Instructions for surveying woody plants in RAPELD grids and modules.

Why monitor trees and ferns?

Trees, ferns and vines define forests. They are the structure of the habitat that houses other plants and animals, and therefore changes in their structure can affect biodiversity. Moreover, they contain most of the forest biomass and are fundamental to the distribution and dynamics of carbon stocks that are currently a major concern for scientists and governments.

How is RAPELD structured?

RAPELD modules are trails and permanent plots standardized systems. The modules consist of trails 5 km 1 km apart from each other. The map shows a grid consisting of a modular system of 5 X 5 km of trails. The black lines represent trails and red represent the uniform distribution of plots (Fig. **1).**

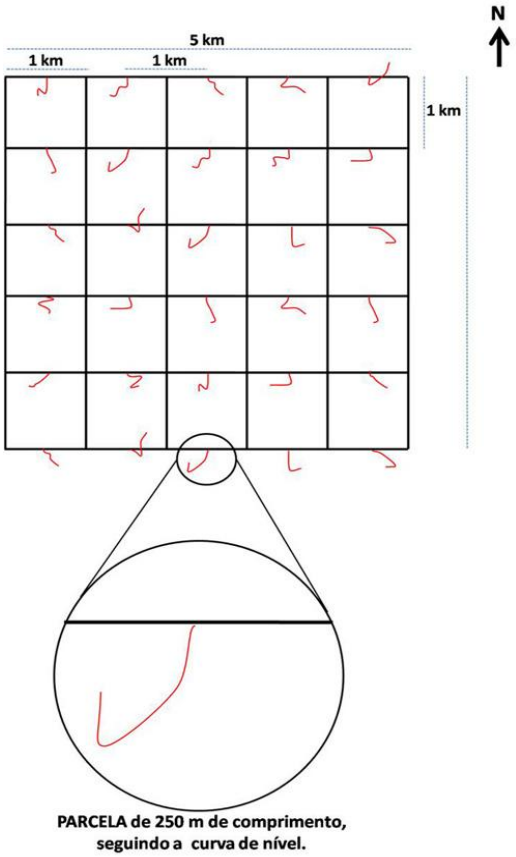

Figure 1. Schematic of a 25 km2 grid used for population studies in large sampling sites. Black lines are the tracks and red lines plots

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The trails are marked with a picket every 50 meters with the track name and the distance along the track (Fig. 2).

Figure 2. Example of a marked trail with PVC picket. The picket has a metal plate that informs the track and position in meters (3000 m).

Photo - Julio do Vale

RAPELD has several types of permanent plots, but here we will consider only uniform distribution of plots installed every 1 km along the tracks. Currently we began the plots 500 meters from the track early to avoid the effect of the intersection of the tracks.

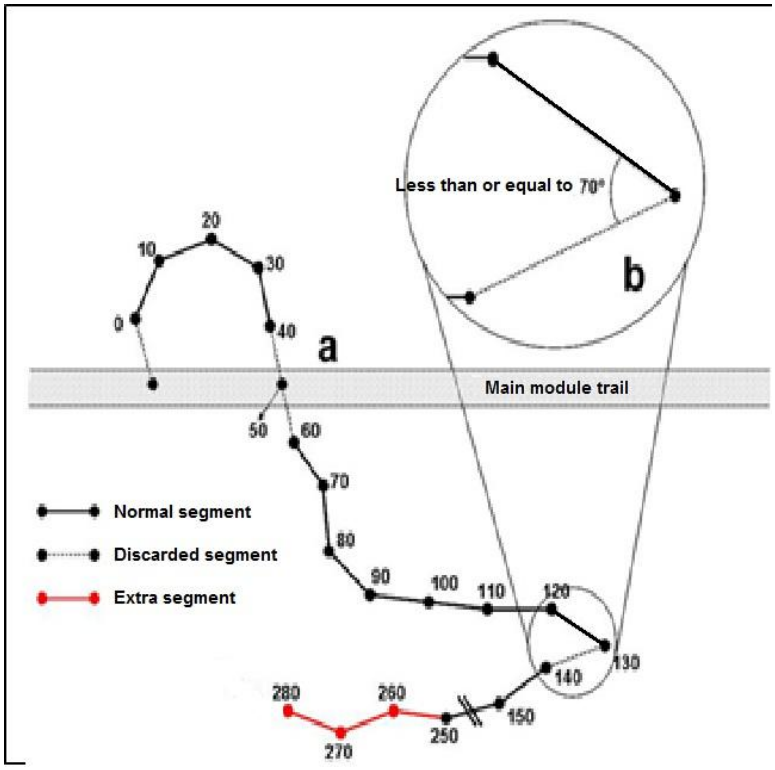

Figure 3. Portion following the contour with straight segments of 10 meters. The dotted lines indicate segments that must be disposed of their sampling. Segments in red indicate segments that have been added. Design: Fabricio Baccaro

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The survey plot is not straight because the survey follows the contour determined by the first picket in the sequence. (Fig. 3). The center line of the plot consists of 25 straight segments of 10 m, each marked by pickets. In the illustration, segments represented by dotted lines must be discarded and not surveyed. They are added to the end of the plot to give a total length of 250m.

