

# Woody Debris Simple Long Transects Protocol

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***Illustrative photos are included at the end of this document. You may want to exclude these photos when printing by printing only pages 1-5.***

## **Introduction**

This document provides a simplified protocol for long transect inventories of fallen coarse woody debris (CWD, diameter at least 100 mm) and fallen fine woody debris (FWD, diameter 20 - 99 mm) that reduces the time spent per piece, and thus enables sampling a longer total length of transect in a given time. This is advantageous because by far the largest source of uncertainty in estimates of woody debris stocks arises from the very high spatial heterogeneity of these stocks, and this uncertainty can only be reduced by collecting data over larger transect lengths. Analyses of data collected on the Barro Colorado Island (BCI) 50 ha plot during 2008-2016 show that > 100 km of transect are needed in order to obtain an estimate of the total volume of woody debris to within 10% with 95% confidence.

In this simplified protocol, no woody debris pieces are collected, and no penetrometer measurements are taken. Pieces are simply censused as they are encountered, and marked with paint to make it possible to distinguish them in subsequent censuses. At the same time, some simple ancillary data are collected so that these data can also be used to estimate the rate of branchfall and the proportion of woody biomass in branches.

The Excel workbook that accompanies this document contains a relevant datasheet.

## Sampling Design

The necromass of fallen woody debris is estimated using line-intersect surveys in which pieces of woody debris that intercept the transect are measured at the point where they cross the transect. The transects are all oriented parallel to one edge of a plot and follow marked plot navigation points (e.g. 20x20 m lines) for ease and speed of implementation.

This simplified long transects protocol should be carried out every year. Half of the length of the transects is repeated every year, and half is repeated every three years (or longer). We recommend censusing along at least 20 km of transects every year.

### Placement of transects

For a 1000 x 500 m plot in which 20x20 m lines are marked, the following is one possible sampling design:

Year 1: Along the side of the plot that is 1000 m long, place transects every 40 m starting at 20 m and continuing to 980 m. Along the side of the plot that is 500 m long, place transects every 40 m starting at 20 m and continuing to 500 m.

Year 2: New transects along the 1000 m side: every 80 m starting at 40 and continuing to 1000. New transects along the 500 m side: every 80 m starting at 40 and continuing to 440. Repeat transects along the 1000 m side: every 80 m starting at 60 and continuing to 940. Repeat transects along the 500 m side: every 80 m starting at 60 and continuing to 460.

Year 3: New transects along the 1000 m side: every 80 m starting at 0 and continuing to 960. New transects along the 500 m side: every 80 m starting at 0 and continuing to 480. Repeat transects along the 1000 m side: every 80 m starting at 60 and continuing to 940. Repeat transects along the 500 m side: every 80 m starting at 60 and continuing to 460.

Year 4: same as year 1.

Year 5: same as year 2.

Year 6: same as year 3.

And so forth.

On some plots, there are trails along some of the transect lines. For example, at Pasoh, there are trails at at 200,400,800, and approximately 600 on the 1000-m side of the plot, and at 100,300 and 400 on the 500-m side of the plot. Because woody debris is removed from trails, and placed on nearby areas, transect lines that are right on trails should be eliminated from the census.

## **Materials Needed in the Field**

- 1) Short ruler (preferably modified to start exactly at 0 mm and end at 100 mm)
- 2) Large caliper (0-1270 mm; e.g. Haglöf Mantax)
- 3) Small caliper (0-50 mm)
- 4) Compass
- 5) Protractor (or simply a sheet of paper showing an image of a protractor)
- 6) Spray paint appropriate for use in the forest
- 7) Clipboard, datasheets and pencil OR tablet with Google sheets

## **Defining Fallen Woody Debris**

Before detailing the protocol for measuring pieces of fallen woody debris that intersect the transect, we need to define what is included in this category. Here, we define fallen woody debris as dead wood and bark on the forest floor that is at least 20 mm in diameter (diameter here refers to the width of the cross-section of the piece). This includes wood and bark from trunks, branches, buttresses, and even roots if above-ground. It does not include standing dead trees. The remains of woody debris are considered soil or below-ground woody debris and not included as fallen woody debris if the material is powdery (particle diameter less than 5 mm) and gravity has flattened the remains so that the height of a cross section is estimated to be less than 20 % of the width, or if the piece is not visible without digging. When a piece has always been split into several pieces (e.g. *Ficus*) or has split during the decomposition process, these pieces are considered one piece if they are continuous or nearly continuous in the cross-section – specifically, if there is less than 10 mm of void space between different parts (Photo 1). A piece is not considered fallen woody debris if it is not supported in at least three locations by its branches or stem touching the ground or other pieces of fallen woody debris (thus, for example, dead branches that are hanging from the canopy and do not touch the ground are not considered fallen woody debris).

