da Silva P. J[1], Araujo A. G[2], Carvalho L[3], Verçosa P. J[4], Tavares A[5]

[1, 2, 3, 5] Campus de Engenharias e Ciências Agrárias, Federal University of Alagoas, Brazil, [4] Instituto de Computação, Federal University of Alagoas, Brazil [1, 2, 3, 5] {gabriela.araujo; luis.carvalho; julio.silva; marcos.barrozo; acftavar}@ceca.ufal.br, [4] jpsv2@ic.ufal.br

Determination and calculation of eucalyptus biomass from LiDAR sensor data and projection of available biomass

17th International Conference on Precision Agriculture and 11th Brazilian Congress on Precision and Digital Agriculture

13-15 July 2026

Porto Alegre, Brazil

Abstract.

Eucalyptus (Eucalyptus spp.) is one of the most widely cultivated forest species in Brazil and worldwide. Eucalyptus biomass is organic matter derived from the eucalyptus tree which can be used as a renewable energy source. In recent years, advances in remote sensing technologies have made it possible to estimate forest biomass more accurately and non-destructively, with the use of LiDAR (Light Detection and Ranging) sensors being particularly noteworthy. This system emits rapid laser pulses to measure the distance between the sensor and the targets on the surface, allowing three-dimensional models of vegetation to be obtained. Thus, LiDAR has become a valuable tool for measuring forest structure, enabling the estimation of volume, height, and canopy density, which is essential information for calculating eucalyptus biomass. The objective of this study was to determine and calculate the amount of eucalyptus biomass using LiDAR sensor data in CloudCompare software. The point cloud used was from a eucalyptus area on Campus de Engenharias e Ciências Agrárias (CECA), Rio Largo, State of Alagoas, in an area of 2 hectares. This process was done using CloudCompare software. A horizontal section was made parallel to the ground below the eucalyptus trees using the Cloth Simulation Filter (CSF) tool and algorithm, which extracted the points on the surface discretely in the point clouds captured by the LiDAR sensor to isolate only the area of interest, i.e., the trees present in the area. To find the volume of the point cloud, it is necessary to use the Compute 2.5D Volume tool, with the grid spacing parameter value used at 0.01. This resulted in an average volume of 568.543 m^3 with an accuracy of 81.9% in relation to the cells counted. The metric density of common eucalyptus is 0.53 g cm^{-3}. Another method used was the equations for partial estimation of available biomass, with the goal of comparing the results with the data obtained from CloudCompare. Calculation to estimate available biomass showed an average of 2.16 tons per tree. From a total of 215 trees, it was possible to determine the average weight of biomass found at 464.4 tons. The index based on the volume of the point cloud captured by the LiDAR sensor resulted in 313.28 tons, or 1.46 tons per tree. The difference between the biomass values found was 32.59%. It can be observed that while both methods presented variation in biomass estimation - which is expected, considering sampling and methodological error - the process for determining the amount of biomass in eucalyptus from the point cloud volume proved effective since it uses standardized digital processing derived from LiDAR sensor data instead of other methods that are subject to variations resulting from manual collection and operational steps.

The authors are solely responsible for the content of this paper, which is not a refereed publication. Citation of this work should state that it is from the Proceedings of the 17th International Conference on Precision Agriculture and 11th Brazilian Congress on Precision and Digital Agriculture. EXAMPLE: Last Name, A. B. & Coauthor, C. D. (2026). Title of paper. In Proceedings of the 17th International Conference on Precision Agriculture and 11th Brazilian Congress on Precision and Digital Agriculture (unpaginated, online). Monticello, IL: International Society of Precision Agriculture and Brazilian Congress on Precision and Digital Agriculture.

However, as it is based on average and estimated parameters, further research is needed to improve the precision and accuracy criteria for biomass calculations.

