

Long Plots Rapid Mangrove Forest Transects



Assessing Mangrove Forest Biomass and Forest Condition using Plot-less Sampling (Long Plots)



BIOMASS OF MANGROVE FORESTS – LONG PLOT FIELD METHODOLOGY

In brief: This method describes a practical and effective way to measure biomass and living carbon content of mangrove forests. Descriptors of mangrove forest vegetation units, as key stand structural descriptors, include: plot area; species assemblages; structural form; density of trees; size of individual trees based on height and stem diameter; plus, condition of trees and canopy foliage. This methodology evaluates mangrove forests in a way that is scientifically reliable, accurate, low cost, low skilled, simple, pragmatic and relevant.

BACKGROUND

Mangroves have the distinction of forming unique marine habitats that are both forests and wetlands. As such, they are grouped across a number of international conventions that recognize their immense value and benefit to both coastal and marine environments, and mankind in general. It is important to have a standardized and practical way of characterizing structure and condition of these unique wetland forests.

The basic field assessment unit for this methodology, the 'long plot', is relatively new in concept. It is delineated specifically, to accommodate mangrove forest characteristics. And, the method was proposed to facilitate and speed up forest biomass sampling. Long plots are essentially narrow, 2-4 metre wide, forest plots laid out approximately parallel to the shoreline (Fig. 1). Their great benefit is that plot length depends on tree density. This has been achieved by fixing the number of trees sampled within each plot. In this way, where there are many closely spaced trees, plots will be shorter in length than where trees are large and far apart. This method has a number of important advantages, including: standardisation of sampling effort; and, removal of guess work in making sure a

representative number of trees have been sampled. There is considerably less effort, compared with laying out a square plot, as long plots are effectively laid out as work progresses. It is easier to keep track of completed trees and, it is easier to locate, establish and tag plots for future reference and re-assessment. The number of trees sampled is considered best around 30, but this number can be verified in this method using data collected, and 50 trees is ideal and preferred if possible. Long plots are sampled so comparisons between accumulative variances in stem diameter can be made for progressively larger plots, and larger numbers of trees.

This method can be extended further for estimations of biomass and carbon sequestered by mangrove forests (see Methods also for measurement of Tree and Forest Allometry). The method is: easy and practical, requiring a minimum of skill levels and special equipment – useful to rural communities; accurate and reproducible – as well as being recognised and useful to scientists and managers.

SAMPLING PROTOCOL AND METHODS

Study design and vegetation zones

To make appropriate biomass estimates, it is necessary to consider key stand structural descriptors, including: species; species assemblages; structural form; mass of individual trees; size of individual trees; density of trees in any stand; plot area; condition of trees and habitat; seasonal differences in canopy foliage; and, spatial extent of recognisable vegetation units.

For this reason, it may be necessary to include replicate long plots across each mangrove forest type. These may include three zones characterised by different species and structural elements, such as:

- **Sea fringing, low intertidal** – dense, gnarled trees with a tangle of above ground roots - like *Avicennia marina*.
- **Interior mangrove, mid intertidal** – tall erect trees, tall canopy – dominated by *Rhizophora* along with *Avicennia*.
- **Landward, high intertidal** – tall erect trees – various species – like *Bruguiera* and *Avicennia*

Statistics and replication

In this assessment, you need to know the number of replicates required to achieve a given accuracy when estimating the mean. This requires some knowledge of the population variance either from previous experience or from project sampling. A minimum of four plots is considered necessary for each mangrove vegetation unit. The number can be increased. The aim is to evaluate optimal size plot, based on tree numbers – less than or equal to 50 trees, and how this will minimize variance. If the tree size is relatively even, 30 trees is sufficient.

Field data collection

1. Select mangrove areas for biomass evaluation, as your study area.
2. Within the study area, you will need a number of plots for evaluation of forest structural characteristics. The number depends on the number of mangrove zones (species assemblage types) within the area. A minimum of 4 replicate plots is required in each zone.
3. This study uses the Long Plot method, preferred for rapid, relevant and accurate sampling of forest biomass. For assessment of biomass from measures taken see Forest Allometry Methodology.

