terms of number of branches and branch size (as described in *Box M.2*).

What units or classes are used. Firewood can be measure by bundles, weight or volume. One quick method for estimating firewood volume is described in *Box M.4.*

Box M.4. How to estimate the volume of firewood in a tree

The total volume of firewood in a tree will consist of branch as well as possibly trunk volume. Philip (1992) describes a method for measuring a tree's firewood volume called stacked volume (see *Figure M.3*). The branch or trunk wood is cut into standard lengths, for example 1 metre pieces, and these are stacked between four 1 metre tall uprights that are places 1 metre apart in a square. The stacked volume can then be recorded as stacked cubic metres. The solid volume in the stack has been found to be approximately 65-70% of the stacked volume.

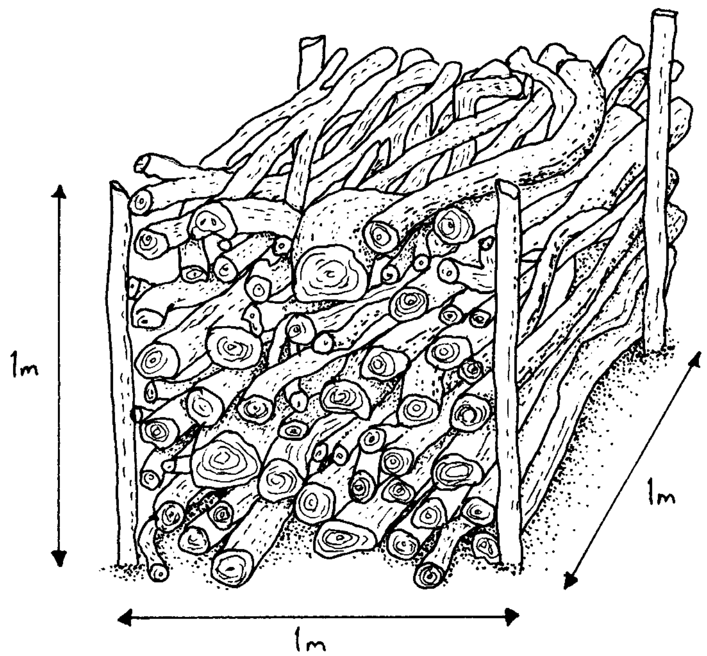


Figure M.3. Philip's method for measuring stacked volume of firewood.

M.4.6. Bark

Description. An example of a valuable bark is that of the cinnamon tree, which can be found growing wild in some parts of Indonesia.

How to measure potential annual productivity. The bark of trees is sometimes harvested non-destructively, sometimes destructively. If the bark is harvested non-destructively, the potential annual productivity should be measured by observing a sample of trees from the time of harvest onwards to see how long it takes for them to replace the harvested bark, as described in *Box M.2*. If the bark is harvested destructively, the potential annual increase in bark volume can be calculated by estimating the bark volume of a tree two times, one year apart, as described in *Box M.5*, below.

What units or classes are used. Bark is usually measured by weight or in bundles of a specified size.

Box M.5. How to estimate the bark volume of a tree without harvesting it.

The volume of the bark on a tree can be estimated by subtracting the volume of the tree if it has been stripped of bark from the volume of the tree with bark still on it. In other words:

$$\text{Bark volume} = \text{Timber volume}_{\text{over bark}} - \text{Timber volume}_{\text{under bark}}$$

Box M.3 describes two methods for estimating the volume of timber. The measurement of diameter (whether mid-diameter or diameter at breast height (dbh), depending upon the method used to estimate volume) needed to estimate the trunk volume over bark should be made in the manner described in *Box M.3*. The measurement of diameter (whether mid-diameter or dbh) needed to estimate the trunk volume under bark can be made in several ways (see *Figure M.4*):

- Cut the bark so that its thickness can be measured with a ruler and subtract this amount (doubled) from the diameter measurement for volume over bark, or
- Remove the bark at diametrically opposed points so that the diameter under bark can be measured with calipers.

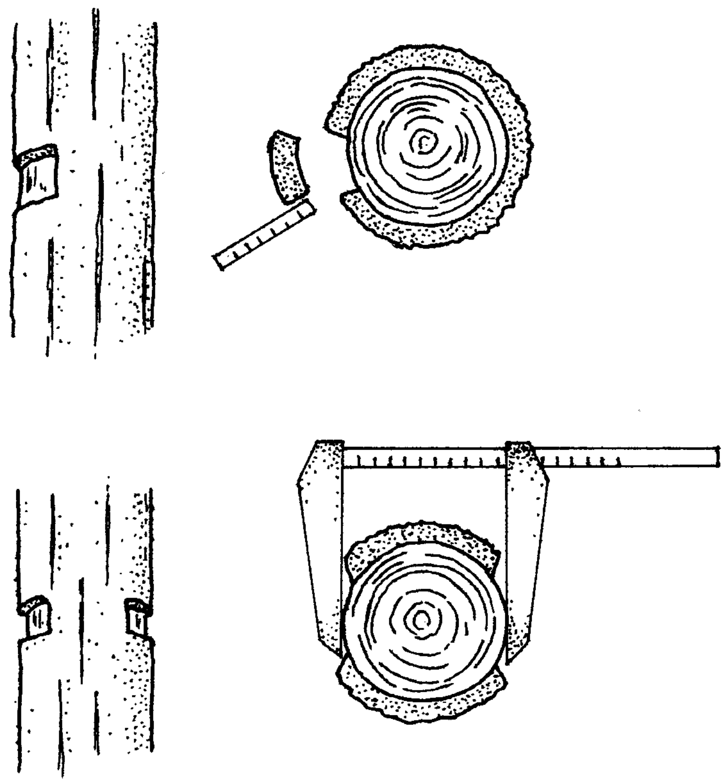


Figure M.4. Two methods for measuring the diameter under bark: a, cut the bark so its thickness can be measured with a ruler and subtract this amount (doubled) from the diameter over bark, and b, remove the bark at diametrically opposed points so that the diameter under bark can be measured with calipers.

M.4.7. Epiphytes

Description. Epiphytes are shrubs or herbs that grow on trees rather than on the forest floor. They are predominantly found on canopy trees with large branches. Orchids are one example of a valuable epiphyte.