All position measurements are made in the portion from the central line. Make sure it listed through the pickets. In the lines that demarcate the right side of the center aisle (displacement) and the limit of track 1 the pickets do not have cards.

Sampling

The sampling zones differ depending on the group of plants and their size (Fig. 4).

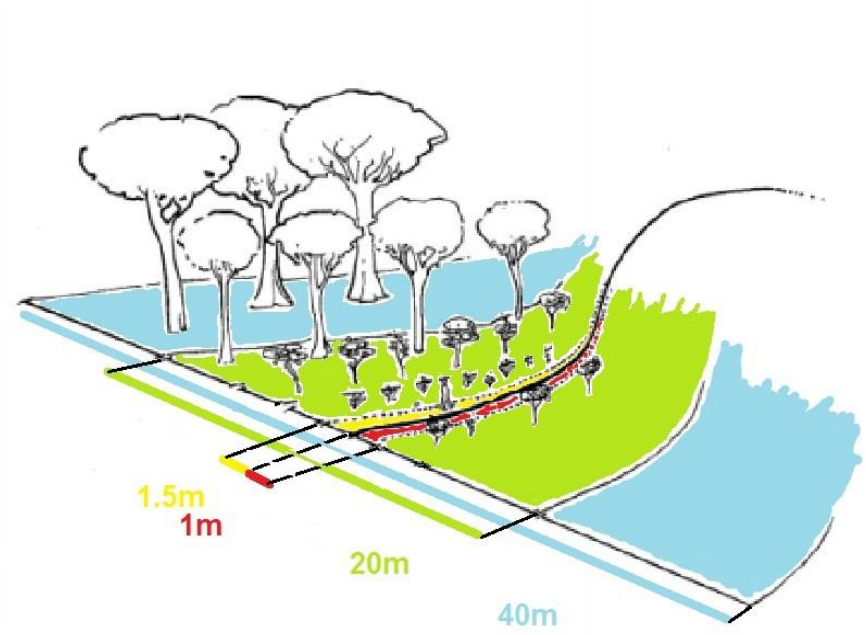

Figure 4. Trees are measured in zones of different width depending on the type of survey. In Zone 1 (the "sensitive zone") all trees with a diameter at breast height (DBH) ≥ 1 cm are measured, in the 20m zone trees with a DBH ≥ 10 cm and in the 40m zone trees with a DBH ≥ 30 cm.

Sampling ranges for each tree size class:

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The sensitive zone is a strip 1.5m wide to the left of the centre line as you look from the start of the plot to the end. Several different organisms are sampled in this zone and it protects small survey subjects from being damaged while other procedures are being carried out.

This zone should be marked out and all sampling should be done without entering it (Fig. 5). If is absolutely necessary to enter it to collect of samples for example, you should not put more than one foot inside and always take care to not step on anything which might be the subject of a subsequent survey.

Figure 5. The photo shows (from front to back) the right hand edge of the corridor (red string), the centre line with yellow measuring tape, and the left-hand limit of the sensitive zone (red string).

(photo - Fernanda Coelho).

When RAPELD was being developed, different zone 1, and corridor widths were tried and tested. Survey sites may contain survey strips and/or corridors of the following widths and it important to check previous data sheets to confirm this. Zone 1 may be on the left or the right.

Site	Zone 1L (m)	Zone 1R (m)	Corridor (m)
Ducke	3	3	2
Atumã - AM	4	0	0,5
Sinop - MT	4	0	0,5
Viruá - RR	4	0	0,5
Maracá - RR	4	0	0,5
Cuniã - RO	1	0	0,5
BR - 319	1	0	0,6

Table 1 - Widths tested for zone 1 to survey vegetation structure at different sites.

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Zone 2 plants with DBH ≥ 10 cm are sampled in a strip 20m wide (10m on either side of the central line). The left hand side will include the sensitive zone, (zone 1) where all plants greater than 1cm in diameter have already been surveyed.

Zone 3 plants (trees) greater than 30cm DBH are surveyed in a strip 40m wide (20m on either side of the centre line). On the left, this will include zones 1 and 2, where all plants up to 10cm DBH have already been surveyed. On the right-hand side, all plants greater than 10cm DBH have already been surveyed in zone 2.

Supplies Needed:

Before leaving for the field, check that you have the necessary worksheets to record your data (available from http://ppbio.inpa.gov.br). These include:

- Metadata tables that describe information on the time, place, methods and persons involved in the work.

- The worksheets for recording your survey data. Waterproof folder or plastic box for blanks or completed sheets.

- A map of the module or grid and maps of the center lines of the plots to be sampled.

The map is important because centerlines are not always continuous (Fig. 3), and you need to know this in advance so that you know which segments should be sampled. Check out the maps of your site on the PPBio site (http://ppbio.inpa.gov.br) or on the website of your project.