Keywords. *LiDAR, CloudCompare, Biomass estimation, Eucalyptus.*

1 Introduction

Eucalyptus (*Eucalyptus spp.*) is one of the most widely cultivated forest species in Brazil and globally, owing to its rapid growth, high productivity, and broad adaptability to diverse edaphoclimatic conditions (FAO, 2020). Originating in Australia, Tasmania, and other islands in Oceania, there are approximately 730 botanically recognized species. However, no more than 20 of these are currently utilized for commercial purposes worldwide (EMBRAPA, 2019). These attributes make eucalyptus an important raw material for various sectors, including energy, timber, and pulp and paper. In addition to its economic relevance, eucalyptus plantations play a fundamental role in carbon sequestration, contributing to the mitigation of climate change effects (Gatto et al., 2010).

Eucalyptus biomass is organic matter derived from the eucalyptus tree. This material can be used as a renewable energy source, helping to reduce reliance on fossil fuels and mitigate the environmental impacts associated with energy generation (Potencial Florestal, n.d.). According to Embrapa (2025), biomass is a critical indicator of both productive yield and the sustainability of forest management. Therefore, estimating the biomass of eucalyptus crops is essential for achieving greater economic gains.

In recent years, advancements in remote sensing technologies have enabled more precise and non-destructive estimations of forest biomass, notably through the use of LiDAR (Light Detection and Ranging) sensors. This system utilizes laser light pulses to measure the distance between the sensor and targets on the Earth's surface, allowing for the generation of three-dimensional vegetation models (Hyyppä et al., 2008). Consequently, LiDAR has become a valuable tool for measuring forest structure, making it possible to estimate volume, height, and crown density—information that is essential for calculating the biomass of eucalyptus plantations (Pereira et al., 2021). The objective of this study was to determine and calculate the amount of eucalyptus biomass using LiDAR sensor data processed in the CloudCompare software.

2 Methodology

2.1 LiDAR Image processing

The point cloud utilized was sourced from a 2-hectare cultivated eucalyptus area located at the Campus of Agricultural Sciences and Engineering (CECA), in the municipality of Rio Largo, State of Alagoas. Before initiating the processes and methods to effectively calculate the eucalyptus biomass, it is necessary to process the point cloud imagery obtained by the LiDAR sensor (Figure 1). This procedure was conducted using the CloudCompare software, which, as previously discussed, allows for highly flexible handling of the file and its associated data.

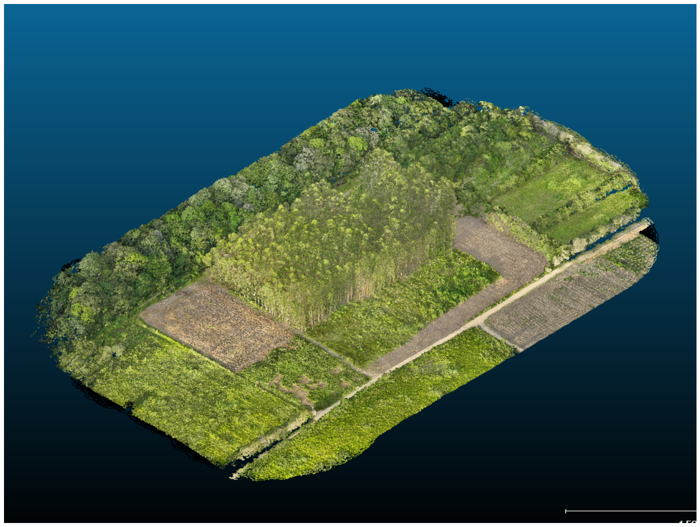

Fig 1. Point cloud image obtained by the LiDAR sensor in a eucalyptus area, opened in the CloudCompare software. Source: Authors (2025).

2.1.1 Tree isolation

Initially, it is necessary to separate the area of interest from the rest of the imagery; for this purpose, the polygon cropping tools native to the CloudCompare software were employed. Because the objective was to calculate the biomass exclusively for the eucalyptus trees, it is crucial to crop only the point cloud that identifies this specific plant species. Therefore, a horizontal section relative to the ground beneath the eucalyptus trees was executed using the Cloth Simulation Filter (CSF) tool and algorithm, which discretely extracts surface points from the point clouds captured by the LiDAR sensor (Zhang et al., 2016).

Once completed, the result is an RGB point cloud containing only the trees present in the area (Figure 2). This increases the accuracy of the ensuing biomass calculation, as there will be no significant interference from elements below the study target, such as shrubs, fallen leaves and branches, or other types of vegetation cover on the soil surface.