How to measure potential annual productivity. Epiphytes are often harvested opportunistically, for example after a tree falls or is felled. Thus their host plant is often destroyed during the harvest. However, sometimes the host is not destroyed, such as when the harvester climbs the tree to collect the epiphyte. If epiphytes are most often harvested destructively, it is most likely that the number of epiphytes on the tree are related to the tree's diameter at breast height (dbh) or crown diameter. To determine this relationship, a sample of trees (of the species known to have high quantities of the epiphyte of interest) would need to be felled and the epiphytes on their branches counted. This would be feasible if the trees were to be felled for their timber anyway. If epiphytes are most often harvested non-destructively, the best way to measure their recovery is to observe the tree's upper branches at regular intervals, either with binoculars or by climbing the tree, to see how long it takes for the epiphytes that were on them before the harvest to be replaced, both in number and approximate size.

What units or classes are used. Epiphytes are usually sold by the plant, rather than by weight or size. However, this will depend upon the species of the epiphyte.

M.4.8. Leaves

Description. The leaves of plants, whether trees, palms, climbers, shrubs, or herbs, have many uses. Sometimes they are used to wrap food, sometimes as cooking herbs, sometimes as medicines. Some uses require only the young leaves, others require leaves of all ages.

How to measure potential annual productivity. Leaves are generally harvested without destroying the plant on which they are growing. However, sometimes they are harvested by cutting down entire branches rather than individual leaves. Measure potential annual production, whether for individual leaves or branches, as described in *Box M.2*. This method will be relatively easy for smaller plants such as shrubs or herbs, but difficult for trees. In palms, including rattans, leaves are produced one at a time, growing from the top of the stem. If the uppermost leaf (or its leaf base, if the leaf itself has been harvested) can be marked at the time of harvest, the number of leaves that grow above it can be easily seen and counted at intervals of time after harvest.

What units or classes are used. Leaves are often sold by weight, in some cases wet weight, in other cases dry weight. Sometimes leaves are sold in bundles.

M.4.9. Honeybee hives

Description. Wild honeybee hives are usually found on canopy emergent trees (i.e. trees that grow much taller than the average tree height of a forest). These trees are found mostly along the edges of rivers. Often the trees are claimed and owned by one individual or family, who return to harvest the trees' hives repeatedly over many years.

How to measure potential annual productivity. Honey is not usually harvested in a way that destroys the tree, although it usually destroys the hive itself. Local villagers are likely to know how long it takes the hives to recover to levels where another harvest can be made. However, another way to determine this is to observe the tree's upper branches at regular intervals, either with binoculars or by climbing the tree, to see how long it takes for the hives that were on them before the harvest to be replaced, both in number and approximate size, as described in *Box M.2*.

What units or classes are used. Honey is usually sold by liquid volume or by weight.

M.4.10. Resin or sap

Description. Some common resins and saps in Indonesia include damar and rubber. Rubber is an introduced species that now is found in semi-wild in agroforests as well as in plantations.

How to measure potential annual productivity. Resins and saps are not usually harvested destructively. It is difficult to determine the recovery period for resins or saps, although a detailed study could be developed. Another option is to ask the villagers how long they wait before visiting the same tree, and use this length of time as your period of recovery. This method assumes that the villagers have long since worked out the period between harvesting that optimises productivity. Peters (1992) recommends that a given tree be measured more than once, over the course of a year at least, in case there is seasonal variation in production levels.

What units or classes are used. Resins and saps are usually measured by weight or liquid volume.

M.4.11. Fruit (including flowers, fruit, nuts, seeds)

Description. The flowers, fruits, nuts and seeds of plants have a variety of uses for villagers.

How to measure potential annual productivity. Fruit are usually harvested non-destructively. As a plant's fruit would have been shed regardless of whether they were harvested or not, it is not possible to measure the time to their recovery. Instead you should determine the amount of fruit that can be harvested over the course of a year, and the time period between periods of fruit production. The potential annual productivity is then calculated by dividing the former measurement by the latter.

There are a number of ways to estimate the amount produced by any given tree, depending upon the nature of the tree, or the nature of the fruit. Each sample tree should be observed to see how much fruit is produced over the year, or, if the fruit is produced seasonally, over the fruiting season. These observations of fruit production can be done in two ways:

- Count the fruit directly, with or without binoculars. This is suitable for trees with large fruit that are few in number and easy to see (i.e. trees like jackfruit, which produce clumps of fruit on their trunks).
- Count the fruit fall using the method described in *Box M.5*, below. This is suitable for tall trees that produce too many fruit for direct counts to be possible.

Box M.5. How to estimate the potential annual productivity of fruit that are difficult to count directly in the canopy

Peters (1996) describes a method of counting fruit production over one fruiting season. The first step is to determine the area of ground underneath the tree that is covered by the tree's crown (called the crown area). This can be done by measuring the distance from the trunk to the crown edge along four perpendicular radii (*Figure M.5*). These distances can be sketched on graph paper, and the area calculated by counting the squares on the graph paper. This crown area should be divided into four, along the perpendicular radii mentioned above. Plots should be randomly placed in each quarter of the total area, with a quarter of the total number of plots allotted to each quarter area (this is done because often there is more fruit fall to one side of a tree than another). There are two options for determining the total number of plots:

- Sample a proportion of the crown area (for example 10% of the crown area),
- Sample a constant number of plots for each tree, regardless of its crown area (for example, 3-4- plots to each quarter area).

Plots are usually one metre by one metre in size. They should be numbered, their corners marked with stakes, and their boundaries marked with string. Once counted, the fruit should be removed from the plot so that they are not counted the next time. Estimate the amount of fruit produced by the tree by multiplying the crown area by the average number of fruit found in the plots over the course of the fruiting season.

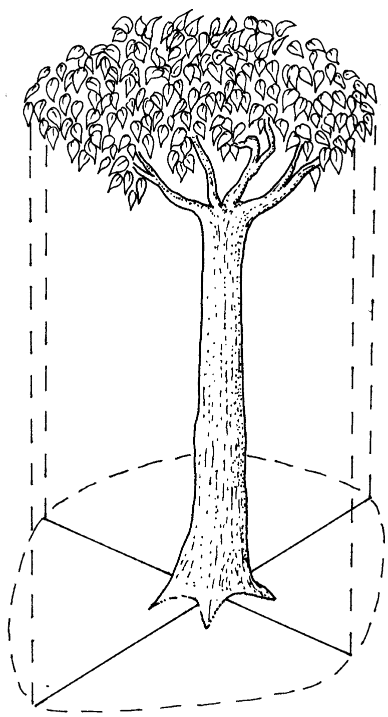


Figure M.5. Measuring the distance from the tree's trunk to the crown edge along four perpendicular radii.

