# Trial Data Analysis for GEF Carbon Sampling Methodology Design

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This document presents the results of a data analysis exercise conducted on the GEF 2017 field trial data. As part of the trial, allometry was conducted for all plant species in five plots. Two plots were located in degraded thicket and three in intact thicket. Allometric models for thicket species were obtained from Marius van der Vyver (van der Vyver 2017). Where there were measurement records for species that hadn't yet been identified, an allometric model for what is assumed to be a similar species was used. E.g. for "Asparagus hairy", the "Asparagus capensis" model was used.  No obvious species choice could be made for some of these unidentified measurement records. The records for these cases formed a small portion of the total and were omitted from the analysis.

## Woody Canopy

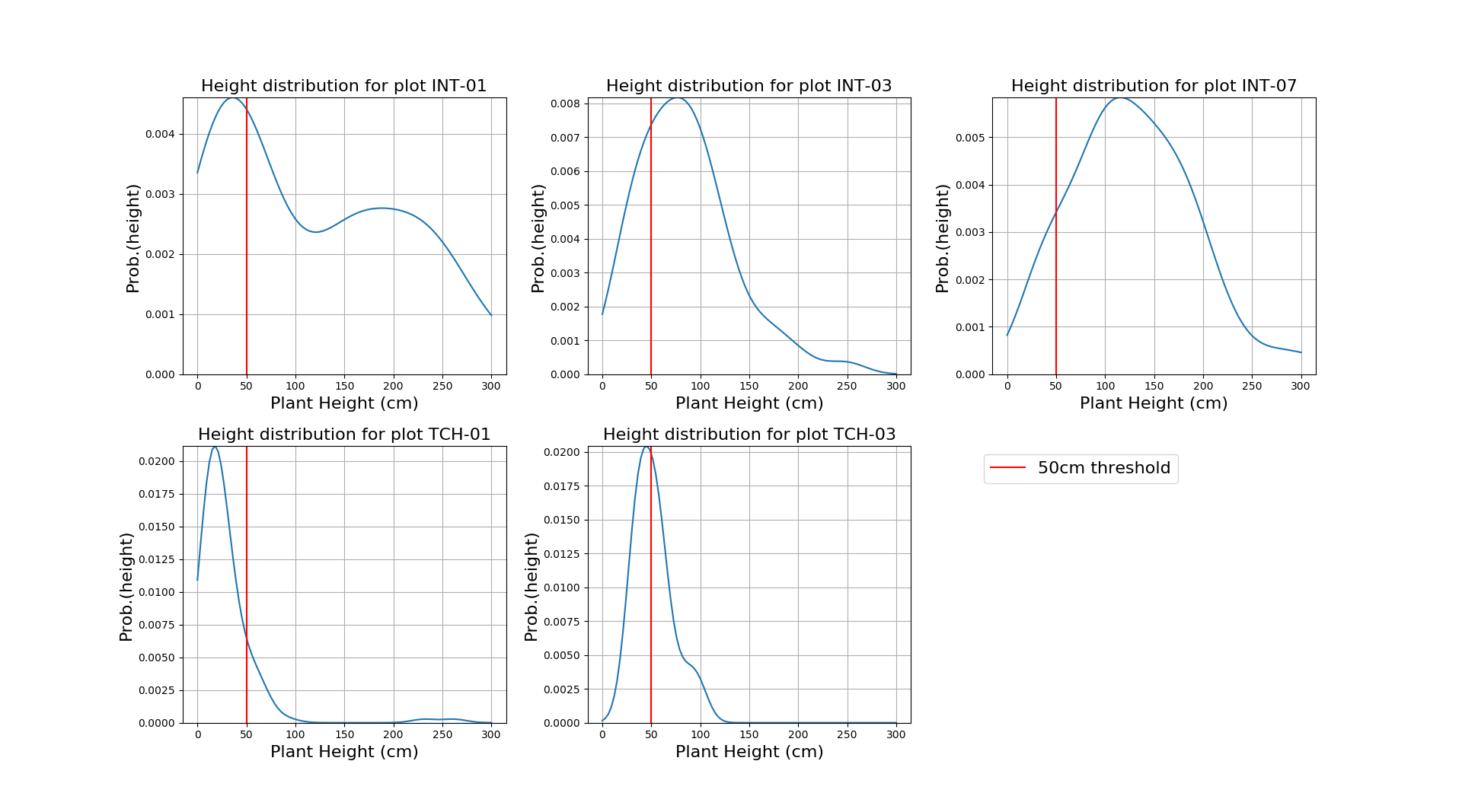


Figure 1 Height distributions per plot

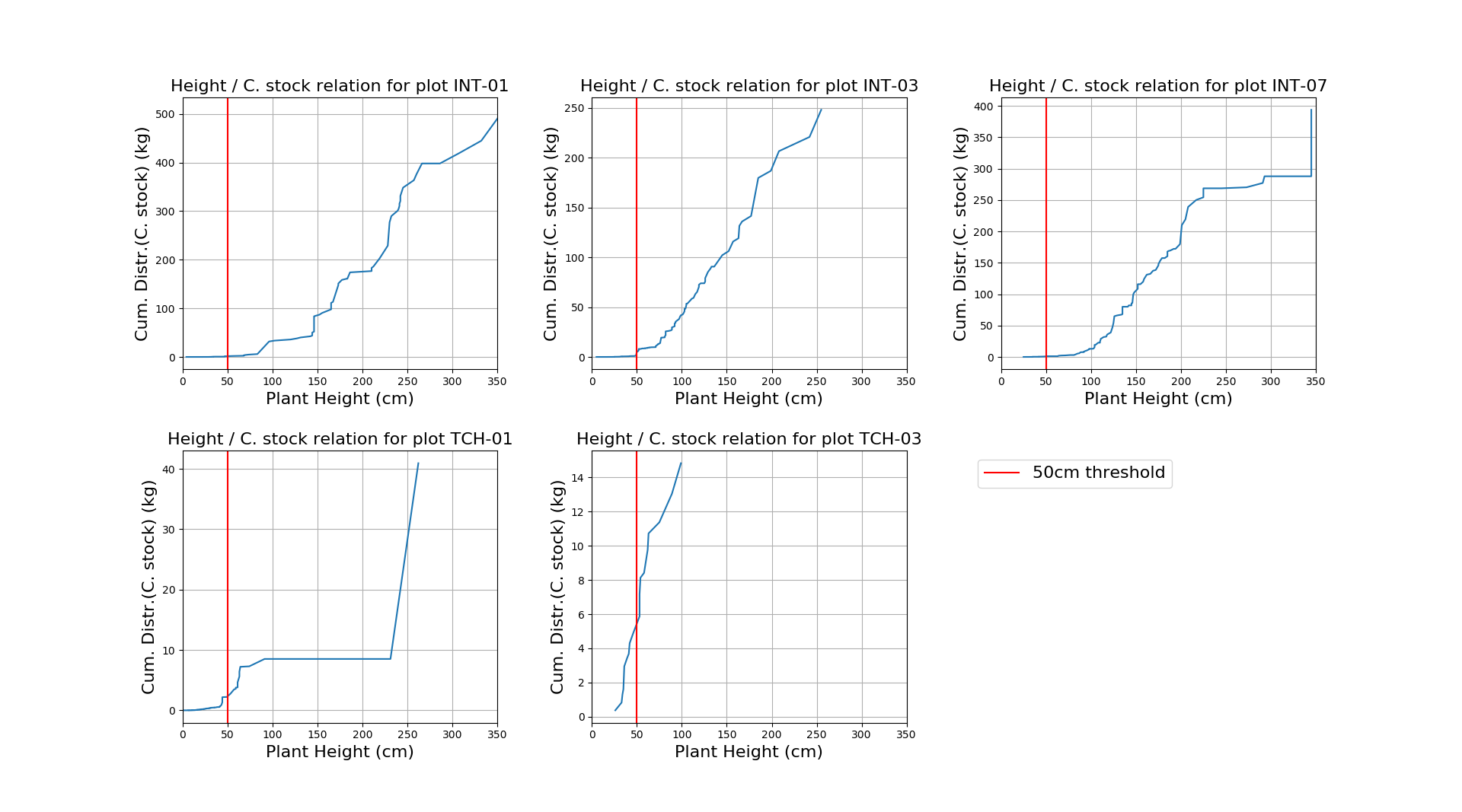


Figure 2 Carbon stock cumulative contributions by plant height