FIELD METHODOLOGY FOR RAPID MANGROVE BIOMASS SURVEYS: LONG PLOTS

Field surveys in mangrove forests

The primary objective is to rapidly and accurately determine key biodiversity and biomass characteristics of mangrove stands. These characteristics include: species composition, tree density, tree height, stem diameter and canopy cover. The basic field assessment unit is a plot of sampled trees, although it is useful to record other information, such as, which mangrove species dominate the canopy – as might be viewed from remote sensing imagery. The field methodology outlined here does not specifically sample trees below a certain diameter (around 5 cm), nor sample low-lying, ground cover of seedlings or other species. A sample data sheet is included below.

Location and establishment of field assessment units

Mangrove areas, and particularly the zones, are often relatively narrow. Plot location and orientation may be standardised to fit within these features. For instance, plots are best kept narrow (like 2m wide) and orientated along tidal contours – notably laid out parallel to the sea or channel edge. This will have the effect of minimising variability of species and structural assemblages dependant largely on inundation frequency and elevation.

Long plot setup

Specific steps to setting up a long plot are:

1. **Select the plot** location by choosing a start point (Fig. 1), usually a tree, within the broad vegetation area selected. Look along the proposed path of the long plot to make sure it is largely representative of the dominant vegetation zone to be sampled.
2. Attempt to **run the transect along the zone**, parallel to zone edges, away from edges to avoid edge-effect and avoid light-gaps and disturbance if this is not characteristic of the forest.
3. In the 'Site' box **record on the data sheet**; a unique name for the plot, along with the locality, and a brief description of the site (width of mangrove stand, distance from waters edge, condition, etc). Permanent tags can be left to mark the plot, as required.