In some plants, the nuts or seeds of interest are found in varying numbers within a larger fruit. Peters (1996) recommends that at least fifty of these fruit be opened and the number of nuts or seeds found within them counted, in order to determine the average nut or seed production of one fruit.

What units or classes are used. Fruit are often sold by weight. Sometimes they are sold by the individual fruit, possibly graded by size (small, medium or large) or quality (grade A, B, C). Sometimes they are sold by the bunch.

N

Botanical Specimen Forms

Objectives

By the end of this appendix, you should be able to do the following:

N.1. Obtain and photocopy a botanical specimen form for trees, climbers, shrubs and herbs,

N.2. Obtain and photocopy a botanical specimen form palms (including rattans), and

N.3. Obtain and photocopy a botanical specimen form for bamboos.

Introduction

This appendix contains botanical specimen forms for recording information in the forest about any plants which you are collecting. There are three forms, as follows:

- *Figure N.1*, for trees, climbers, shrubs and herbs,
- *Figure N.2*, for palms (including rattans), and
- *Figure N.3*, for bamboo.

These forms may either be photocopied or used as a basis for designing your own forms. The forms should be used in accordance with the instructions provided for their use in *Chapter 15*.

Figure N.1. Botanical specimen form for trees, climbers, shrubs and herbs

Collector:		**Collection number:**	
		Date:	

Botanical name:	
Local name:	

Local information (e.g. meaning of name, uses for plant, significance of plant):

Location of collection:	

Environmental information about the location of collection (e.g. altitude, forest type, soil colour and composition, topography, whether the plant is exposed to sun or shade, and what direction the slope is facing)

Description of general appearance of plant

Tree, climber, shrub or herb:	
Single stemmed or clumped:	
Shape of trunk (if tree):	
Height (length, if climber):	
Diameter:	

Sketch of general appearance of plant:

Figure N.1. (reverse side of page)

Description of plant parts

Outer and inner bark (colour, consistency and smell, and whether they change colour after being exposed to air):
Sap or latex (colour, consistency and smell, and whether it changes colour after being exposed to air):
Wood (hardness, colour and the smell produced from a cut in the trunk):
Leaf type (whether simple or compound; if compound, draw the pattern of the leaflets):
Leaf (colour, consistency and smell):
Flower (colour and smell) or fruit (colour, consistency, smell and taste):
Roots (any special characteristics):

Checklist of plant parts to collect:

- ☐ Leaf
- ☐ Stem (with bark, if tree)
- ☐ Flowers/fruit
- ☐ Roots

Figure N.2. Botanical specimen form for palms (including rattans)

Collector:		**Collection number:**	
		Date:	

Botanical name:	
Local name:	

Local information (e.g. meaning of name, uses for plant, significance of plant):

Location of collection:	

Environmental information about the location of collection (e.g. altitude, forest type, soil colour and composition, topography, whether the plant is exposed to sun or shade, and what direction the slope is facing)

Description of general appearance of plant

Single stemmed or clumped:	
If clumped, are stems close together or spread out:	

Sketch of general appearance of plant

Figure N.2. (reverse side of page)

Description of plant parts

Stem

Height of the stem (length, if rattan):	
Internode length:	
Diameter of stem (Diameter without leaf sheath, if rattan):	
(Diameter with leaf sheath, if rattan):	

Leaf

Length of petiole:	
Length of midrib of leaf:	
Total leaf length:	

Leaflets

Number of leaflets on one side of midrib	
Leaflets regular or grouped:	
If leaflets grouped, how many per group:	
Flowers/fruit	
Colour, smell and taste	

Roots

Any special characteristics:	

Checklist of plant parts to collect:

- ☐ Stem
- ☐ Leaf sheath
- ☐ Petiole
- ☐ Leaf (up to 3 sections)
- ☐ Climbing whip (if rattan)
- ☐ Inflorescence
- ☐ Roots

Figure N.3. Botanical specimen form for bamboo

Collector: | **Collection number:**

Date:

Botanical name:

Local name:

Local information (e.g. meaning of name, uses for plant, significance of plant):

Location of collection:

Environmental information about the location of collection (e.g. altitude, forest type, soil colour and composition, topography, whether the plant is exposed to sun or shade, and what direction the slope is facing)

Description of clump:

One clump or many clumps:

Diameter of clump:

Description of largest accessible culm (stem):

Total height of the culm:

Length of fifth internode from base of culm:

Diameter of fifth internode from base of culm:

Length of longest internode on culm:

Number from base of culm of longest internode:

Checklist of plant parts to collect:

- ☐ Culm (5th internode)
- ☐ Culm sheath
- ☐ Leafy twigs
- ☐ Branch complement
- ☐ Rhizome

O

Compilation and Calculation Forms

Objectives

By the end of this appendix, you should be able to do the following:

O.1. Obtain and photocopy, if desired, a Compilation Form, and

O.2. Obtain and photocopy, if desired, Calculation Forms 1 and 2.

Introduction

This appendix contains:

- *Figure O.1*, a Compilation Form, for sorting and arranging the inventory data gathered in the field,
- *Figure O.2*, Calculation Form 1, for calculating density and quantity without their precisions, and
- *Figure O.3*, Calculation Form 2, for calculating density and quantity with their precisions.

These forms may either be photocopied or used as a basis for designing your own forms. The forms should be used in accordance with the instructions provided for their use in *Chapter 17*.

Figure O.1. Compilation Form

Area and Forest Type: Page ______ of ______				Resource Category 1:		Resource Category 2:		Resource Category 3:		Resource Category 4:		Resource Category 5:	
Team	Date	Line	Plot	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)	No. of plants (y)	(y^2)
Total for page:													
Total for area or forest type:													

Figure O.2. Calculation Form 1

Form for calculating the density (average number of plants per ha) and quantity (number of plants in a given area or forest type) of a given resource category

Area or forest type: ______________________________

Resource category: ______________________________

To estimate the density in units of number of plants per plot:

1. Sum of the number of plants in all plots: $\Sigma y =$ _______

2. Number of plots: $n =$ _______

3. Density in units of number of plants per plot: $\frac{\Sigma y}{n}$, $\overline{y} =$ _______

To change the density to units of number of plants per hectare:

4. Size of each plot in hectares: $a =$ _______

5. Density in units of number of plants per hectare: $\frac{\overline{y}}{a}$, $\overline{Y} =$ _______

To estimate the quantity of plants in a given area or forest type:

6. Size of area or forest type in hectares: $A =$ _______

7. Quantity of plants in area or forest type: $\overline{Y} \times A$, $Y =$ _______

Figure O.3. Calculation Form 2

Form for calculating the density (average number of plants per ha) and quantity (number of plants in a given area or forest type) of a given resource category, as well as their respective confidence ranges and the sampling error %.