Figure 1 and Figure 2 are intended to inform the design of nested plots with a possible plant threshold height. Figure 1 shows the plant height distribution for each plot. These are kernel density estimates (KDE).  Plants under 50cm comprise a substantial portion of the records.  Figure 2 shows the quantity of carbon contributed by plants of different heights.  These graphs display the cumulative carbon contributions ordered by plant height for each plot.  For all plots except TCH-03, the carbon contributed by plants with heights under 50cm makes a very small contribution to overall carbon.  For TCH-03, these smaller plants contribute about 40% of the total carbon. This plot, however, has the lowest total carbon overall, meaning the 40% contribution is relatively insignificant in terms of total carbon.  I believe these results support the use of a nested plot design.  While plants under 50cm form a substantial portion of the measurements, they contribute very little to total carbon. I suggest using a 5x5m nested plot, where all plants are measured, and then only measuring plants taller than 50cm in the rest of the containing plot.  The carbon for plants under 50cm in the 5x5m nested plot can be extrapolated to the containing plot.  The 5x5m size is a loose recommendation and could perhaps be made smaller.  This analysis suggests the nested plots will be beneficial for both degraded and intact plots. Practically, however, it may not be easy to quickly judge plant height in dense intact thicket.

Plot

yAA

xA

AText

Ellipse section A

(xA + yA) / 2

Circular approximation B

Figure 3 Edge intersected canopy area and approximation

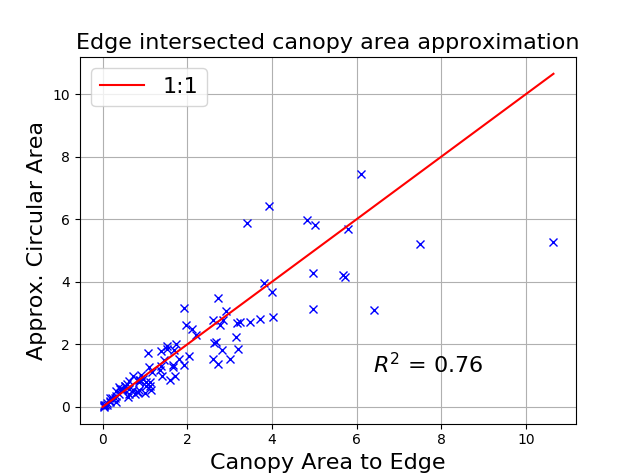


Figure 4 Edge intersected canopy area approximation

Figure 3 and Figure 4 give a rough indication of how well canopy area can be approximated with a modified allometry approach, for the special case of plant canopy overlapping the plot boundary.  Figure 3 defines the areas being measured and approximated. Actual canopy is modelled by an ellipse that intersects the plot boundary to give the elliptical section area A. This area is approximated by the circular area B, which is effectively the standard allometric approach used in Marius’ models. A number of randomly sized and positioned ellipses were generated and their corresponding intersected areas calculated as indicated in Figure 3. Figure 4 shows a scatter plot of area A versus the approximated area B for these ellipses. I think these results indicate that the approximation is acceptable.