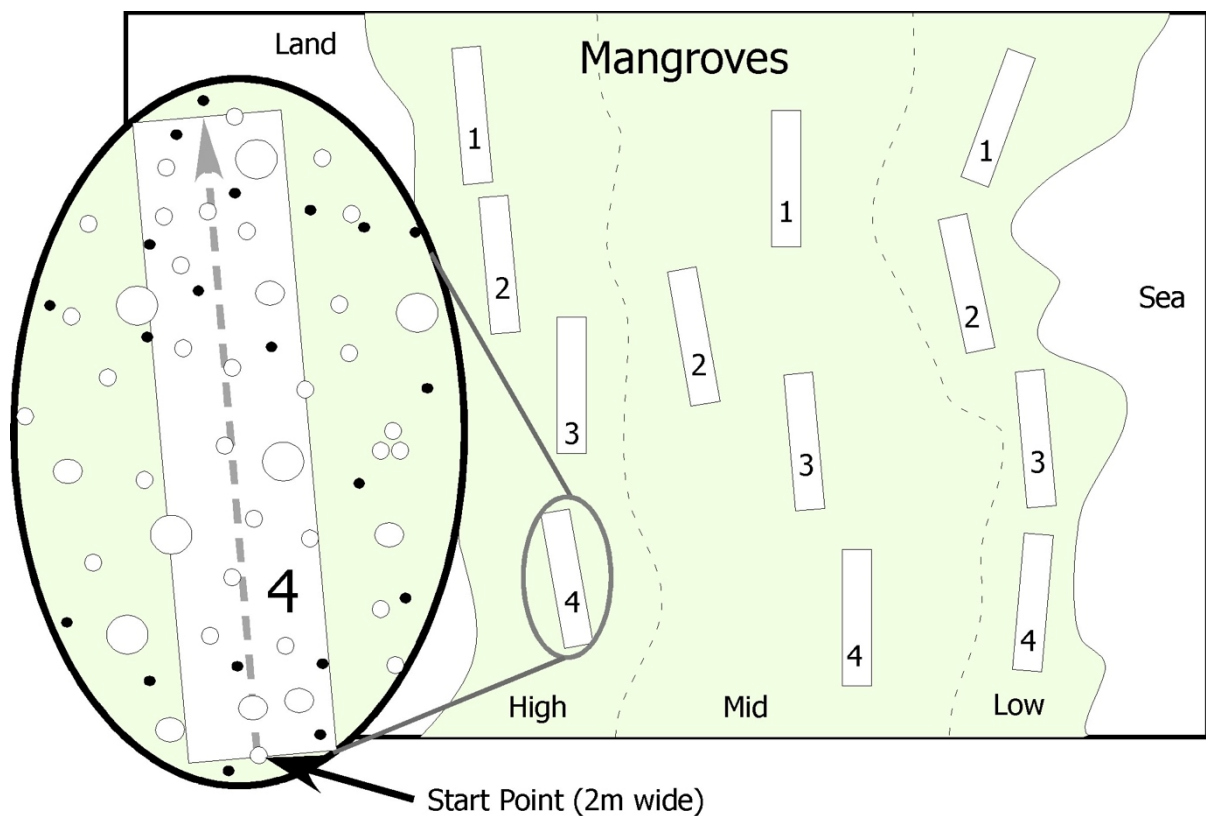


Fig. 1. Layout and site characteristics of long plots (2m wide) for a replicated sampling design comparing three mangrove forest zones at low (sea edge), mid (intermediate) and high (upland margin) intertidal positions between sea and land.

4. Take a **GPS reading** at the end of the plot, noting which end of the plot it is (e.g. whether it is the most southerly end of the plot etc). Record the locality in digital degrees using the WGS84 datum on the data sheet. Also record the 'Mark', or waypoint number from the GPS on the data sheet.
5. After fixing one end to the start point, **lay out a measuring tape** (or rope marked at one metre intervals) parallel to the shoreline. In the circumstances, this might be 30m. If more tape/rope is needed, this can be extended progressively – or, the tape/rope can be released and pulled along further.
6. **Take a photograph** along the transect at either 2, 5 or 10m intervals (depending on transect length) and note the photo time.
7. Use a 2m pole (~2.5 cm diameter pvc pipe, or large ruler) laid perpendicular either side of the tape/rope, or alongside, to indicate width of the plot. Width can be increased in low density sites, making sure to write down on your data sheet whatever width is used. The pole is moved along the tape as work progresses from tree to tree – confirming each tree as either within, or not within the plot. Tree position is taken as the point where you will measure stem diameter.
8. Moving along the tape progressively (i.e. trees 1, 2, 3 etc in Fig. 1), **measure: stem girth** with a small tape measure; **tree height** with a measuring pole or educated estimate; **estimate tree lean, tree condition distance from start point, distance from the tape, the side of the tape**; and, **the identification and count of plants less than 1 metre tall**. Data are recorded on the data sheet until at least **30 trees have been recorded** including **at least LIVE 25 canopy trees**. Note, there are more detailed descriptions of key measurements given below.

9. After measuring all trees, **record the length of the plot** to the next full metre mark, measured from the start point. Include all trees within the last metre of the tape, even if this makes the total more than 30.
10. The rule for deciding whether trees are in or out, is as follows: the position of the tree is determined by where you would measure the stem girth; **if the stem section is mostly within the plot then it is recorded. (>50% in)**
11. **For trees with multiple stems, record each stem separately**, including girth, height and condition. Label stems as A, B, C .. Measure stems in clockwise direction to make sure you don't miss any.
12. **Take a photo of the canopy every 10m**, or if less than 40m, take a photo every 5m. A minimum of 4 canopy photos is necessary per transect.
13. For cut stumps, record the species and stem diameter from the usual place – and place this in the 'cut stump' section on the data sheet.
14. At the beginning and the end of the transect and at 5 metre intervals, **record the species, number and approximate height of seedlings** in a 1 x 1 m quadrat, along with the number and approximate height of low-lying species.
15. **Take sample specimens of any trees not identified in the field**, with a comment to record this specimen on the data sheet. Photographs and other referenced comments are useful as well.
16. **Take photographs along the plot tape both ways** and other photos of the surrounding forest. This should be accompanied with notes about the forest and any other plant species seen in the area.
17. As soon as possible, after leaving the field, data must be entered into an electronic database or spreadsheet for archiving and later assessment.