Area or forest type: ______________________

Resource category: ______________________

To estimate the density in units of number of plants per plot:

1. Sum of the number of plants in all plots: Σy = ______

2. Number of plots: n = ______

3. Density in units of number of plants per plot: $\frac{\Sigma y}{n}$, $\overline{y}$ = ______

To estimate the confidence range in units of number of plants per plot:

4. Sum of the squared number of plants in all plots: $\Sigma(y^2)$ = ______

5. Correction for mean: $\frac{(\Sigma y^2)}{n}$ = ______

6. Sum of squared deviations from the mean: $\Sigma(y^2) - \frac{(\Sigma y^2)}{n}$, SSy = ______

7. Variance of mean: $\frac{SSy}{n(n-1)}$, $V\overline{y}$ = ______

8. Standard error of mean: $\sqrt{V\overline{y}}$, $SE\overline{y}$ = ______

9. Student's t at P = 0.1 (or P = 0.05): t = ______

10. Confidence range in units of number of plants per plot: $\pm t \times SE\overline{y}$, c = ______

(Calculations continue on reverse side of page)

Figure O.3. Calculation Form 2 (reverse side of page)

To estimate the density and confidence range in units of number of plants per hectare:

11. Size of each plot in hectares: $a =$ ______

12. Density in units of number of plants per hectare: $\frac{\bar{y}}{a}$, $\overline{Y} =$ ______

13. Confidence range in units of number of plants per hectare: $\pm \frac{c}{a}$, $C =$ ______

To estimate the quantity and confidence range in a given area or forest type:

14. Size of area or forest type in hectares: $A =$ ______

15. Quantity of plants in area or forest type: $\overline{Y} \text{ x } A =$ ______

16. Confidence range of the quantity of plants: $\pm\, C \text{ x } A =$ ______

To estimate the sampling error % of the density and quantity:

17. Sampling error %: $100 \text{ x } \frac{c}{\bar{y}}$, $E\% =$ ______

P

Data Forms

Objectives

By the end of this appendix, you should be able to do the following:

P.1. Obtain and photocopy, if desired, a simple tally form, and

P.2. Obtain and photocopy, if desired, a full data form.

Introduction

This appendix contains data forms for recording data along the inventory lines. There are two forms, as follows:

- *Figure P.1*, a simple tally form for counting plants but recording no further information, and
- *Figure P.2*, a full data form for recording information on the plants and their environment.

These forms may either be photocopied or used as a basis for designing your own forms. The forms should be used in accordance with the instructions provided for their use in Chapters 9 and 13.

Figure P.1. A simple tally form

Area		Team			Date		Line #	
Forest type							Bearing	
Working unit								

Resource information

Plot number	Subplot number	Species code	Number of plants *(tally)*	Number of plants *(sum)*	Notes

Figure P.2. A full data form

Plot information

Area		Team			Date		Line #		Plot #	
Forest type							Bearing			
Working unit										

Subplot information

subplot	slope	aspect	slope position	indicator species 1	indicator species 2	indicator species 3	site description codes
a							
b							
c							
d							
e							

Resource information

all plants					trees	palms	rattans			bamboos	climbers	shrubs	herbs
subplot	species	age class	sex	condition	dbh	height	clump number	ground length	above ground length	clump number	dbh	height	% cover

Figure P.2. A full data form (reverse side of page)

Resource information

all plants					trees	palms	rattans			bamboos	climbers	shrubs	herbs
subplot	species	age class	sex	condition	dbh	height	clump number	ground length	above ground length	clump number	dbh	height	% cover

BIBLIOGRAPHY

Alder, D. and Synott, T. J. 1992. Permanent sample plot techniques for mixed tropical forest. *Tropical Forestry Papers* 25.

Carter, J. 1996. Recent approaches to participatory forest resource assessment. *Rural Development Forestry Study Guide 2*, Overseas Development Institute, London.

Chambers, R. 1991. Participatory rural appraisals; past, present and future. *Forests, Trees and People Newsletter* No. 15/16.

Chambers, R. and Guijt, I. 1995. PRA - five years later. Where are we now? *Forests, Trees and People Newsletter* No.26/27.

Dawkins, H. C. 1971. Techniques for long-term diagnosis and prediction in forest communities. In E. Duffey and A.S. Watt (Eds.), *The Scientific Management of Animal and Plant Communities* (pp. 33-44). 11th Symposium of the British Ecological Society, Norwich, 1970. Blackwell, Oxford.

Flavelle, A. 1996. *Community Mapping Handbook: A Guide to Making Your Own Maps of Communities and Traditional Lands*. Endangered Peoples Project Society and Lone Pine Foundation.

Freudenberger, K. S. 1994. *Tree and Land Tenure Rapid Appraisal Tools*. Food and Agriculture Organisation of the United Nations. Rome.

Peters, C. M. 1996. The Ecology and Management of Non-Timber Forest Products. *World Bank Technical Paper* No. 322.

Philip, M. S. 1994. *Measuring Trees and Forests* (2nd edition). CAB International, Wallingford, Oxon OX10 8DE, UK.

Poole, P. (ed.) 1995. Geomatics. *Cultural Survival Quarterly*. Winter 1995 Vol. 18/4

Pretty, J. N., Guijt, I., Thompson, J. and Scoones, I. 1995. *Participatory Learning and Action, A Trainer's Guide*. International Institute for Environment and Development, London.

Thompson, J., Shah, J. and Foellmi, E. 1994. *Planning for Change: Participatory Rural Appraisal for Community-Based Development*. Report on Training Workshop and Follow-up Activities Organised by the Kalam Integrated Development Project and International Institute for Environment and Development. Islamabad.

Warner, K. 1995. *Selecting tree species on the basis of community needs*. Food and Agriculture Organisation of the United Nations. Rome.