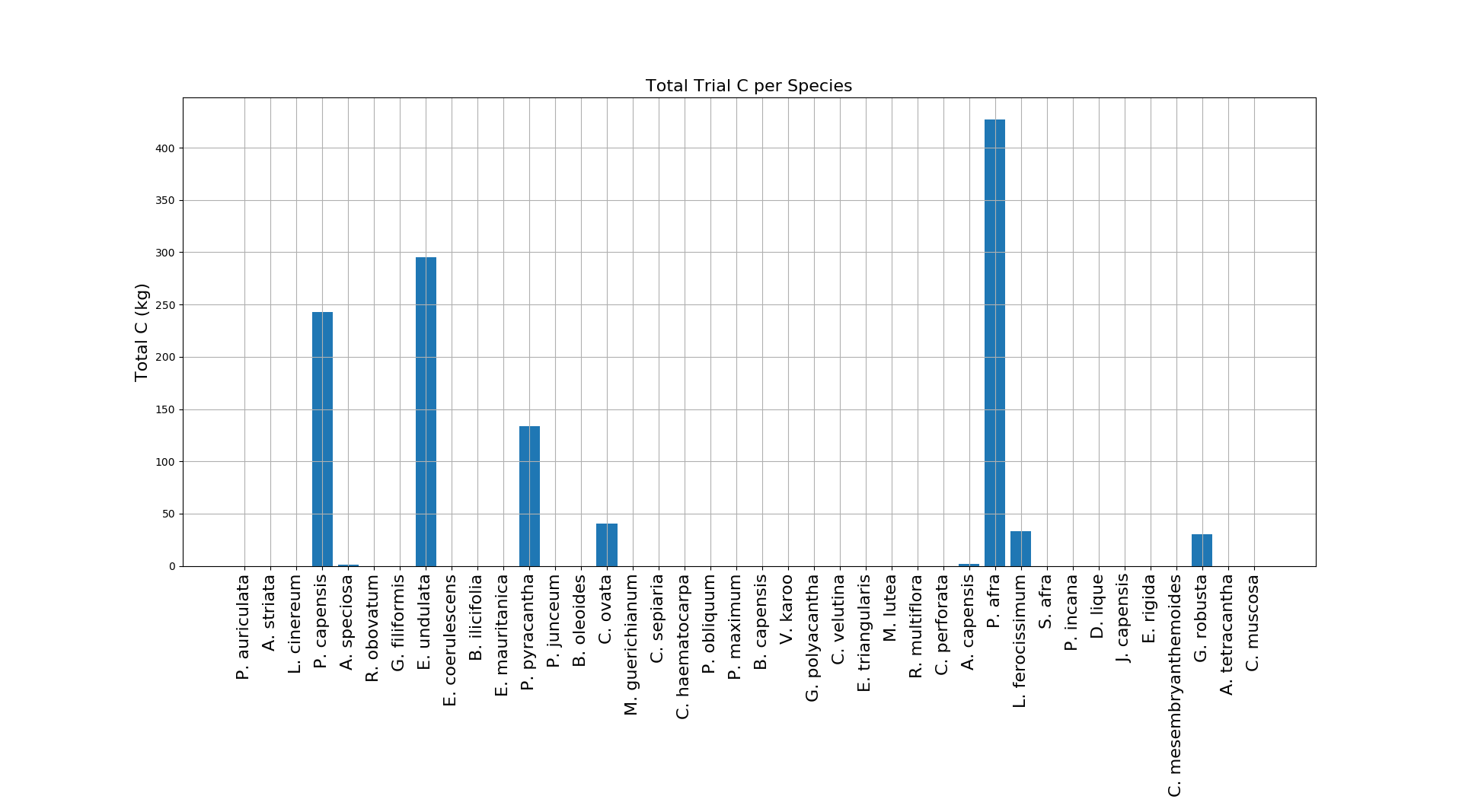


Figure 5 Total carbon per species over all plots

Figure 5 shows the total carbon contributed by each species over all of the trial plots. The four biggest contributors are *P. afra, E. undulata, P. capensis* and *P. pyracantha*.