For the survey:

- 50 m tape measure(s) (for measuring the x coordinate)
- 30 m tape measure (for measuring the y coordinate)
- Vernier caliper for measurements of smaller plants (e.g. less than 6cm in diameter)
- A Diameter Tape which is used to determine the diameter of the tree by measuring the circumference.
- 1.50m graduated rod to measure the y coordinate in the sensitive zone.
- Rods with a 1.60m and a 1.30m mark to mark the spot where the identification tag is attached and to determine where to measure the diameter (POM) respectively.
- Crayons to mark the POM (1.30m) and the location of the tag (1.60 cm)
- Yellow waterproof paint
- Thin, flat paint brush with a long handle
- Thinners or turpentine
- A paint pot.
- Rags for cleaning the paintbrush.

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- Numbered aluminum tags
- ½" galvanized flat-headed nails
- Hammer
- Telephone wire (or similar)
- Folding aluminum ladder. (The length of the ladder will vary according the height of the buttress roots that exist in your survey area.)
- Pencil with eraser
- Clipboard
- Permanent marker
- 4 x 4m tarpaulin (to shelter the team if it rains).
- Plastic string
- Assorted bags and backpacks for carrying equipment.
- Assorted plastic bags for protecting equipment/clipboards etc from the rain.
- Umbrella
- Machete

Before you start sampling:

Check the metadata records for the location of the plot to be sampled and walk the trail to the picket marking its position. The plot itself usually starts 10m to the right of the trail and is on the same contour as the main trail picket.

The survey can take 3 to 4 days depending on the conditions, the weather, the number of plants to be recorded and the people involved. If equipment theft is not likely to be a problem, you can set up a small camp (4x4 m) with canvas and string in the middle of the main trail near the entrance of the plot to protect heavy equipment from the rain and avoid having to transport it every day.

OK, now we are ready to begin our field survey. The survey is most effective when done by 6 people. The team should be organized as follows:.

Two people assemble and organize the camp.

Two people to check the plot from start to finish, making sure that the pickets have tags and positioned correctly with the string still intact and make the necessary repairs. Check for segment overlaps.

Two people mark out the sensitive zone with string and auxiliary pickets. This string is not for measuring the X and Y coordinates. Its function is to guide people who are walking in zone 2.

The dynamics of the measuring and marking process:

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A 50 m tape is fixed to the first picket 0, positioned along the center line and attached to the next picket. It will be used to determine the X coordinate and should be taut and not sagging. Check that it is correctly

In the case of the tape runs out before or after the multiple paddocks of 50 m a new paddock is placed in 50 m of the tape. It is important to note the effective size as the segment had during measurements (p. Ex. 48.75 m, 52.3 m). Although the segments are straight, the tape should follow the curves that exist along the plot.

Each sampling range is performed separately from start to finish of the plot, as shown in Fig. 6.