## **Where to census Fine Woody Debris (FWD) and Coarse Woody Debris (CWD)**

The transects are divided into sections of 20 m. Pieces of coarse woody debris are measured on the entire transect. If a given piece crosses the transect twice, it is measured at both intersections (Photo 2), with those measurements recorded on separate lines of the datasheet. Pieces of fine woody debris, are measured only in a 1-m subsection of each 20-m section. For consistency, this 1-m subsection should always be on the same end of each section; for example, always the southern end for NS transects and always the western end for EW transects. Henceforth, we will refer to this as the “bottom” end of the section.

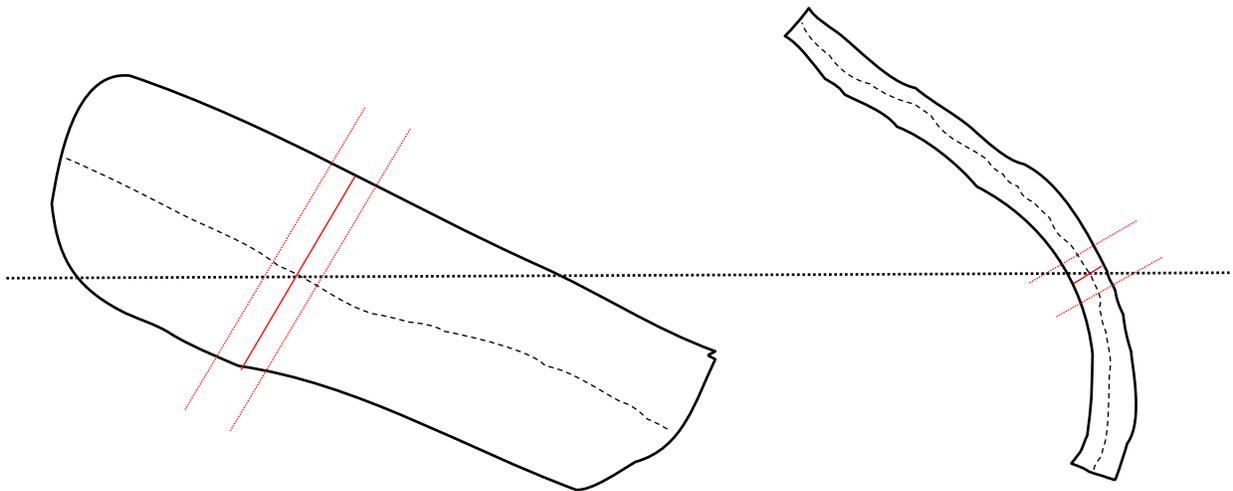
At the bottom end of each transect section, observe whether the first 1 m includes any pieces of woody debris having a diameter of 20-99 mm at the intersection point. For any candidate pieces, check whether the intersection point of the transect and the central axis of the piece of woody debris really is displaced less 1 m from the bottom end of the transect section by using the scale

of the large calipers. Remember that the 1 m should be measured horizontally (not parallel to the ground).

In locating the intersection of the transect and the central axis of pieces of coarse woody debris, an error of 1 m in the location is acceptable. So when the transect runs between coordinate markers in the plot, simply walk towards the next coordinate mark and carry out the measurements on the way. The intersection should be located more accurately if a piece ends close to the transect and there is doubt as to whether its central axis actually intersects the transect. In this case a person standing at one coordinate mark can check whether the piece should be included or not by simultaneously sighting to the next coordinate mark, or by using a compass.