INDEX

A

Access routes to the inventory area 65

Accuracy
  How to improve 3, 155, 156, 175, 180, 310–316
  Importance in participatory inventory 3, 222

Aerial photograph
  Assessing whether it has the required information for making a planning map 65–67
  Copying one using tracing paper 69
  Description 290
  How to obtain one 291–292
  Making a planning map using one 67–74

Age, plant 107–111, 330, 334. *See also* **Young plants**

Aim of manual 1

Altitude. *See* **Information about the inventory area**

Analyses needed for different inventory purposes 273–280

Angle of the slope. *See* **Slope, angle of the**

Approximations to assess compatibility of cost and precision. *See* **Compatibility of cost and precision**

Area, inventory
  Determining the inventory area (Objective 3) 38–39
  Determining the subdivisions of the inventory area (Objective 4) 39–41
  Determining what information about the inventory area is wanted (Objective 5) 42

Area size, estimating. *See* **Size of an area, estimating**

Area, smaller. *See* **Subdivision by area**

Area, table for converting units of 95

Aspect. *See* **Information about the inventory area**

B

Back bearing 75, 77

Balancing cost and precision. *See* **Compatibility of cost and precision**

Bamboo
  Age classes 110
  Botanical collection form for 357
  Making botanical specimens in the forest of 196–197
  Size classes 115
  Writing notes for botanical specimens of 190

Base line 96–98

Bearing. *See also* **Orientation**
  Calculating the opposite or perpendicular bearings of a bearing 304
  Following a bearing in the field 305
  Holding a compass to take a bearing 300–302
  Taking a bearing from a map 303
  Taking the bearing of a feature 305

Blocks
  A type of working unit 90
  Subdivision by area into 39

Borderline plants. *See* **Plot boundaries**

Botanical collection forms
  Calculating how many you will need 56
  Examples of the forms 353–357
  How to fill them in 187–190

Botanical specimens
  Collection in the forest
    Making specimens 191–197
    Numbering and labelling 197
    Writing notes in the field 187–190, 191–197
  Equipment you will need for making 56, 60
  Organising the schedule for collecting them 138, 140, 140–141
  Preservation in the camp or forest
    Preserving in methylated spirits 197–201
    Pressing 199–201

Boundary, inventory area 33, 38, 81, 210–211

Boundary, plot. *See* **Plot boundaries**; **Plot boundary**

Boundary, subdivision 33, 41

Boundary traverse. *See* **Traverse, boundary**

Boundary, working unit 90

Breast height, diameter. *See* **Diameter at breast height (dbh)**

C

Calculation form
  For calculating the density and quantity with precision 222–224, 361–362
  For calculating the density and quantity without precision 220–222, 360
  For calculating the precision obtainable for a given number of plots 272
  How many will you need 218, 220

Calculations
  Calculating the density and quantity with precision 222–224
  Calculating the density and quantity without precision 220–222

Centre point of a plant 176. *See also* **Plot boundaries**

Checking the inventory work
Assessing the checks 182–183
Conducting the checks 182
Discussing the checks in the final report 231
Importance for improving accuracy 3, 180
Organising the schedule for making checks 139, 181
Setting the check objectives 181

Climber
Age classes 110
Botanical collection form for 353–354
Making botanical specimens in the forest of 191–192
Size classes 115–116
Writing notes for botanical specimens of 188

Clinometer 56, 61, 119, 296

Clumped plants, what to do with 106, 116

Coefficient of variation % (CV%). *See also* **Reassessment of compatibility of cost and precision**
Calculating CV% 270–271
Definition of CV% 269
Form for calculating CV% 272
Using CV% to select the most variable resource for reassessment of cost and precision 269

Collecting botanical speciments 187–197. *See also* **Botanical specimens**

Compass
Description of a compass 299–300
How to hold a compass 300–302
How to use a compass
Calculating the opposite or perpendicular bearings of a bearing 304
Following a bearing in the field 305
Measuring the angle of the slope 119, 297
Taking a bearing from a map 303
Taking a bearing of a feature in the field 305
Training the inventory team in how to use a compass 148–152
Type needed for participatory inventory 57

Compass person
On a surveying team 75–76
On an inventory work team
Doing 100% enumeration 167–168
Sampling with inventory lines 169–175

Compatibility of cost and precision
Making approximations to assess it when planning the inventory 44, 264–267
Reassessing it after one week of inventory work 141, 264–265, 268–271

Compilation form
Calculating how many you will need 56
Example of a compilation form 359
How to fill it in 216

Compiling the inventory data 216

Concerns of villagers regarding forest and resources
Facilitating a discussion with villagers of 28, 249, 251–259
Preparing to facilitate a discussion with villagers of 27, 249, 251–259

Condition, plant 116–117, 334

Confidence limits 43, 223

Confidence range 43, 222–224, 263, 361–362. *See also* **Precision**

Cost
  Choosing the cost limits desired for the inventory 42–43
  Compatibility with desired precision 43, 44, 263
  Definition of 42, 263

Cost efficiency. *See also* **Precision**
  How to improve 3–4
  Why systematic strip sampling is cost efficient 314
  Why we have chosen the orientation of the lines fo 315–316

Cover, percent (%) 116

Cross-tie 76, 80

D

Data compilation 216

Data form
  Calculating how many you will need 55
  Designing a data form 125–127
  Examples of some data forms 364–366
  Guidelines for good data recording 177

Date on a map 73, 81, 212, 287

Decision making in the village (Stage I of participatory inventory)
  Determining the inventory objectives 32–45
  Determining the inventory purpose 26–30
  Introducing participatory inventory to the villagers 10–23
  Selecting the inventory team and work dates 48–50

Degrees of freedom 223

Density of a resource
  Calculating the density 219–221
  Definition of 16
  Explaining to the villagers how to calculate it 22
  How reliable is this estimate? 222

Diameter at breast height (dbh)
  Description 111
  How to measure it for normal trees 321–322
  How to measure it for problem trees 323–324

Direction. *See* **Bearing**; **Orientation**

Distance, horizontal. *See* **Horizontal distance**

Distance, slope. *See* **Slope distance**

Distance, table for converting units of 282

Duties
  Camp duties 136
  Inventory work team duties 136–137
  Inventory work team leaders' duties 137

E

Enumeration, 100%
- Choosing 100% enumeration or sampling 85–86
- Conducting one in the forest 167
- Planning one using the planning map 87–88

Enumerators on an inventory work team 175–177

Environmental information. *See* **Information that is wanted about the environment**

Equipment
- Equipment needed for participatory inventory that might be unavailable in the village 55–56, 56–62
- Equipment needed for work in the forest 135–136

Error, sampling. *See* **Precision**

F

Facilitator
- Definition 244
- Qualities to look for in a facilitator 245–246

Features
- Local names for 73, 81
- Making a cross-tie to 76

Field press. *See* **Press, field**

Field reference sheets
- Designing 127
- Examples of 128–130

Final map
- Explaining to the villagers what it is 14–15
- Including it in the final report 230, 231
- Making the final base map 207–211
- Making the final methods map 211–213
- Making the final results map 15, 213–214
- Presenting it at a general village meeting 236