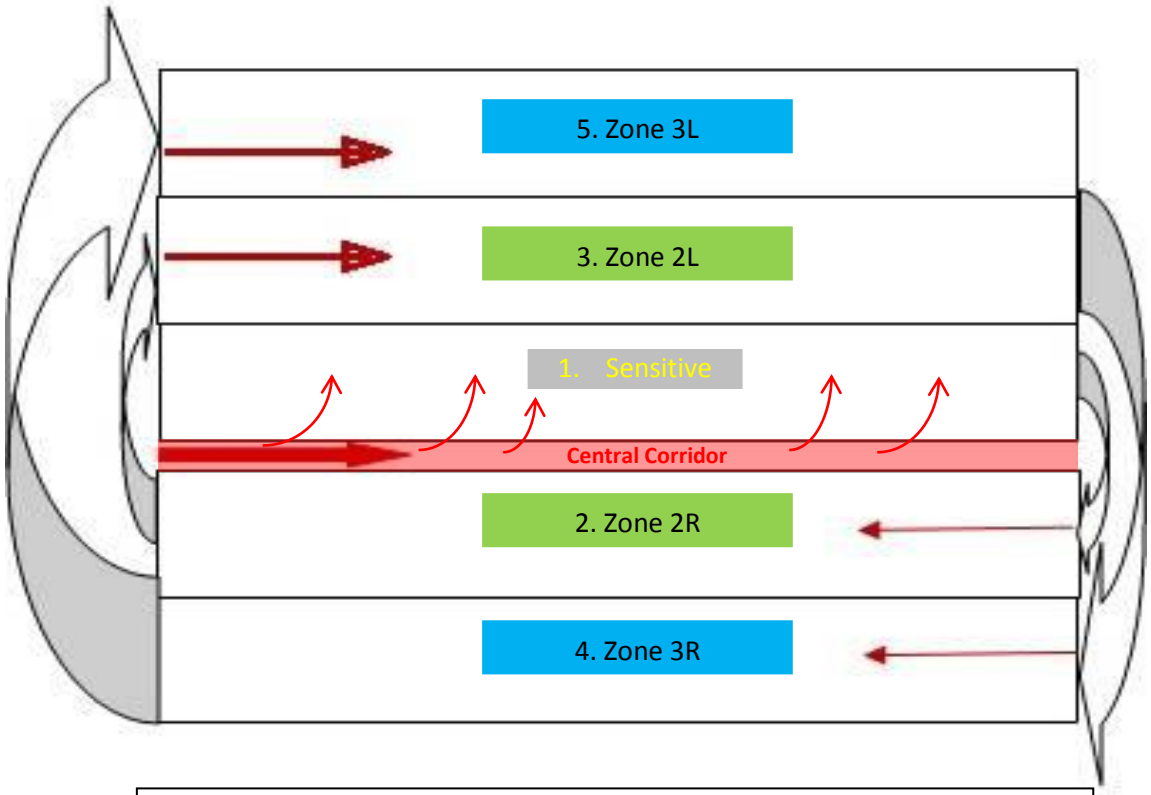

Figure 6. Diagram showing the sequence in which the surveys are carried out. The central corridor (from where the X and Y coordinates are taken) defines which side is right and which is left. The red arrows indicate the direction in which sampling is carried out.

Surveying the zones.

Start by surveying the sensitive zone as you work down the central corridor.

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Always avoid entering the sensitive zone.

Measurements should always be made from the center line.

Always finish a zone before starting another (from the beginning to the end of the plot).

The measurements in the zones are made alternately on the left and right-hand sides of the centerline. This information should be recorded in the appropriate column of the data table.

Measurements in the sensitive zone, zone 2L and zone 3L start at picket 0 and go until the last picket in the plot.

Measurements on the right start at the last picket. The tape remains fixed and the X coordinate distance decreases as the survey progresses.

The trees are included in the respective sample groups when more than half of the tree is within the zone (Fig. 7).

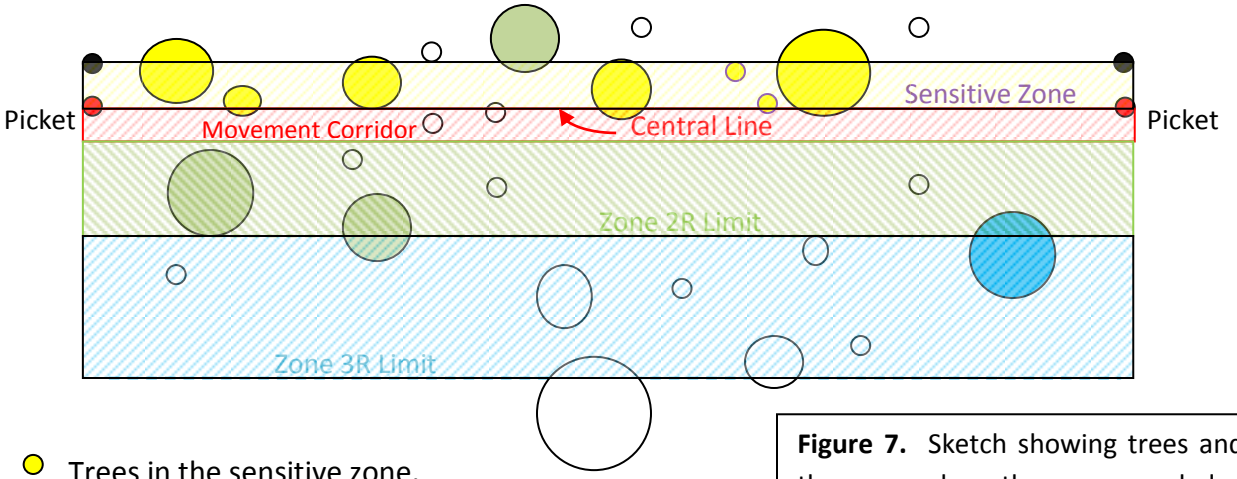

Figure 7. Sketch showing trees and the zones where they are recorded.

- Trees in the sensitive zone.
- Trees in 2R
- Trees in 3R
- Trees not included in survey (too small for the zone or outside the appropriate zone).

Taking measurements in the sensitive zone.

The data measurements for each tree must be taken and recorded before moving on to the next tree. The measurements should be made in the following sequence: X, Y coordinates, tag number, the diameter (DBH) and the point where the measurement was made, POM, and the condition of the tree and finally, paint should be applied to the POM.

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Coordinating the team and recording the data is the responsibility of "the recorder" who remains in the central corridor. The recorder should have a clipboard with the data sheet, the protocol (plastic) with instructions on how to measure and record the condition of the trees, and a map showing the outline of the plot. The recorder must complete the header of each new sheet with the site data, date and participants. The recorder must be aware of all the group`s activities and keep a rhythm and fluidity to the team.

The reading of the X and Y coordinates is made by someone in the central corridor. A 1.5 m graduated rod is used to measure Y without entering the sensitive zone. This person carries the numbered tags and gives them to the team measuring the diameter.

A team of two measures the diameter, marks the POM, makes observations on the condition of the tree and attaches the numbered tag to the tree. One walks down the center corridor and the other in zone 2. Each person measures the trees in their reach, so that it is seldom necessary to enter zone 1. It is sometimes necessary to carefully put one foot in. Remember that this zone will also be used to study herbs and other small organisms.