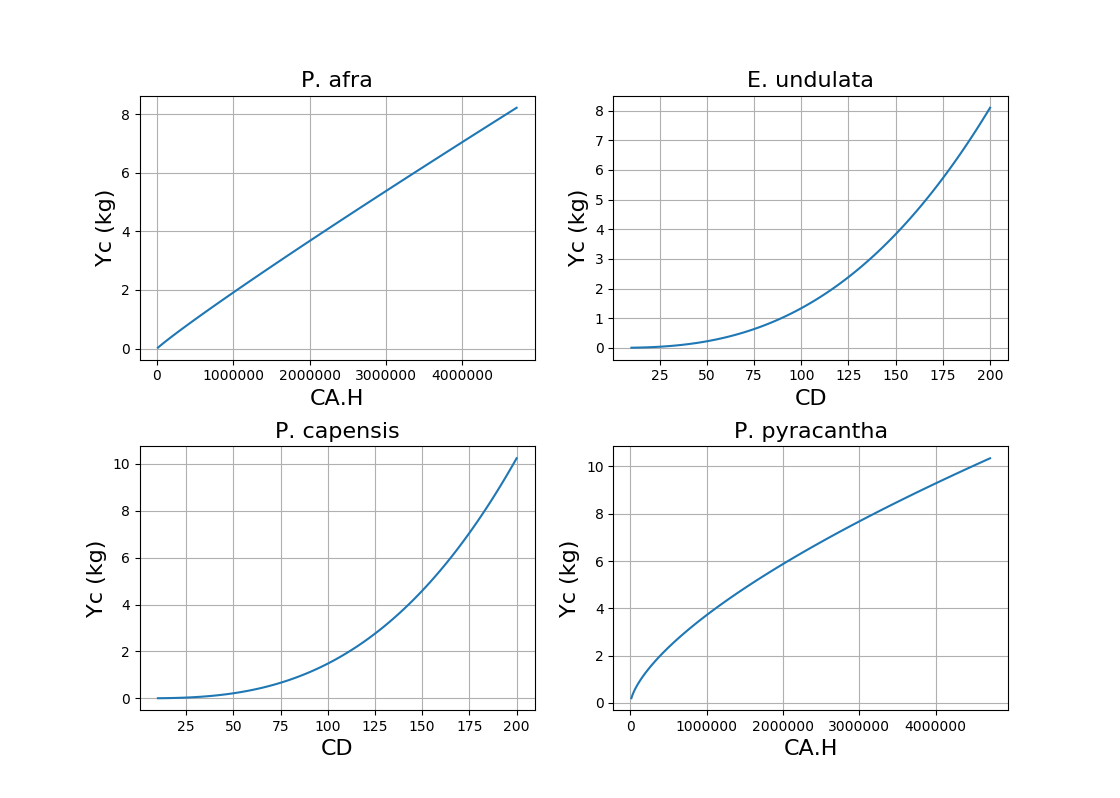


Figure 6 Carbon Vs allometry for key species

Figure 6 shows how carbon (*Yc*) varies with the allometric measure (*x*) for each of the four key species’ allometric models. See Marius’ allometry table for further details of the models and their parameters. This plot was produced to give an indication of how linearly or otherwise carbon scales with plant dimension. It is (questionably) useful for informing the decision of how to treat plants overlapping the canopy boundary. E.g. if half the plant is overlapping and is measured, do we expect to get half the carbon from the allometric model?

My preference for treatment of plants overlapping the plot boundary is to measure them as indicated in Figure 3. These results somewhat support this approach. I believe the strongest reason for this approach over others is a more conceptual one i.e. for degraded plots, containing possibly one or two large trees, it is likely to give the most accurate results. This is because it represents an appropriate portion of each tree rather than omitting or excluding it entirely.

## Dead Wood

Lying dead wood carbon stocks were estimated with Equation 6 from the CDM AR-Tool12 document (CDM 2015). Standing dead wood measurements were treated as lying dead wood and modelled as such, with Equation 6. It was not possible to apply specific CDM standing dead wood models, as only line transect diameter measurements were made during the trial (these models require height and stem diameter measurements to be made for dead wood inside the plot boundaries). The “default” carbon estimation approach of Equation 9 could also not be tested, as no default factor is available for arid habitats (see Section 8.1, Table 5 - (CDM 2015)).

The fixed parameters in Equation 6 were set as follows:

Table 1 - Dead wood paramaters

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Description** | **Value** |
|  | Sample plot area (ha) | (10x10)/(100x100) = 0.01 |
|  | Carbon fraction of tree biomass (dimensionless) | 0.48 (Powell 2009) |
|  | Basic wood density for species *j* (t d.m.m-3) | 0.5 for all species (estimate from dry-wet ratios in van der Vyver (2017)) |
|  | Sum of lengths of the transects (m) | 100 |
|  | Density reduction factor for nth piece of wood (dimensionless) | 1 for solid  0.8 for intermediate  0.45 for rotten  (CDM 2015) |