Field measurement techniques

Species identification

Find a relevant and easy to use field identification guide, like 'Australia's Mangroves' by Duke (2006).

Tree girth and stem diameter

The aim is to measure stem diameter of trees and shrubs as proxies of their standing biomass. Stem diameter is a standard unit used in biomass calculations in forest research – more so than any other descriptor of forest structure, including tree height. In mangrove forest research, stem girth is often easier to measure in the field using a small tape measure – afterwards the measures are converted to diameter using simple circle trigonometry. As a further general rule, girth measures of mangrove trees are to be measured at varying distances above ground (see Fig. 2), depending on: species, size, lower stem shape, above ground root junctures, position of lowest branching, and misshapen stems.

In terrestrial forestry and silviculture, a standard is taken at 1.3 m above the ground. This standard is not suitable or generally practical for mangrove forests (also see Appendix 3), making most applications of this terrestrial standard measure unsuitable. So, a majority rule is followed, where: **stem girth is measured at the first uniform stem section immediately (specifically 0.1 m) above the highest established prop root or buttress, and below the lowest branch juncture** (Fig. 2). In the extreme case of individual mangroves with multiple stems emergent from the ground, each stem must be scored using the majority rule, with a

note recording a common link between each stem.

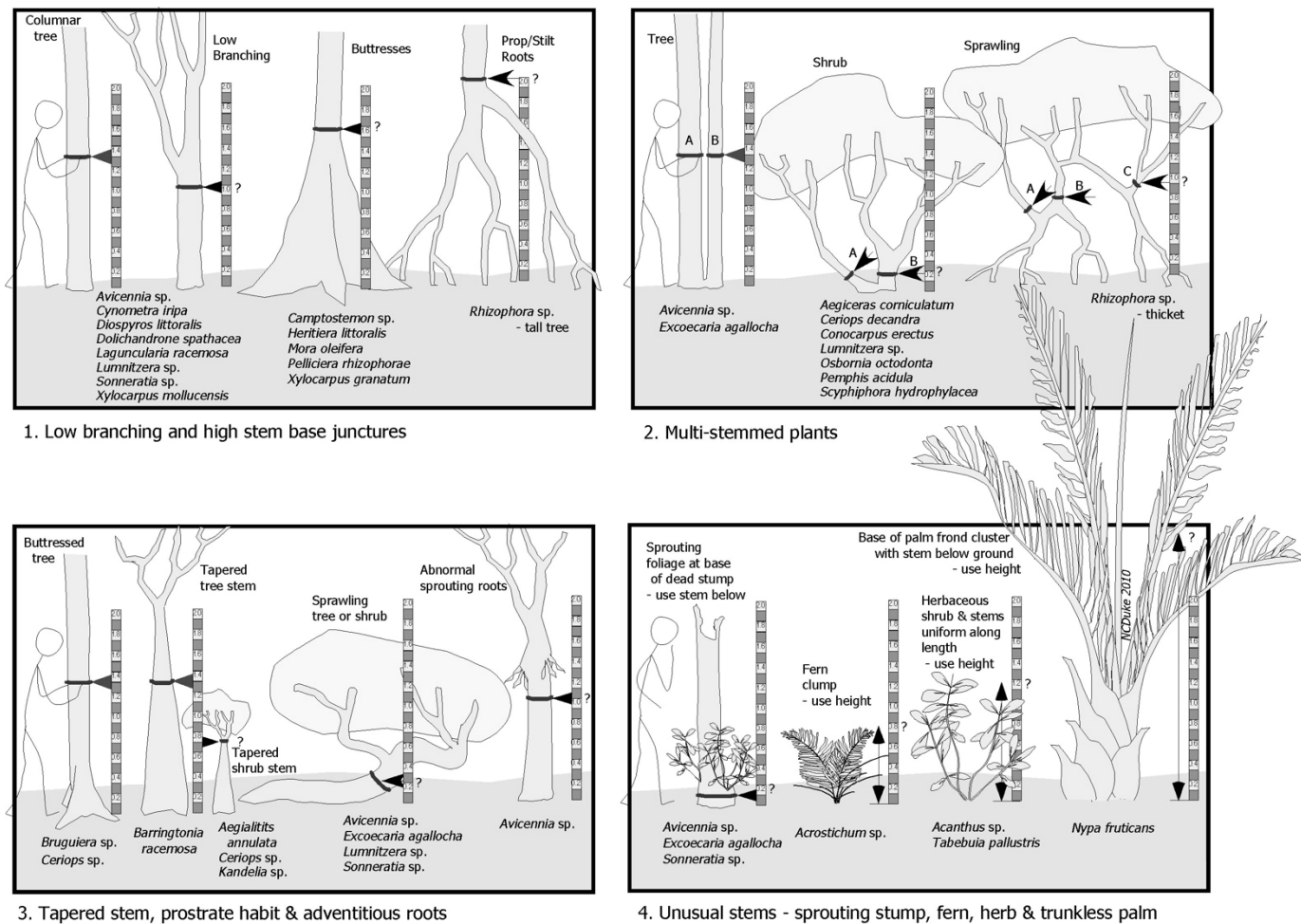


Fig. 2. Position for measurement of stem diameter in mangroves depends on stem shape and features, and the 1.3m standard. Also see Appendix 3.

Tree height

Tree height should be determined with as much accuracy as possible, depending on the equipment and expertise available. Up to 5 metres in height, a height pole is the best method. For taller trees, trigonometric methods or a laser device is useful. Vertical height should be scored in all cases, but for obviously leaning trees the overall percent lean from vertical should be scored. These data can be used later to adjust trigonometric calculations related to biomass. Height data is often important for verification of biomass calculations for species without specific allometric equations, and for small trees.