The point where the diameter was measured (POM) is painted with yellow paint by a person who is positioned in the corridor. To avoid entering the sensitive zone, use a brush with a long handle or attach it to a long stick.

To optimize the process, when one person finishes measuring a tree, they fix the identity tag while the other person starts measuring the next tree. To avoid numbering mistakes it's a good idea to occasionally check with the recorder if the numbering of the tags corresponds to the to the worksheet.

Surveying Zones 2 and 3.

The recorder and assistant must stay in the corridor, while the other members of the team go to the sampling zone. Keep outside the sensitive zone, when surveying on the left.

Measurement of X and Y coordinates. (Tree mapping.)

The X coordinate is taken from the centerline measuring tape. The Y coordinate is the shortest distance from the 50m centerline tape to the estimated centre of the tree. The assistant takes up a position perpendicular to the tree and indicates its location to the team in the sampling zone. It may help to use a couple of the aluminium rods to form a 90^0 angle. Figure 8.

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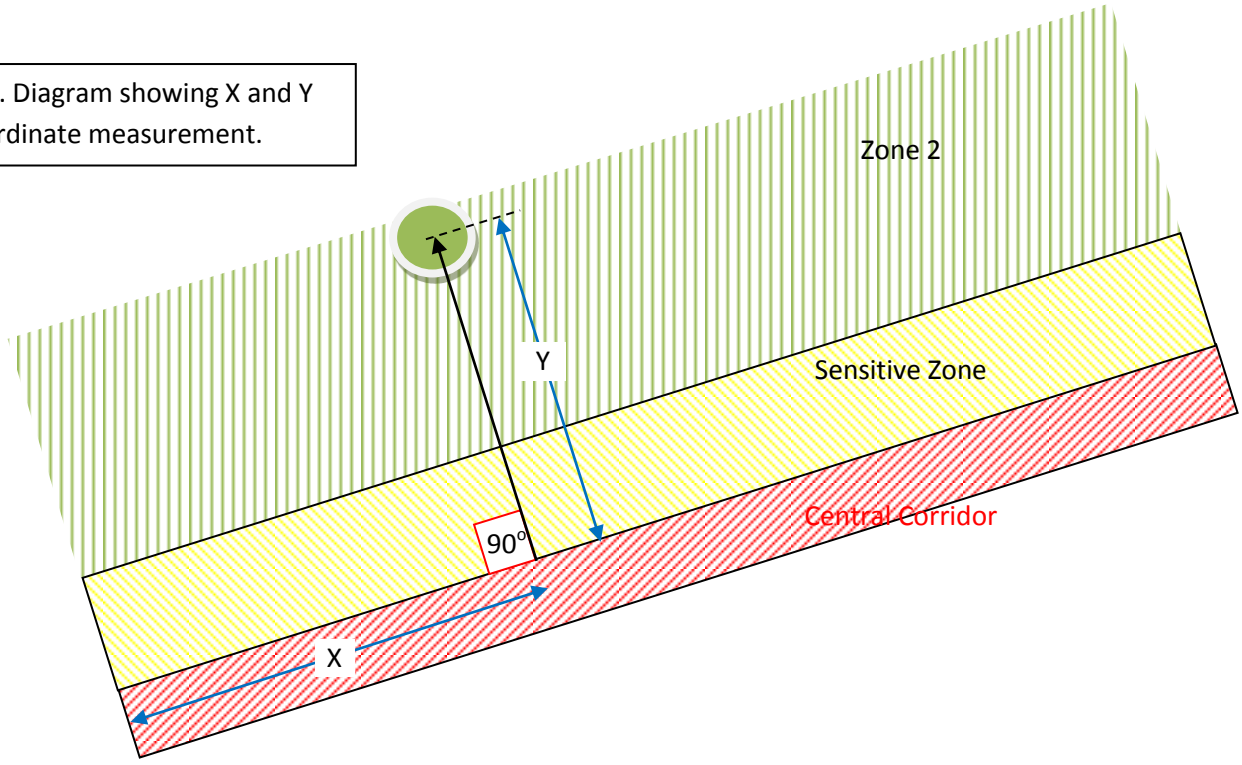
Figure 8. Making a 90º angle.

(Photo - Fernanda Coelho).

A graduated rod is used to measure the Y coordinate in the sensitive zone; otherwise, the 30m tape is used. The measuring device must be kept horizontal and at right angles to the plant that is being surveyed. The tree`s center is the center of the base of the tree at ground level; the Y coordinate being made at right angles to one side of tree and the X coordinate at right angles to the centerline. See Figure 9.

Figure 9. Diagram showing X and Y coordinate measurement.



The person in the corridor adjusts the two measuring tapes until they form an angle of 90 °. She will tell the recorder the distance from the paddock (X axis) and the distance the tree is the central corridor (Y axis). The ends of the tape measures must be at the same height, so that the measure is horizontal, as illustrated in Fig. 10.