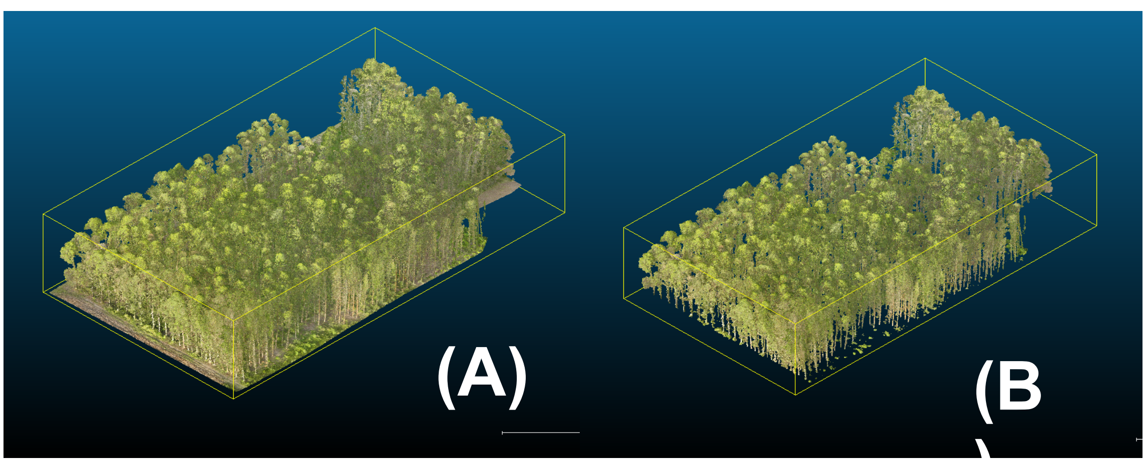

Fig 2. Point cloud image of the eucalyptus trees before cropping (A) and after cropping (B). Source: Authors (2025).

2.1.2 Point Cloud volume indices

Next, the file was exported to Scalar Fields (SF) for the three-dimensional Z coordinate on a representative color scale (Figure 3). These fields are datasets in which each point in space has a single associated numerical value; this value has no direction, only magnitude. This procedure is conducted to obtain the volume index of the point cloud captured by the LiDAR sensor for the trees. Since biomass is fundamentally the product of an object's volumetry and its constituent density, we can infer that the volume of the point cloud—which characterizes the shape of the tree—when multiplied by the average density of a eucalyptus tree, will yield its biomass.

To determine the volume of the point cloud, the Compute 2.5D Volume tool is utilized. This tool employs information from the three-dimensional Scalar Fields to calculate the volumetric average of the layer used for both the object (in this case, the eucalyptus trees) and the discarded surface (Figure 4), with the grid spacing parameter set to 0.01. This resulted in an average volume of 568.543 m³ with an accuracy of 81.9% relative to the counted cells. According to Shizuo et al. (2020), the metric density of common eucalyptus is 0.53 g/cm³. Using the basic density equation, we establish:

$$Biomass = Density \cdot Object\ Volume$$

$$Biomass = 0{,}53\ g/cm^3 \cdot 568{,}543\ m^3$$

$$Biomass = 301.327.790\ g\ or\ 313{,}278\ t$$

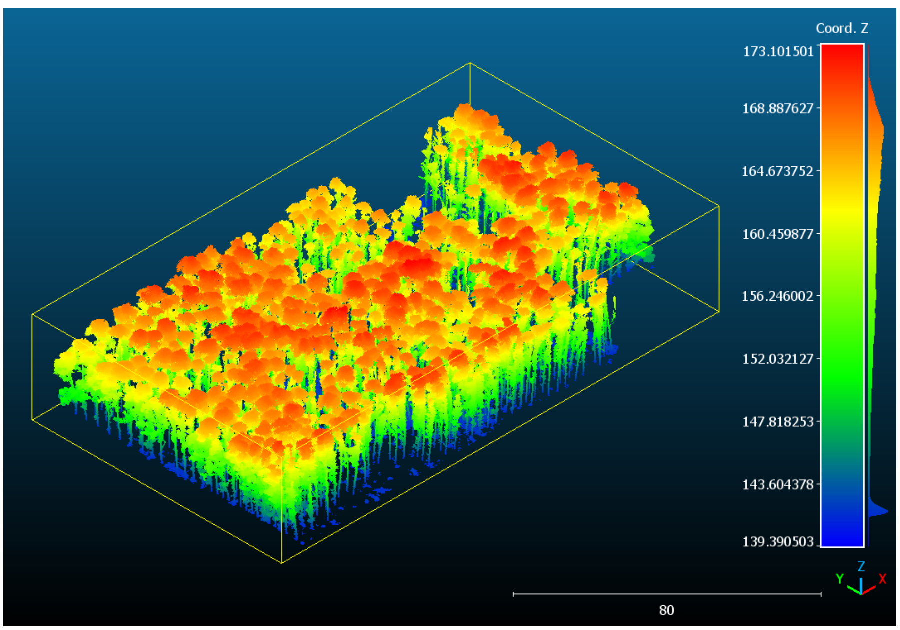

Fig 3. Point cloud image in Scalar Fields on the three-dimensional Z coordinate with representative colors. Source: Authors (2025).

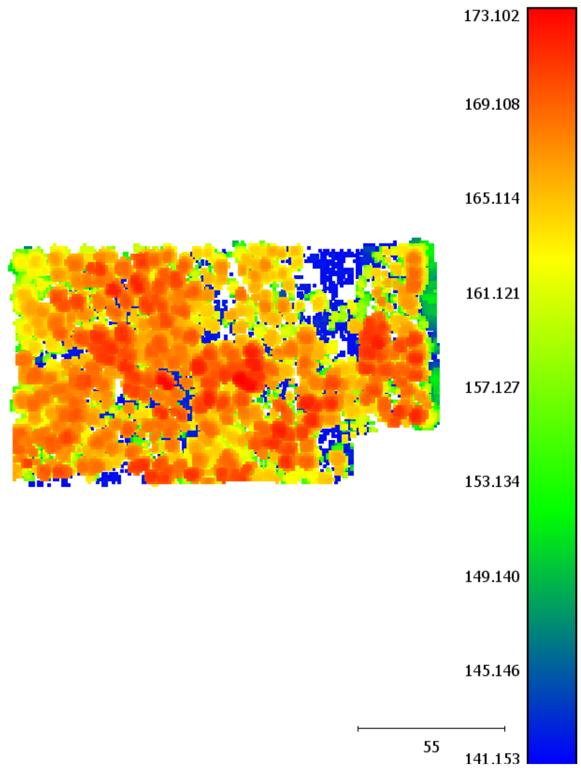

Fig 4. 2.5D volume computation performed using the software. Source: Authors (2025).

2.2 Biomass Calculation

To obtain a more concrete result based on the discovered parameters, it is necessary to utilize additional metrics to determine the biomass value of the eucalyptus trees. For this, we applied the partial biomass estimation equations proposed by Luis et al. (2023) as a comparative method alongside the point cloud volume indices found—thereby establishing a more precise hypothesis.

2.2.1 Point cloud volume indices

The metrics utilized for biomass determination were:

1. Identified species;
2. Diameter at breast height (DBH/DAP);
3. Total height (ht);
4. Height to the base of the crown (hc); and
5. Crown projection in N/S and E/W directions (CDNS; CDEW).

Utilizing the LiDAR data as the primary resource, in this instance with a reduced sample size, the partial biomass estimation equations were calculated using stem biomass (ws), bark biomass (wb), branch biomass (wbr), total aboveground biomass (wa), root biomass (wr), and, ultimately, total biomass (wt).

2.2.2 Projection of available biomass

Based on the metrics presented, the equations were:

$$ws = 0{,}009964 \cdot DAP^{1{,}780459} \cdot ht^{1{,}369618}$$

$$wb = 0{,}000594 \cdot DAP^{2{,}379475} \cdot ht^{1{,}0849888}$$

$$wbr = 0{,}095603 \cdot DAP^{1{,}674653} \cdot (\frac{ht}{DAP})^{-0{,}85073}$$

$$wa = ws + wbr + wl$$

$$wr = 0{,}2487 \cdot wa$$

$$wt = wa + wr$$

After applying these values, we can obtain a reliable estimate of the total biomass of the studied area, with approximately 215 eucalyptus trees (Table 1):

Table 1. Calculator of Available Biomass in the Eucalyptus area, generated from parameters and metrics inferred from LiDAR sensor data. Source: Authors (2025).