Final report
- Designing the report for outsiders 229
- Designing the report for villagers 229
- Explaining to the villagers what it is 16
- Suggested outline for report 230–232

Follow up to the inventory
- Follow up activities needed for different inventory purposes 273–280
- Holding a village meeting to plan it 236–238
- Writing about it in the final report 232

Forest resources. *See* **Resources, forest**

Forest type. *See* **Subdivision by forest type**

Form
- Botanical collection. *See* **Botanical collection form**
- Calculation. *See* **Calculation form**
- Compilation. *See* **Compilation form**
- Data. *See* **Data form**

Fraction scale. *See* **Scale, fraction**

Front person on the inventory work team 168–169

G

General village meeting. *See* **Village meetings**

Geographical Positioning System (GPS) 61, 73, 162–163

Graph paper. *See* **Paper, simple grid graph**

Graph scale. *See* **Scale**

Grid reference 73, 81, 212, 286–287

Ground surveying. *See* **Surveying, ground**

Growth form 105–107

H

Harvested annual productivity 336. *See also* **Productivity**

Hectares, table for converting them to other units 95

Height
- Different height measurements on palms 113–114
- Different height measurements on trees 112–113
- Estimating height with a clinometer 326–327
- Estimating height with a ruler and a height pole 325–326
- Measuring height of young plants 331
- Measuring height with a height pole 324–325

Herb
- Age classes 111
- Botanical collection form for 353–354
- Making botanical specimens in the forest of 191–192
- Size classes 116
- Writing notes for botanical specimens of 188

Horizontal distance
- Measuring horizontal distance by holding the rope or tape level 294–295
- Measuring horizontal distance from the angle of the slope and the slope distance 296–299
- Training the inventory team in how to measure it 153
- Why we usually use horizontal distance and not slope distance 294

I

Information about forest resources. *See also* **Resources, forest**
- Determining the type of information wanted for the inventory 37, 105–117
- Determining the range of information to be included in the inventory 37, 117-118
- Information needed for different inventory purposes 273–280

Information about the inventory area. *See* **Area, inventory**
- Determining the information wanted for the inventory 42
- Information needed for different inventory purposes 273–280
- Site description codes 121–122
- Topographic indicators
  - Altitude 119
  - Aspect 119
  - Slope 119
  - Slope position 119–120
- Vegetation indicators 120–121

Information about the village. *See* **Participatory Rural Appraisal**
  How to gather this information using PRA 251–259
  What information is needed for participatory inventory 249–250

Information storage and security 232, 236–237

Introducing participatory inventory to the village. *See* **Participatory inventory**
  Holding a preliminary meeting with the village leaders 12
  How to answer the questions that the villagers are likely to have about participatory inventory 11, 12–22
  Questions that villagers are likely to have about participatory inventory 11

Inventory area. *See* **Area, inventory**

Inventory, forestry. *See* **Inventory, standard**

Inventory lines. *See* **Lines, inventory**

Inventory objectives. *See* **Objectives, inventory**

Inventory, participatory. *See* **Participatory inventory**

Inventory plots. *See* **Plots, inventory**

Inventory purpose. *See* **Purpose, inventory**

Inventory results. *See* **Results, inventory**

Inventory table. *See* **Table, inventory**

Inventory team
  Selecting the inventory team 49
  Training the inventory team 146–156

Inventory techniques, standard. *See* **Standard inventory techniques**

Inventory work in the forest (Stage III of participatory inventory)
  Checking the inventory work 180–183
  Collecting botanical specimens 186–201
  Conducting the inventory work 166–177
  Locating the starting point in the forest 158–164
  Organising the inventory work in the forest 134–141
  Selecting inventory work dates 50
  Training the inventory team 146–156

Inventory work team
  Compass person
    Doing 100% enumeration 167–168
    Sampling with inventory lines 169–175
  Duties of team leaders 137
  Duties of team members 136–137
  Enumerators 175–177
  Estimating the number of teams available for the inventory 42
  Front person 168–169
  Recorder 177
  Rope person
    Doing 100% enumeration 167–168
    Sampling with inventory lines 169–175

Islands of forest
  100% enumeration of many small ones 86
  A type of working unit 90
  Subdivision by area into 39–40

Issues in the village to do with forest and resources.
    See **Concerns of villagers regarding forest and resources**

L

Land survey map 74, 289

Latin name 186, 231

Latitude and longitude. *See* **Grid reference**

Legend of a map 73, 81, 212, 287

Length, estimating rattan stem 114–115

Linear traverse. *See* **Traverse, linear**

Lines, inventory
- Establishing them in the forest
  - Team formation for flat terrain 169–170
  - Team formation for steep terrain 170–172
  - What to do when the line crosses an area excluded from the inventory 174–175
  - What to do when the line meets a boundary 172
  - What to do when the line reaches an obstacle or inaccessible area 172–174
- Explaining to the villagers how they are distributed across the inventory area 21–22
- Planning their location using the planning map 88–101
- Spacing and orientation of the lines in systematic strip sampling
  - What orientation to use 88–89
  - What spacing to use 88
  - Why we use this orientation 315–316
- Why we have chosen to do sampling with lines 313–315

Local names
- For features on a map 73
- For forest type 120
- For plants 186

M

Manual
- Aim of manual 1
- How it is structured 5
- How to use 5
- Who this manual is intended for 1

Map, final. *See* **Final map**

Map, land survey. *See* **Land survey map**

Map, multiple purpose. *See* **Multi-purpose map**

Map, planning. *See* **Planning map**

Map, scale. *See* **Scale map**

Map, sketch. *See* **Sketch map**

Map, topographic. *See* **Topographic map**

Mapping techniques, standard. *See* **Standard mapping techniques**

Measuring plant size, standard procedures for
- Estimating volume 343–344
- Importance for improving accuracy 3
- Measuring diameter at breast height 321–324
- Measuring or estimating height 324–327

Meeting, general village. *See* **Village meetings**

Meeting, small group. *See* **Village meetings**

Metres, a table for converting them to other units 282

Misuses of participatory inventory, explaining to villagers what they are 18

Multi-purpose mapping, what to do if making a map for purposes other than participatory inventory 2

N

North symbol 73, 81, 212, 284–285

O

Objective methods for selecting plots
 Definition 310–312
 Importance for improving accuracy 3