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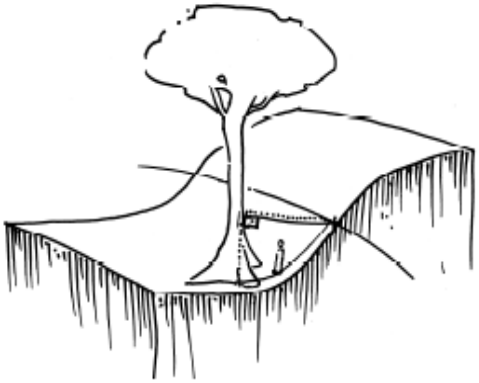

Figure 10. The distance to the tree is measured with a horizontally stretched tape.

Illustration: Karl Mokross. Photo: Fê Coelho

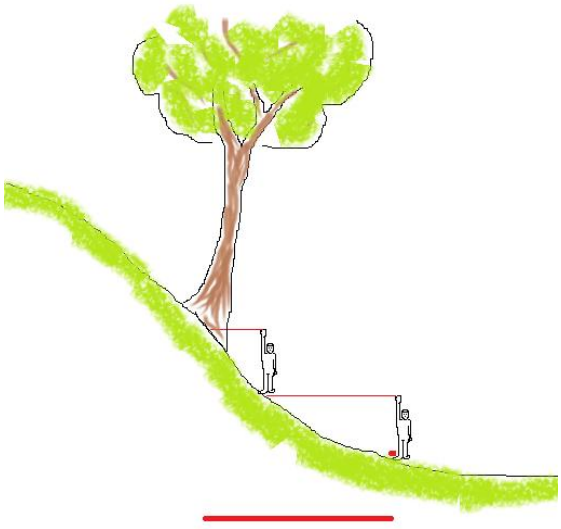

Figure 11. When the survey is carried out on very steep ground, the horizontal measurement of distance may be made in stages as shown.

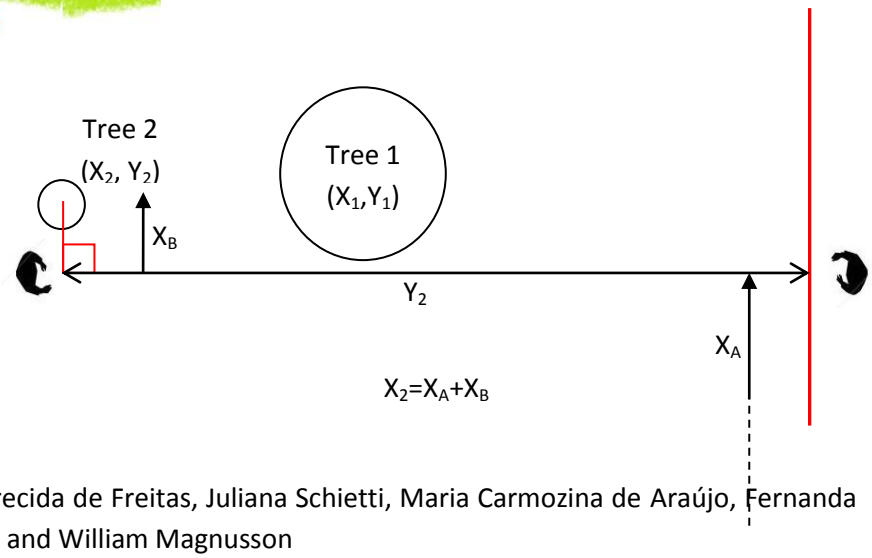

Figure 12. Sometimes a large tree will be in the way of a smaller tree.

by: Carolina Castilho, Maria Aparecida de Freitas, Juliana Schietti, Maria Carmozina de Araújo, Fernanda Coelho, Tim Vincent, Flávia Costa and William Magnusson

Very large trees or buttress roots may prevent the observer from detecting the trees behind them. When this happens, stretch the tape to one side of the large tree and measure the Y coordinate of the centre of the smaller tree at right angles to the tape. It may be that the X coordinate is the same or add the distance along the centre line (X_A) to the distance from the Y coordinate line (X_B) to obtain the X coordinate. (Figure 12).

Sometimes a large distant tree in dense vegetation will need the help of several people to remove obstacles and place the tape correctly.

When measurements are being carried out on the right-hand side of the central line, the tape is behind the person who is taking the measurements so as not to step in the sensitive zone. A metal rod lying on the ground perpendicular to the centerline may help guide the positioning of the tape for measuring the Y coordinate.

The tags should be attached immediately after recording the coordinates. Check that the number on the tree is the same as that which has been recorded on the worksheet.

Labeling Trees

The tags are 0.3mm x 2cm x 5cm aluminium, stamped with 8mm numbers and letters. Tags should have a sequential numbering system with a code for the grid or module and the survey plot.

The tags are positioned 1.6m high from the base of the tree (the aluminium rod is 1.6m long) and should face towards the corridor so they can be easily seen.

Sometimes tags are stolen and the number sequence may not be consistent. Ensure that this information is recorded on the metadata worksheet.