Tree lean

Recorded to enable calculation of the total length of the trunk. Easily recorded with a hypsometer laser. Or, visually estimated

Long Plot Methods Summary & Reminders

1. Set up transect along the zone, not across the zone
2. Fill in the top section of every datasheet
3. Take a waypoint using a GPS at the transect start and record coordinates
4. Take a photo looking down the transect
5. Record the start time, compass bearing and location
6. Measure the trees;

Location along tape (mid-point)
Distance to the tree (mid-point)
Side of the plot (left or right)
Girth – as per instructions, not dbh.
Height
Lean (° degrees from vertical)
Canopy
Tree Health

Reminders

- **Minimum** 30 live trees *or* 25 canopy trees.
 - Measure multi-stemmed trees as stem a, b, c. These all count as **ONE** tree.
 - Measure tree height as accurately as possible.
 - Measure tree girth as per instructions – if not dbh then;
below the lowest branch, above the highest prop root, above the buttress
always where the trunk is straight – no bumps and lumps!
7. Record tree health (0-5) see additional notes.
 8. Record seedling species and density (minimum 5 measurements)
Record mangrove epifauna (minimum 5 measurements)
 9. Record sediment salinity, temperature, compaction and sediment type.
 10. Photo canopy cover
– at least 5 per transect. In dense forest every 5m, in open forest every 10m.
 11. Record other observations and make sketches to help you remember later on.
 12. Take a waypoint at the end and take a photo back down the line

Long-plot Mangrove Assessment – Equipment List

Preparing for your study

Safety considerations

- **Deep mud** and **buried sharp objects**
- **Tidal environment** (always consult tide tables)
- **Insect bites** (those with allergies be more prepared)
- **Trip hazards** (mangrove roots) – wear appropriate footwear and watch your footing
- **Sharp objects** on mangrove trunks and roots (oyster shells) – wear long pants and long-sleeved shirts.
- **Dehydration and sunburn** – wear sunscreen & hat, bring and drink water.

