A review of modeling, and simulation for sustainable replanting eucalyptus

Nurhayati Sembiring, Humala Lodewijk Napitupulu, Meilita Triyana Sembiring, and Yasintha Wahida Tiana
Department of Industrial Engineering, Faculty of Engineering, Universitas Sumatera Utara

*Email: yasinthanasution03@gmail.com, nurhayatipandia68@usu.ac.id

Abstract. The growth process of eucalyptus plants in the form of log volume is influenced by abiotic, and biotic factors, which then have a relationship with climate, genotype, soil conditions, both physical, and chemical, silvicultural practices, and forest management. Therefore, to improve forest resilience, and productivity, identification of eucalyptus plants is needed. The most promising tool available to help government, and companies is to use eucalyptus-based models. This model is useful for getting the right planning, assessing the variables that affect climate, and determining long-term direction, and for seeing changes in the forest sector. Individual growth models with trees, and stand levels are needed to estimate future forest structures. The purpose of this study is to provide information about the models, and simulations used in the process of replanting eucalyptus plants that have benefits in various sectors of life.

1. Introduction
Recently it has become a trend throughout Europe to change natural, and semi-natural forests left to plantations [1]. Disturbances in nature, and humans, together with changing climate, changes pose significant challenges in the management of these resources. What often occurs, especially in natural forests, where conflicts can occur in the form of available water, and deforestation for industrial purposes [2]. The most widely planted tree species in the entire world is eucalyptus because eucalyptus from many species has the characteristics of being able to adapt in many different locations, and having benefits for various purposes [3]. Roots in eucalyptus plants play an essential role in natural ecosystems, primarily through the processes of production, exudation, respiration, and decomposition. Besides, tree growth is also very dependent on the function of roots to obtain water, and nutrients. Maintaining and building root systems in natural forests can help trees adapt to climate change that is uncertain [4]. Also, the management of harvest residues also needs to be carried out in eucalyptus plantations. The purpose of replanting eucalyptus is so that sustainability can occur even if it is built on poor soil [5].

Climate differences, soil texture, history of l, and use, and related management factors such as the amount of rotation, age of the plantation, method of the establishment (plantations or shrubs), harvest preparation, and management of crop residues can cause differences in soil fertility, and soil carbon storage in eucalyptus plants [6]. Climate change can also increase the likelihood of drought, leading to tree death [7]. Management decisions are very dependent on the sustainability of economic
performance in the future, to build this expectation, forest growth predictions are used. Using a deterministic approach to forest growth, and stable climatic conditions, most predictions, and consequences based on empirical knowledge. However, climate change cannot be ensured because climate can change in uncertain decades or times. The results in forest growth, and the availability of dynamic, and uncertain carbon. Therefore, a final decision is needed regarding the optimal management solution for the model, and simulation of the eucalyptus replanting plan for sustainability due to the uncertainty of the modeling system parameters, and the changing climate conditions [8].

![Forest surface area](image)

**Figure 1.** Forest surface area

2. **Review methods**

In this study, to create sustainability for future research on how to model, and simulate appropriate for the sustainability of eucalyptus replanting. So a literature review was conducted, and identification of opportunities; some literature has been reviewed in this regard. The research method can provide a describe of the research design starting from the steps that must be done, work procedures, data sources, and in what way the data is obtained, and then processed, and analyzed.

**Step 1.** Determine the research topic to be reviewed as literature

Determination of the topic to be reviewed is one of the critical things in the decision. The topic chosen must be consistent with the current conditions, and the development of science. The topic selected as the literature to be reviewed the Model, and Simulation for Sustainability Replanting Eucalyptus.

**Step 2.** Determine the publication period for review as literature

The primary reference is chosen some research in the period 2018 - 2020. This election is considered sufficient to represent thoughts about the development of science in the present.

**Step 3.** Find the literature to be reviewed

To find the literature that will be reviewed, some literature has been identified from several databases such as Google Scholar, Springer, Science Direct, and an internet search of student journals, and journals publications.

**Step 4.** Choose the literature to be reviewed

The main requirement in selecting literature to be reviewed in the literature that has a clear relationship between the topic of the article that has been chosen, and approved by the authorities.

**Step 5.** Analyze, and understand, and the literature found
The final step in reviewing a journal is to study, understand, and examine articles or journals that have been selected to find out the development of the research from time to time.

For more details on understanding how to do a journal review, this study follows the steps presented in Figure 2.

**Figure 2. Research methodology**

This literature review was set from 2018 to 2020, the search keywords used to collect data are, *Modeling, and Simulation for Sustainable Replanting Eucalyptus*, *Modeling Sustainable Replanting Eucalyptus*, *Modeling for Eucalyptus*, etc.