Objectives, inventory
 Determining the area to be included in the inventory (Objective 3) 38–39
 Determining the desired cost limits (Objective 6) 42–43
 Determining the desired precision (Objective 7) 43–45
 Determining the forest resources to be included in the inventory (Objective 1) 35–36
 Determining the information desired about the forest resources (Objective 2) 36–38
 Determining the information desired about the inventory area (Objective 5) 42
 Determining the inventory objectives 32–45
 Determining the subdivisions of the inventory area (Objective 4) 39–41
 Evaluating whether or not they were met at the end of the inventory 232, 236
 Including them in the final report 230

One hundred percent (100%) enumeration. *See* **Enumeration, 100%**

Organising the work in the forest 134–141

Orientation of a map. *See also* **Bearing**
 Definition 284–285
 Information required for the planning map 65

Orientation of inventory lines. *See also* **Bearing**
 For 100% enumeration 87–88
 For sampling 88–89
 Why we have chosen this orientation for sampling 4, 315–316

Outputs, inventory
 Explaining to the villagers what they are 14–16, 27

P

Palm
 Age classes 108–109
 Botanical collection form for 355–356
 Making botanical specimens in the forest of 193–195
 Size classes 113–114
 Writing notes for botanical specimens of 189–190

Participation, explaining to the villagers what it is and why it is important 12–13

Participatory inventory
 Applying PRA techniques to 1–2
 Applying standard inventory techniques to 2
 Applying standard mapping techniques to 2
 Definition 1

Determining whether more than one inventory is needed 34
Evaluating it at the end of the inventory 232, 237–238
Explaining to villagers how it differs from standard inventory 14
Explaining to villagers how it is done 17
Explaining to villagers what it is 13
How it was developed for this manual 1
How it was evaluated and improved for this manual 4
Introducing it to the villagers 10–23
Main stages of 5

Participatory Rural Appraisal (PRA)
How it is applied to participatory inventory 1–2
How to do PRA 252
Information about the village that may be needed for participatory inventory 249–250
PRA techniques used to gather information
Participatory sketch mapping of the village 254
Participatory sketch mapping of the village area 260–262
Scoring and ranking 257–259
Seasonal calendars 256–257
Semi-structured interviews (SSIs) 252–253
Transects 255
Trend tables 255–256
Walks in the forest with forest experts 254
Principles of PRA 251

Photocopies of
Calculation forms 56, 60, 272, 360–362
Compilation forms 56, 60, 359
Data forms 55, 59, 364–366
Scale maps
Photocopying them 68
Reducing or enlarging them 70–71
Simple grid graph paper onto transparent sheets 55, 59

Planning map
Accuracy required 65
Deciding whether you need to make one 66
Information required 65
Making one by ground surveying 74–81
Making one from a scale map, aerial photograph or radar image 67–74
Suitable size 66
Uses 65
Using one to calculate the size of the inventory area 92–95
Using one to find the starting point 158–164
Using one to plan the inventory
For 100% enumeration 87–88
For sampling 88–101
Using one to produce a final map or maps 206–214

Planning the inventory work (Stage II of participatory inventory)
Designing the data form 124–131
Organising the work in the forest 134
Planning the measurement of plants and site 104–122
Preparing the planning map 64–81
Using the planning map to plan the inventory 84–101

Plant age. *See* **Age, plant**

Plant size. *See* **Size, plant**

Plants, small. *See* **Small plants**

Plants, young. *See* **Young plants**

Plot boundaries, determining whether a plant is within them
  How to determine 175–176
  Importance of this for improving accuracy 3

Plots, inventory
  Definition and example 20–21, 315
  Explaining to the villagers how to establish and enumerate them 20–21, 153–156
  How to establish and enumerate them 166–177
  Why we have chosen this plot size 316

Plots, regeneration study 330, 330–331

Plots, total number of
  Calculating the precision obtainable for a given number of plots 268–272
  Importance for improving precision 4, 263

Point of Commencement (POC) in ground surveying 75

Potential annual productivity. *See* **Productivity**

Precision. *See also* **Cost efficiency**
  Calculating it for the density and quantity 222–224
  Calculating the precision obtainable for a given number of plots 268–272
  Compatibility with desired cost limits 43, 263–266
  Definition and example of 3, 43, 263
  How to improve 4
  Importance in participatory inventory 4
  Precision (Sampling error%) desired for different inventory purposes 44
  What to do if different levels of it are needed for different resources or areas 34
  Why number of plots is more important than sampling fraction for improving it 264

Presenting the results of the inventory (Stage IV of participatory inventory)
  Compiling data and making calculations 216–225
  Preparing the final map(s) 206–214
  Preparing the final report 228–232
  Presenting the results to the villagers and planning follow up 234–238

Press, field
  How to make your own 60–61
  Using it to press botanical specimens 199–201

Probability level 43, 223, 270, 318

Productivity
  Annual productivity 335
  Harvested annual productivity 336
  Potential annual productivity 336–339
  Productivity at the time of one harvest 335

Productivity study
  Analysing a productivity study 340–341
  Applying a productivity study to a range of products 342–351
  Conducting a productivity study 340
  Description 38, 333
  Planning a productivity study 334–340
  What inventory purposes it is needed for 273–280

Products, plant. *See* **Productivity study**

Purpose, inventory
Definition of 26
Discussing the inventory results in relation to the purpose 231, 236
Facilitating a village meeting to determine 27–29
How it addresses concerns of villagers 27, 28
Including it in the final report 230
Information and analyses needed for different purposes 273–280
Preparing a village meeting to determine 27
Statement of 28–29, 230
Why it is important 26

Q

Quantity of a resource
Calculating it 219–221
Definition 216
Explaining to the villagers how to calculate it 22
How reliable is this estimate 222

Questions that villagers are likely to have about the inventory 11

R

Radar image
Assessing whether it has the required information for making a planning map 65–67
Copying one using tracing paper 70
Description 290–291
How to obtain one 291–292
Making a planning map from one 67–74

Random selection or sampling 100, 312–313

Range of information about plants. *See* **Information about forest resources**

Ranking. *See* **Participatory Rural Appraisal**

Rattan
Age classes 109–110
Botanical collection form for 355–356
Making botanical specimens in the forest of 193–195
Size classes 114–122
Writing notes for botanical specimens of 189–190

Reassessment of compatibility of cost and precision 141, 268–272.
See also **Compatibility of cost and precision**

Recorder on an inventory work team 177

Reference point
Description 65
Finding a starting point in the forest by walking from a reference point 159–161

Regeneration study
Analysing a regeneration study 332
Conducting a regeneration study 330–331
Description 38
Planning a regeneration study 330
What inventory purposes it is needed for 273–280