Personal equipment

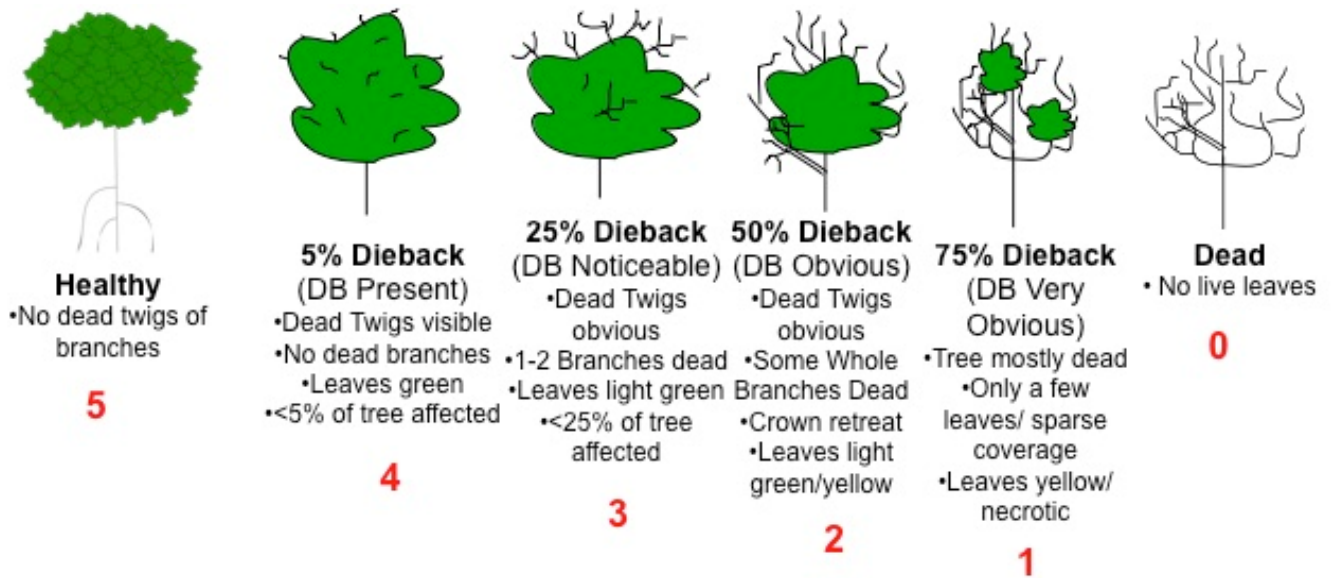
- **Covered shoes** - appropriate for working in wet muddy conditions eg dive boots or old trainers, no wellingtons as they tend to get stuck
- **Hat** to keep off the sun – for working amongst trees and foliage
- **Sunscreen**
- **Insect repellent**
- **Long-sleeved shirt and long trousers**
- **Water bottle**
- **Raincoat and umbrella** to protect people and equipment when it rains.

Project equipment

- **Data Sheets** designed for this project, sufficient copies for all plots planned.
- **GPS** to record waypoints and track, plus batteries and power supply for recharging.
- **Digital camera**, preferably waterproof, good quality at 7-10 megapixel, plus batteries and sufficient memory, power supply for recharging.
- **Transect tape** measure (~50m long) - best replaced by a rope with durable 1m marks along length.
- **2 metre pole** (~2cm diameter pvc pipe) for determining plot width.
- **Diameter tape** for measuring tree diameter or girth - in practice, a dressmakers 1.5m tape measure.
- **Clinometers, hypsometer or other height measuring equipment** – hypsometer best if available, uses a laser distance measurer.
- **Compass** - to determine alignment of plot in the field.
- **Durable tags or flagging tape** – to mark the area location trees, plus the plot locations at respective Start/End Point trees. Flagging tape is suitable – but, make sure to not leave it behind.
- **Quadrats** – 0.5m² and 0.25m² for measuring seedlings and epifauna.
- **Ruler** for measuring seedling height
- **Refractometer, 50ml Syringe and Wash Bottle** (for rinsing) – for measuring sediment porewater salinity
- **Thermometer** – for measuring sediment surface temperature
- **Pencils**, indelible marker, A4-sized plastic bags to cover data sheets.
- **Folder clipboard** to hold data sheets
- Suitable **backpack bags** to carry equipment in the field.
- **POSITIVE ATTITUDE!** 😊