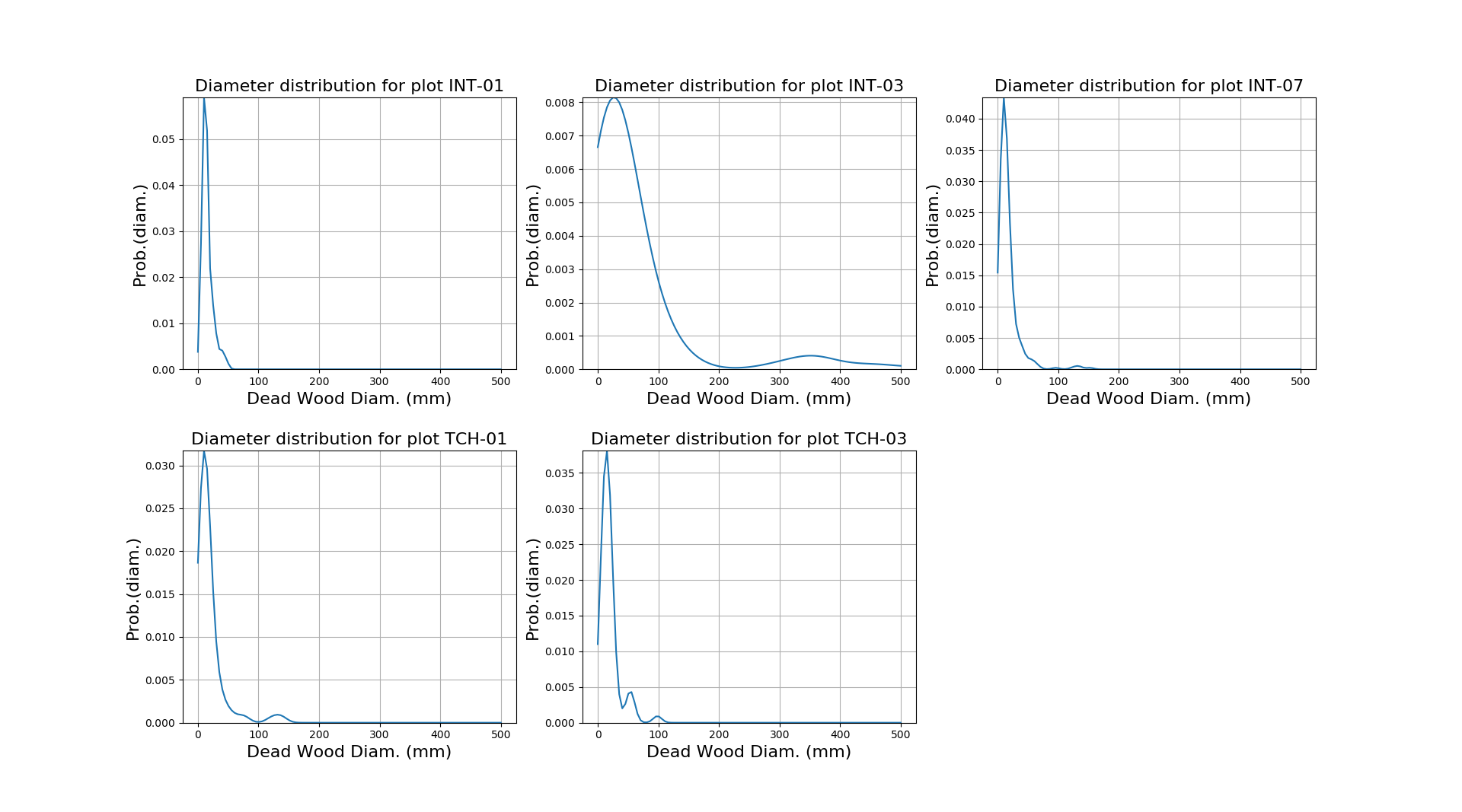


Figure 7 Dead wood diameter distributions per plot

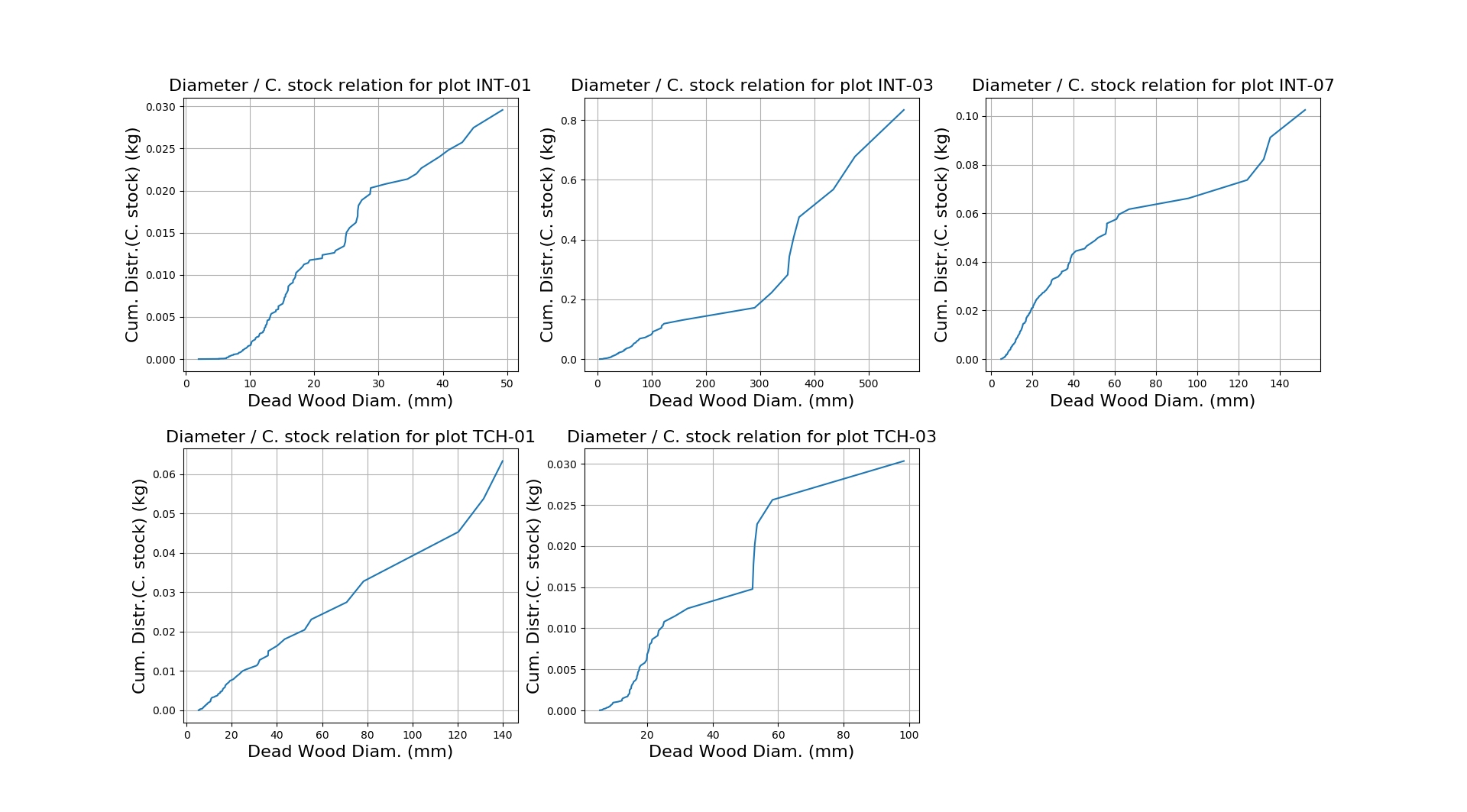


Figure 8 Carbon stock cumulative contributions by dead wood diameter

Figure 1 shows the dead wood diameter distribution for each plot. These are kernel density estimates (KDE).  Diameters under 100mm comprise the majority of the records and 70% of measurements were made on diameters under 20mm.  Figure 2 shows the quantity of carbon contributed by dead wood of different diameters.  These graphs display the cumulative carbon contributions ordered by diameter for each plot.  The carbon is contributed fairly uniformly across the diameter range and there is not an obvious cut-off diameter for a possible nested approach. Nevertheless, limiting measurements to diameters above 20mm, would produce 95% of the dead wood carbon as measured in the trial (while reducing measurements by 70%).

Overall, the dead wood contributes a small fraction to total above-ground carbon (for comparison, see Figure 2 for the woody canopy contributions of these plots). The highest dead wood contribution occurs in INT-03 where it produces about 0.3% of the above-ground carbon. With that in mind, I believe we could exclude the dead wood measurements from the methodology without significantly impacting on measurement accuracy.

## References

CDM. 2015. *A/R Methodological Tool: Estimation of Carbon Stocks and Change in Carbon Stocks in Dead Wood and Litter in A/R CDM Project Activities*.

Powell, Michael John. 2009. “Restoration of Degraded Subtropical Thickets in the Baviaanskloof Megareserve, South Africa.” Rhodes University.

van der Vyver, Marius. 2017. “Thicket Allometric Models.” Nelson Mandela University.