### Measurements of woody debris

*Diameter / width.* Use calipers to measure the diameter of the piece of woody debris; specifically, measure the “width” of the piece when looking down on it, measuring perpendicular to the central axis of the piece (Figure 1). For pieces 50 to 1270 mm in diameter, the diameter is measured using a large caliper (Photo 3) or a small caliper. For pieces greater than 1270 mm in diameter (and thus greater than the maximum width that can be measured using calipers), hold two long straight items (caliper blades, rulers, or just sticks) vertically to define the opposite edges of the piece of wood at the point of measurement, and then measure the distance between them. As the very large pieces potentially represent a large proportion of total necromass they should be measured as precisely as possible.



*Figure 1. In this view from above, two pieces of woody debris (outlined in thick solid black lines) intersect a transect (thick dotted black line). The central axis of the pieces are shown in thin dashed black lines. Diameter measurements are taken perpendicular to the central axis at the point of intersection (thin solid red lines).*

*Height (some CWD only).* If a piece of coarse woody debris (>100 mm diameter) is obviously noncircular in diameter, such that the height and width are substantially different (>20%), measure the height of the piece as well.

*Inclination (CWD only).* The inclination of the central axis of the piece at the point where it intersects the transect can be assessed visually, with reference to a protractor or image of a protractor (Figure 2). The inclination should be estimated to the nearest 5 degrees. If the piece is horizontal, then 0 degrees is recorded.

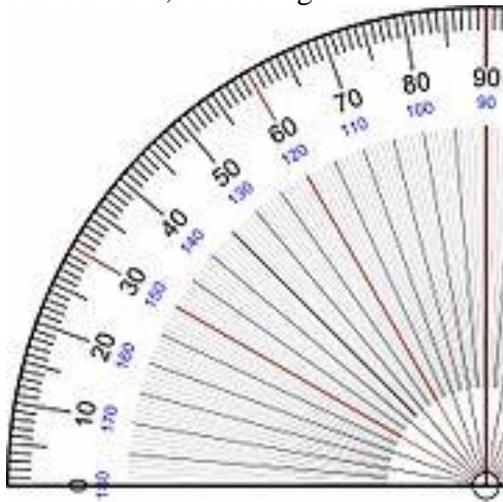


Figure 2. A protractor, showing 5-degree lines of inclination.

*Orientation (CWD only).* The orientation of the central axis of the piece is measured with a compass. The direction relative to magnetic north is measured pointing from the larger to the smaller end of the piece, and recorded to the nearest 5 degrees (Photo 4).

*What part?* Observe the piece of woody debris. At the point where the piece of woody debris intersects the transect, is that part of a trunk of a tree (T), a branch of a tree (B), or a liana (L)? If you cannot tell, write NA.

*What fell?* Observe the larger piece of woody debris. Can you tell if what fell is a complete tree (C), a part of the tree including some trunk and branches (P), a branch or branches alone (B), or a liana (L)? If you cannot tell, write NA.

*New piece?* If this is a repeat census of a previously censused transect, then check the piece of woody debris for signs of spray paint indicating that it was included in a previous census. If this is a first census of this transect, or there is no sign of spray paint, record Y for new piece. If the transect was previously censused and spray paint is evident on the piece, record N.

### **Marking censused pieces**

Finally, use spray paint to mark the piece of woody debris. If possible, spray it somewhat to the side of where it intersects the transect (to minimize any impact on the decay rate of the piece at the point where it intersects the transect).



Photo 1. These remains of a stem or large branch are still woody debris as the pieces are solid enough to be lifted. Powdery remains are woody debris only if their height is more than 20 % of the width of the cross-section. The central group is one piece of coarse woody debris as all the small pieces are connected. The few pieces in the right separated from the central group are individual pieces of fine woody debris.