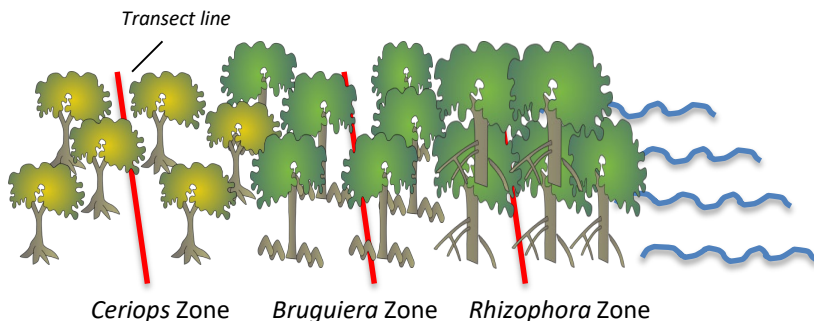
Additional Information

Tree Health Scores

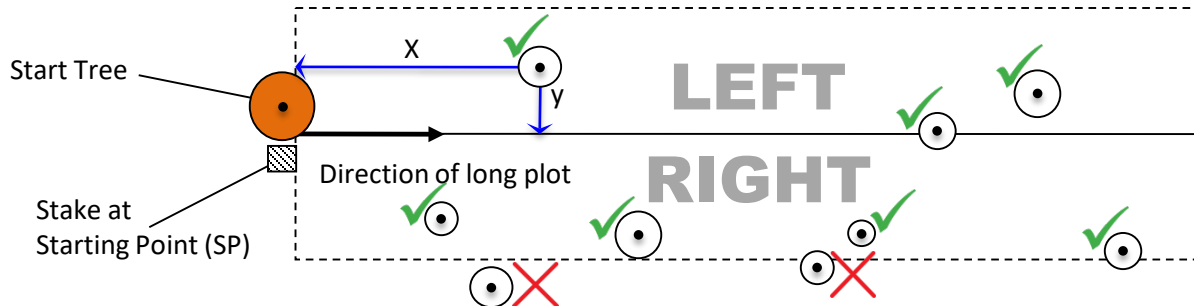


TRANSECT SETUP

Transects run parallel to the shoreline and perpendicular to the tidal profile in the middle of mangrove forest zones