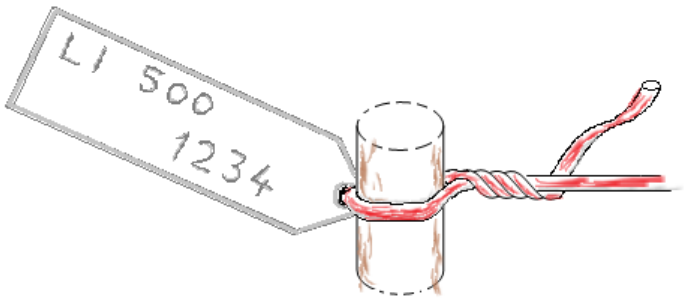

Figure 13. For plants with a DBH between 1 and 10 cm the tags are attached with plastic coated wire (telephone wire). Tie a slip knot in the wire so that as the plant grows, the loop can expand.

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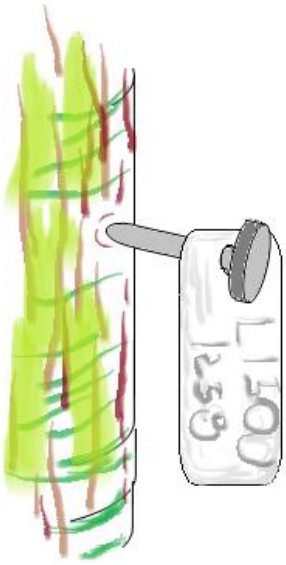


Figure 14. Tags on trees greater than 10cm in diameter are secured with standard 2½" galvanized nails. Fixing the nail at an angle greater than 90^{o} helps to stop water from entering the hole made by the nail. About 1/3 of the nail should be hammered into the tree. Make sure that it is secure and move the tag away from the tree as far as possible.

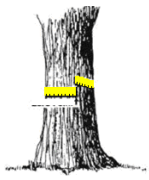
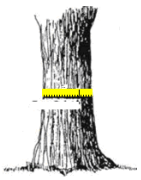
If there is a fork in the tree lower than the height at which the tag needs to be attached, then each fork of the tree must be labeled and recorded on the data sheet. The tags have the same number, followed by a letter (A, B, C ..) to identify them.

How to measure trees

The diameter is measured 1.3m from the ground and after the tree has been labeled. The height is read from the graduation on the aluminium rod and marked with a wax crayon. For trees of less than 6cm in diameter a Vernier caliper can be used. Ensure that it is horizontal and rotate it so that it measures the maximum diameter of the tree at that point.

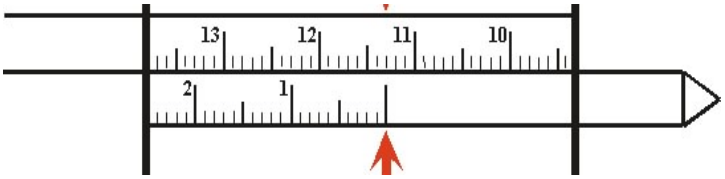
Larger diameters are measured with a diameter tape (e.g. Forestry Suppliers, model 283 D) or a conventional tape with accuracy of ± 1 mm. The conventional tape measurement is converted to diameter by dividing by 3.14. The tape type should be recorded on the metadata worksheet. Tapes stretch and should be regularly changed.

Remove loose bark, lichens, mosses, termites etc from where the diameter is to be measured, but don`t cut lianas, vines, or epiphytes, just move them to one side as far as it is possible.

 **WRONG**	 **RIGHT**	Ensure that the tape is horizontal, straight and taut and take the reading from right to left.

by: Carolina Castilho, Maria Aparecida de Freitas, Juliana Schietti, Maria Carmozina de Araújo, Fernanda Coelho, Tim Vincent, Flávia Costa and William Magnusson

The reading shown below is 11.30 cm, NOT 12.70cm.



Reading a diameter tape is always made from right to left.

The following guide shows where a tree should be measured

Where should the diameter be measured?

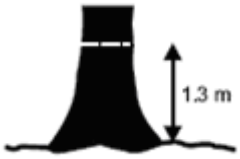
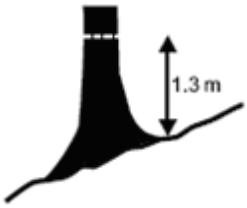
	The diameter is measured 1.30m from the ground wherever possible. A graduated metal rod ensures a uniform measurement.	
	Slope with vertical tree.	Measure the diameter at the highest point of the ground.
	Slope with inclined tree.	Measure the diameter following the slope of the tree at the highest point.
	Flat ground with inclined tree.	Measure the diameter following the slope of tree as shown in the diagram.

Table 2 – Measurement for trees at 1.30m. Condit (1998)

by: Carolina Castilho, Maria Aparecida de Freitas, Juliana Schietti, Maria Carmozina de Araújo, Fernanda Coelho, Tim Vincent, Flávia Costa and William Magnusson

When the trunk of the tree has some kind of irregularity (nodes, deformities, holes etc.) or buttress or adventitious roots, the diameter is measured as per the following table. This new height (POM) needs to be measured and recorded on the data sheet.