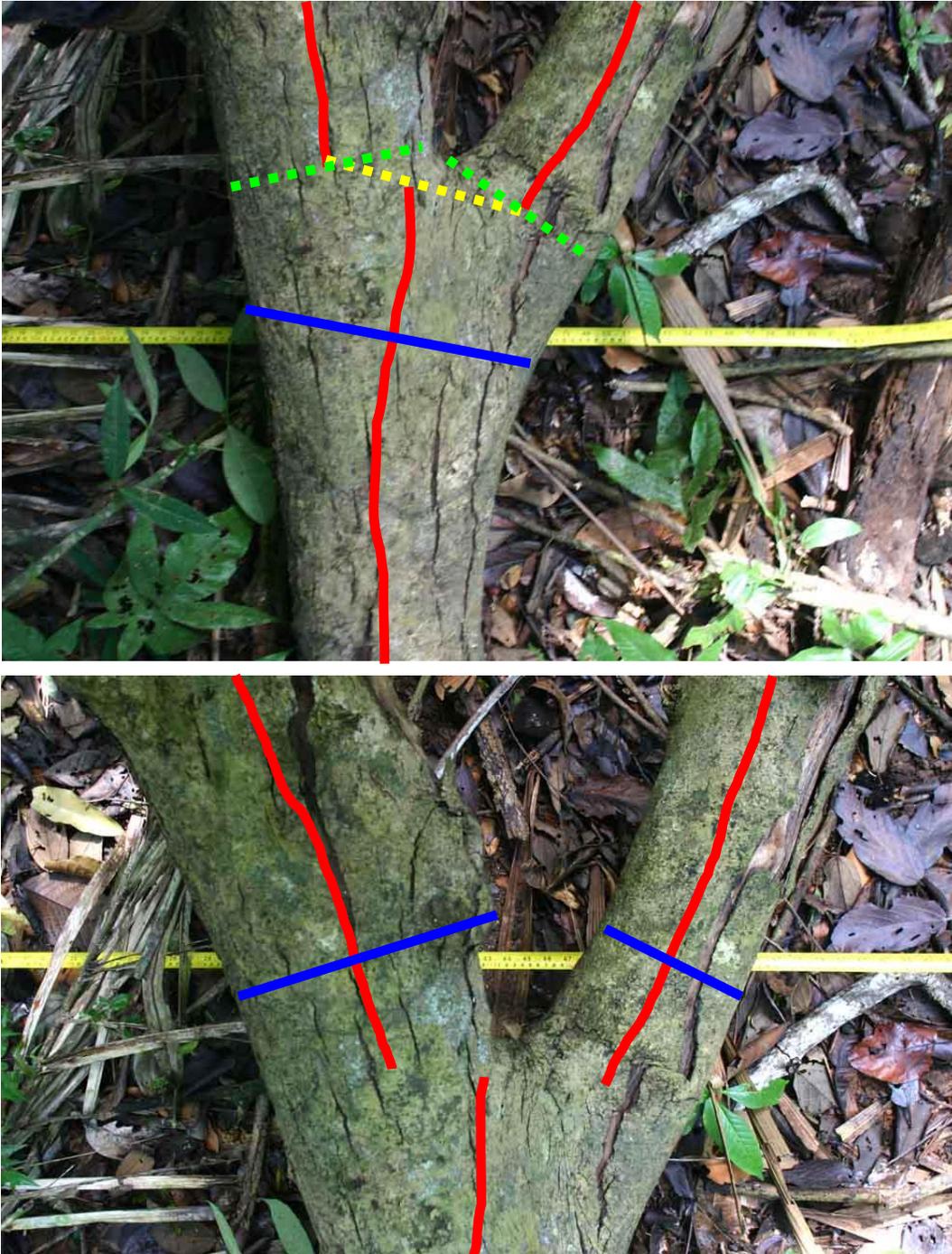


Photo 2. The central axes (shown in red) of a piece of wooden debris run through the centroids of the cross-section. When a piece of woody debris branches, the central axis splits as shown. Note that the lower axis stops on the line running between the lower ends of the upper axes. Depending on the location of the transect, shown here by the measuring tape, the piece is measured at either one or two places. Top: If the transect intersects the piece below the fork, only one measurement (shown in blue) is made. Bottom: if the transect intersects above the fork, two measurements are made. Note that the measurements are made exactly at the intersection with the transect – deformations are not avoided.



Photo 3. The diameter of a piece of coarse woody debris is measured using a large caliper. Because the two blades of the calipers bend easily, care must be taken to apply the correct amount of force so that the blades remain parallel. (This can be practiced by measuring diameters of small objects such as sticks, placing them at various positions between the blades while observing whether the blades are parallel.)



Photo 4. The orientation of a piece of coarse woody debris is assessed by placing the compass so that the compass points from the larger to the smaller end of the piece (for this model compass, the direction is indicated by the two narrow red arrows above the dial). Then turn the dial so that North points to magnetic North (here the red end of the needle between the white marks) and read the direction (degrees indicated at the white triangle above).