Available biomass calculator for an eucalyptus plantation				
Biomass origin	Calc. code	Results (ton)	Tree count	Total biomass (ton)
Stem	*ws*	1.68	215	464,7665608
Bark	*wb*	0.04		
Branches	*wbr*	0.01		
Total Area	*wa*	1.73		
Roots	*wr*	0.43		
Total biomass	*wt*	2.16		

3. Results and Discussion

Using the calculations structured for the biomass estimation, it was determined that the average weight for each *Eucalyptus globulus* tree is approximately 2.16 tons. Following the count of planted trees in the experimental field, which totaled 215, it was established that the average weight of the biomass present in the site's eucalyptus trees is 464.4 tons. This value is based on the calculation of average and approximate parameters, meaning it does not yield the exact weight of the present biomass.

The index derived from the point cloud volume captured by the LiDAR sensor—which, when compared to the biomass projection method proposed by Luis et al. (2023), appears promising and less labor-intensive—resulted in 313.278 tons, or 1.457 tons per tree. The observed biomass value is 32.59% lower than the calculated biomass projection. However, when considering the margin of error anticipated for these estimates—both in the biomass projection and the volume index estimation via CloudCompare—this value still represents a significant and relevant quantity.

4 Conclusion

Despite the discrepancy in the values found between the biomass projection and the volume estimate derived from the captured point cloud, it is observable that while both present a certain degree of variation (which is expected, considering the sampling and methodological errors inherent in biomass estimates), the procedure for determining eucalyptus biomass quantities from point cloud volume proved effective. This effectiveness stems from its reliance on standardized digital processing derived from LiDAR sensor data treatment, serving as an alternative to other methods that are highly susceptible to variations caused by manual data collection and operational constraints. Nonetheless, because this method relies on average and estimated parameters, future research is necessary to refine the precision and accuracy criteria of these biomass calculations.

References

Zhang, W., Qi, J., Wan, P., Wang, H., Xie, D., Wang, X., Yan, G. An Easy-to-Use Airborne LiDAR Data Filtering Method Based on Cloth Simulation. *Remote Sensing*. 2016; 8(6):501.

FAO. *Development of Eucalyptus Plantations — an Overview*. Roma: FAO, 2020.

EMBRAPA. *Cultivo de eucalipto em propriedades rurais*. Brasília: EMBRAPA, 2015.

EMBRAPA. Florestas — Eucalipto. Resource Document: https://www.embrapa.br/florestas/eucalipto. Accessed 10 November 2025.

Gatto, A. et al. Estoques de carbono no solo e na biomassa em plantios de eucalipto. *Revista Brasileira de Ciência do Solo*, v. 34, p. 1069–1079, 2010.

Potencial Florestal. Biomassa de eucalipto: o que é e para que serve? Disponível em: https://potencialflorestal.com.br/biomassa-eucalipto/. Accessed 10 November 2025.

Shizuo, M., Itamar, A. B., João, B. V. C. Produção de biomassa de tronco de Eucalyptus benthamii submetido à aplicação de lama de cal, cinza de madeira e calcário no Oeste Catarinense. *Embrapa Florestas*, 2020. 12 p. - (Documents / Embrapa Florestas, ISSN 1980-3958 ; 346).

Hyyppä, J. et al. Forest Inventory Using Small-Footprint Airborne LiDAR. In: Topographic Laser Ranging and Scanning, *CRC Press*, 2008.

Pereira, G. H. A. et al. Estimativa de biomassa aérea de eucalipto a partir de dados LiDAR aerotransportados. *Revista Árvore*, v. 45, e4535, 2021.

Luis, P; Jani, P; André, S; Joaquim, S; Domingos, L. *Relatório da análise de dados LIDAR tratados, nas áreas experimentais, para quantificação de biomassa* . UTAD. 2023.