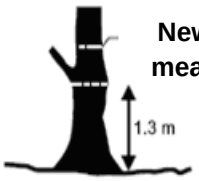
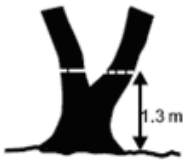
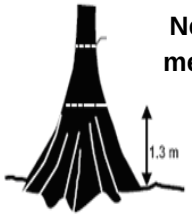
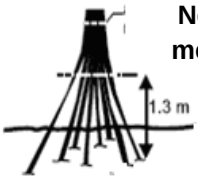
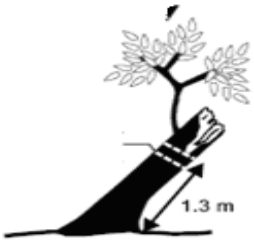
	Tree with injury node or abnormality.	Measure the diameter above the abnormality where the tree is cylindrical. Record the new POM.
	Fork at 1.30m.	Measure the diameter 20cm below the fork. Record the new POM.
	Fork below 1.30 m	Measure the diameter of each branch at 1.30m. Record the data as separate entries.
	Tree with buttress roots at 1.30m.	Measure the diamter at least 1m above the roots, where the trunk is cylindrical. Note the new POM.
	Tree has roots at 1.30m.	Measure the diamter at least 1m above the roots, where the trunk is cylindrical. Note the new POM.
	Broken tree with new growth at 1.30m	Measure the diameter 20cm below the break. Note the new POM and the condition of tree.

Table 3 – Diameter measurements not made at 1.30m. Condit (1998)

Painting the Point Of Measurement (POM)

by: Carolina Castilho, Maria Aparecida de Freitas, Juliana Schietti, Maria Carmozina de Araújo, Fernanda Coelho, Tim Vincent, Flávia Costa and William Magnusson

Paint the tree so that the mark is visible from the central corridor. Paint just above the wax crayon line so that the diameter tape can be relocated at exactly the same point. A single layer of paint is sufficient and it isn`t necessary to paint around the entire circumference of the tree.

Protocol for the inclusion of spaces and overlaps.

The positions of the trees are determined by their X and Y coordinates. However, it may also be useful also record the segment where the tree is located. This is usually easy, but if the plot is not straight, the tree may lie within an overlap (in green) or a space (in red) between the segments.

When there is a **convex** angle between segments, there will be a space between the 2 segments that should be included in the survey. Organisms in this area are included in the previous segment.

When there is a **concave** angle between segments, they will overlap. Organisms within this overlap are also included in the previously surveyed segment.

The same protocol applies for the return survey from finish to start.

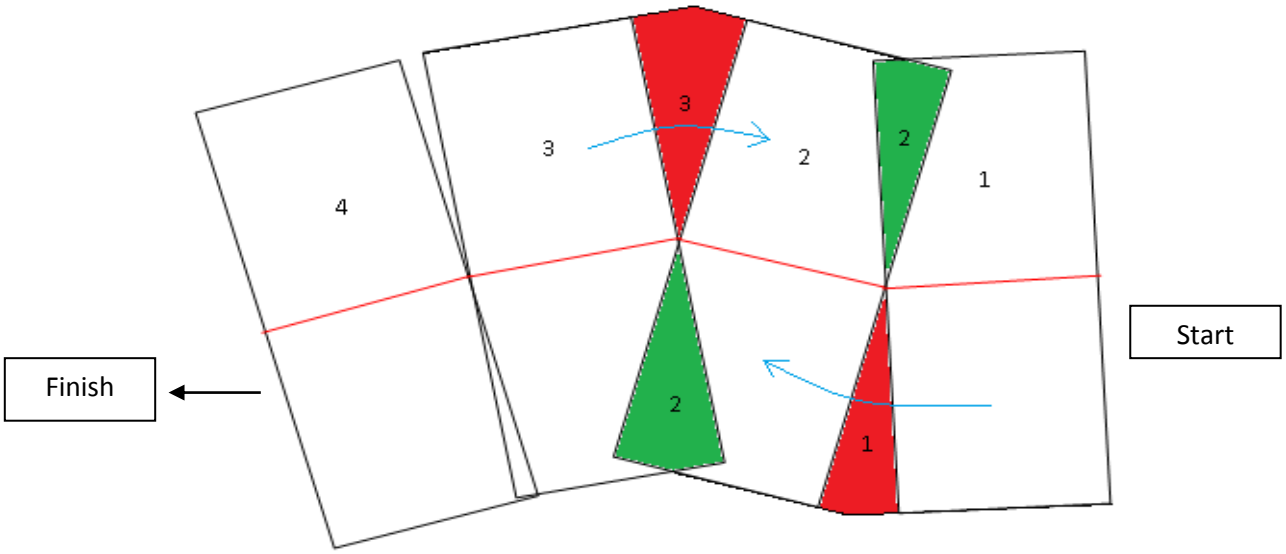


Figure 15. Inclusion of organisms where there are segments that have spaces between them, or overlap.

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