Report, inventory. *See* **Final report**

Resources, forest
Determining the most important ones for a village 36
Determining what information about them is wanted for the inventory 36–38
Determining which are to be included in the inventory 35–36

Results, inventory
Explaining to the villagers how they are shown in a table 15–16
Explaining to the villagers how they are shown on a map 14–15
Presenting them to the villagers at the end of the inventory 236

Risks of participatory inventory. *See* **Misuses of participatory inventory**

Rope person on an inventory work team 169–175

S

Sampling
Deciding whether to do sampling or 100% enumeration 85–86
Definition 2
Explaining to the villagers what it is 20
Planning sampling with inventory lines using the planning map 88–101

Sampling design 88, 230, 313–315. *See also* **Systematic strip sampling**

Sampling error % 43, 224. *See also* **Precision**

Sampling fraction, its influence on the precision 264

Scale
Adding it to a map 73
Calculating distances on the ground from distances on the map and vice versa 282–284
Fraction scale 282–283
Graph scale 283–284
Matching scale to size of inventory area 70
Modifying the scale by enlarging or reducing the scale map 70–71

Scale map
Assessing whether it has the required information for making a planning map 65–67
Copying one by photocopying 68
Copying one using tracing paper 68–69
Description and examples 289–290
Enlarging and reducing the scale 70–71
How to obtain one 291–292
Making a planning map from one 67–74

Schedule, inventory
Explaining it to the villagers 19
For all the work in the forest 141
For the working unit 138–141

Scoring. *See* **Participatory Rural Appraisal (PRA)**

Security of inventory information. *See* **Information storage and security**

Sex, plant 116, 334

Shrub
Age classes 111
Botanical collection form for 353–354
Making botanical specimens in the forest of 191–192
Size classes 116
Writing notes for botanical specimens of 188

Simplicity
Importance in participatory inventory 3
Why systematic strip sampling was chosen for partipatory inventory 313–315
Size of an area, estimating the 92–95
Size, plant 111–116, 177. *See also* **Small plants**
Sketch map
Making a sketch map 260–262
Using it to add information to the planning map 73, 81
Using it to discuss inventory objectives 33, 38
Slope. *See* **Information about the inventory area**
Slope, angle of the 77, 296–308
Slope distance 77, 294, 298–299
Slope position. *See* **Information about the inventory area**
Slope table
For establishing the inventory line 308
For ground surveying 306
Table to use for determining horizontal distance when making a map by ground surveying 298
Small group meeting. *See* **Village meetings**
Small plants. *See also* **Size, plants**
Choosing a lower limit to the range of sizes to include in the inventory 117–118
Enumerating them in an inventory 177
Why they are costly to include in the inventory 37
Smaller area. *See* **Subdivision by area**
Spacing of inventory lines 88
Square metres, converting to other units of area 95
Standard inventory techniques
Explaining to villagers how it differs from participatory inventory 13–14
Explaining to villagers what it is 13
How it is applied to participatory inventory 2
Standard mapping techniques 2
Standard procedures for measuring plant size. *See* **Measuring plant size, standard procedures for**
Starting point
Choosing which method to use to find the starting point 159
Finding the starting point by using GPS 162–163
Finding the starting point by walking from a completed inventory line 162
Finding the starting point by walking from a reference point 159–161
Statement of inventory purpose
Adding it to the inventory report 230
Using it as a visual display for village meetings 33
Writing it with the villagers 28–29
Station of a traverse 75
Step chaining on steep slopes 295
Storage of inventory information. *See* **Information storage and security**
Student's 't' table
Definition 318
How to use it 319
The table 319
Using it in calculations 223, 270

Subdivision by area
  Determining whether an inventory area should be subdivided 39
  Types of smaller areas 39–40
Subdivision by forest type
  Determining whether an inventory area should be subdivided 40
  Recording forest type for productivity study 334
  Types of forest types 41
  Vegetation indicators for forest types 120–121
Subjective methods for selecting plots 310–312
'Successive approximation' method of determining a sustainable level of harvesting 280
Surveying, ground, making a planning map by 74–81
Systematic selection or sampling 312–313
Systematic strip sampling
  Description of 88–89
  Importance for improving cost efficiency of 4

T

Table, inventory
  Explaining to the villagers what it is 15–16
  Including a table or tables in the final report 231
Table, slope. *See* **Slope table**
Table, Student's 't'. *See* **Student's 't' table**
Table, volume. *See* **Volume, table**
Team, inventory. *See* **Inventory team**
Topographic map 289–290
Tracing a scale map, aerial photograph or radar image 68–70
Training the inventory team
  Importance for improving accuracy 3
  Organising the schedule for training 141
  Planning the training session 147–148
  To enumerate the plants and record the information 155–156
  To establish the inventory line 153–155
  To use the compass 148–152
Transparent photocopy of simple grid graph paper. *See* **Photocopies of**
Traverse
  Boundary or closed traverse 74
  Linear or open traverse 74
  Making a map from traverse information 78–80
  Making a traverse 75–76
  Recording a traverse 77–78
Tree
  Age classes 108
  Botanical collection form for 353–354
  Making botanical specimens in the forest of 191–192
  Size classes 111–113
  Writing notes for botanical specimens of 188
Type, forest. *See* **Subdivision by forest type**
Type of information about plants. *See* **Information about forest resources**

U

Units, working. *See* **Working units**

Universal Transverse Mercator (UTM). *See* **Grid reference**

Uses of participatory inventory, explaining to the villagers what they are 28

V

Village leaders
  Holding a preliminary meeting to introduce participatory inventory 12
  Signing a statement of inventory purpose 28

Village meetings
  General village meetings 242
  How to facilitate decision making 247
  How to make presentations 246–247
  How to plan a village meeting 243–245
  Small group meetings 242–243
  To determine the inventory purpose 27–30
  To discuss and determine the inventory objectives 33–45
  To introduce participatory inventory to the villagers 12–23
  To present the results of the inventory and plan follow up 235–238

Volume, timber 343–344

W

Watersheds
  A type of working unit 90
  Subdivision by area into 39–40

Who the manual is for 1

Work, inventory. *See* **Inventory work**

Working units
  Deciding whether to divide an inventory area into working units 90
  Difference between working units and smaller areas 92–93
  Types of working units 91–92

Y

Young plants
  Choosing a lower limit to the range of ages to include in the inventory 117–118
  Enumerating them in a regeneration study 330
  Why they are costly to include in the inventory 37. *See also* **Age, plant**