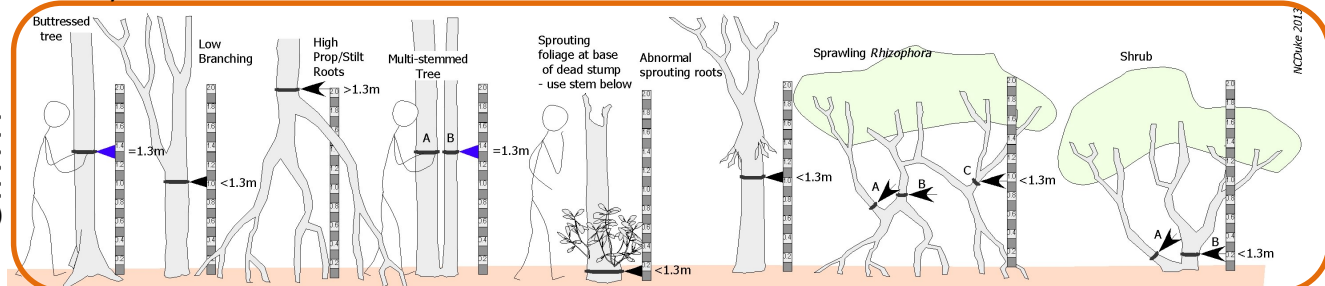


START



****Only record trees with Girth > 10cm**

GIRTH



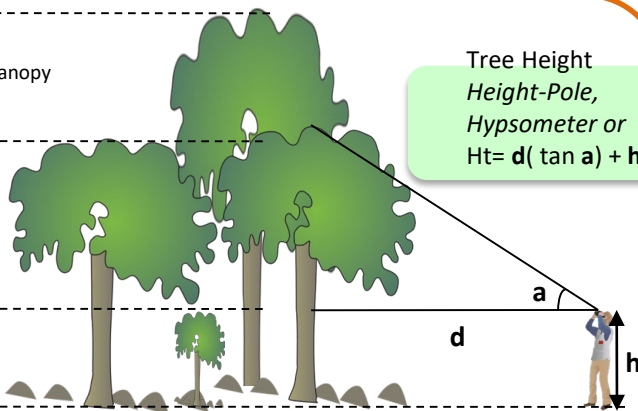
Girth (=circumference) measured above highest buttress/prop root & below branching

CANOPY & HEIGHT

Emergent
Tree crown above canopy

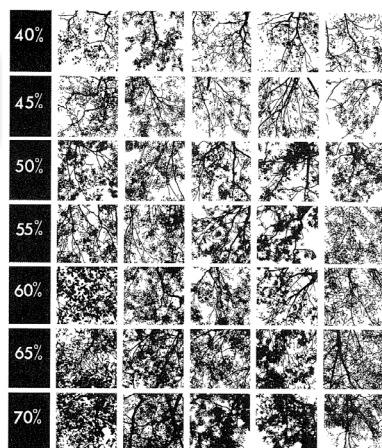
Canopy
Even crown level of climax trees

Sub-canopy
small mature trees

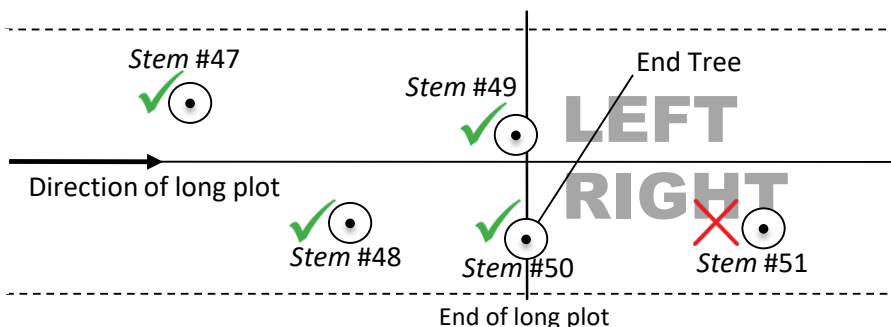


Tree Height
Height-Pole,
Hypsometer or
 $Ht = d(\tan a) + h$

Estimate Canopy cover every 5m



END



End of long plot checklist

- ✓ 50 stems (>30 living)
- ✓ >25 canopy stems
- ✓ Record total plot length
- ✓ Take photo along plot
- ✓ Equal LEFT & RIGHT plot
- ✓ End time + GPS
- ✓ Damage & likely causes

Long Plot Tree Damage Codes

Live Trees

Blank Live Healthy

LC Live with low canopy cover

ID Live with insect damage (herbivory)

LTW Live with dead twigs

LDB Live with dead branches

LF Live Fallen Tree

LBT Live Broken Trunk

LHD Live with Cut or Trimmed Branches

LSD Live with grazing damage

Dead Trees

DTW Dead with twigs

DB Dead with branches

DT Dead trunk (no branches)

ST Dead stump (<1m tall)

DF Dead Fallen

DC Dead Cut (>1m tall)

STC Dead Stump Cut (<1m tall)

PAGE 1

Date:	Start Time:	Location:	
	End Time:	Forest Type:	
Collectors:		Plot number:	
Start Coords & WP:		Distance to shore:	
End Coords & WP:		Plot Length:	Plot Width:
Compass Bearing from Start:			

[illegible]

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