| Keywords of Literature Review | Keywords of Literature Review |
|-------------------------------|-------------------------------|
| **Modeling, and Simulation for Sustainable Replanting Eucalyptus** | Penin, L. Peleteiro, et al. [9], Tan, Tina Co Nnie Sen, Tushar Kanti [10] |
| **Modeling Sustainable Replanting Eucalyptus** | S, andoval López, et al. Jianhui Liao, D, andan Zhou et al. D. R.M. Tardy, et al. |
| **Modeling for Replanting Eucalyptus** | McMahon, Devin E. Vergütz [11], Freitas, Eliane Cristina Paiva et al. [12] |
### Table 1. Keywords data literature search (2018 – 2020)

| Keywords                     | Literature Review                                                                 |
|-----------------------------|-----------------------------------------------------------------------------------|
| Modeling, and Simulation    | Marcelo M.R. Portugal, et al.                                                      |
| Eucalyptus                  | John Paul Burkhart, et al.                                                         |
|                             | Clayton Alcarde Campoe, et al.                                                     |
| Replanting Eucalyptus       | Subhan, Ermal Salampak                                                            |
|                             | Embang [13], Masson, Marcus                                                       |
|                             | Vinicius Tavares [14]                                                             |
| Sustainable Eucalyptus      | Cardona, S, andra                                                                 |
|                             | Gallego, et al [15], Jonker, Jan                                                   |
|                             | G.G. Junginger [16], Dutra, Jezrael Rossetti                                     |
|                             | Moni Ribeiro Filho [17]                                                           |
| Modeling for Eucalyptus     | Sen, Kamalesh                                                                     |
|                             | Datta [18], Alex, andre, Vinicius Souza [19]                                      |

### Table 2. Number of articles per database

| Database     | Quantity |
|--------------|----------|
| Book         | 1        |
| Sciencedirect| 20       |
| Student Paper| 3        |
| Publication  | 7        |
| Springer     | 4        |
| **Total**    | **35**   |

### 3. Literature review

Discussed the literature that has been selected from several data such as books, book reviews, journal publications, as well as from searches through the internet. Then the literature is mapped in several conclusions, as shown in table 3.

### Table 3. Literature reviews on various topics in modeling and simulation

| Authors                  | Research Focus                                                                                                                                                                                                 | Years | Country  |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------|
| Santos et al. [20]        | This literature focuses on two models, namely glyphosate herbicide, and sulfentrazone-ethyl in eucalyptus plants to prevent the formation of A.psidii during infection of eucalyptus leaves to increase susceptible basal resistance, and inhibit the infectious track that occurs. | 2019  | Brazil   |
| Vale, Mário Mateus, et al. [21] | The model used in this research is the process of melting catalyzed by acid, atmospheric pressure for the development of environmentally friendly, and innovative one-component polyurethane, obtained from the melting of biomass, and byproduct industries, namely cork powder, and eucalyptus bark. | 2019  | Portugal |
Table 3. Literature reviews on various topics in modeling, and simulation for sustainable replanting eucalyptus

| Authors                          | Research Focus                                                                                                                                                                                                                                                                                                                                 | Years | Country   |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------|
| Chu, Shuanghuang Ouyang et al.   | Currently, there are many recommendations for planting. But it has less influence on various ecological processes. This research focuses on Chinese plantations to determine the benefits of eucalyptus trees that are rich in these benefits. Two models were used in this study, namely: With 60% of eucalyptus trees, and broadleaf native trees, and Planting broadleaf trees without depletion.                                                                 | 2019  | China     |
| Voigtlaender, M. et al. [23]     | This study uses a random block design model in four different locations to assess the effects of magnesium tree recognition in eucalyptus plantations                                                                                                                                                                                                 | 2019  | Brazil    |
| Medauar, Caique Carvalho Silva   | For the process of controlling eucalyptus shoots, sampling is done in the field, this study uses a new technology model, commonly known as uncrewed aerial vehicles (UAVs). The use of this technology is to help the process of identifying the vegetative power of eucalyptus plants.                                                                                                                                 | 2020  | Brazil    |
| Elvis Felipe Sentelhas, et al.   | In this study, using several models, including APSIM, FAO, and 3PG. These three models are useful during the calibration, and evaluation process on the performance of the model in Brazil. Also these three models are also helpful in assessing the interpretation of these models, and comparing Eucalyptus simulation models                                                                                                                                                       | 2019  | Brazil    |
| Rodrigues, et al. [26]           | The focus of this research lies in the economic aspects by using the Broken Plus Intact Cells (BIC) model in plants                                                                                                                                                                                                                                 | 2019  | Portugal  |
| Scolforo, Henrique, et al. [27]  | Individual growth models with trees produce accurate st, and tables. The growth, and yield system provided provides a powerful function for updating data, and can provide data on forest reforestation in Brazil. This makes it possible to make clonal eucalyptus st, ands into several products                                                                                                       | 2019  | US, Brazil|
| Carrizo, João, et al. [28]       | The research focuses on the Individual Tree model (ITM) that can project forest st, ands in the future. Using the ITM model, it is estimated that the height, diameter, and individual tree growth is better than other models                                                                                                                                                        | 2019  | Brazil    |
| Elli, et al. [29]                | This study uses a multimodel approach to identify the leading causes of existing problems. Then three simulations of eucalyptus were used, namely 3PG, FAO, and APSIM, to simulate the potential, and growth that could be achieved.                                                                                                                                   | 2019  | Brazil    |
| Tabatabaei Majd, et al. [30]     | The focus of this research is on eucalyptus leaf extract, and zinc divalent zinc ions which are used as metal protectors against corrosion                                                                                                                                                                                                       | 2019  | Iran      |
| Salinas, Carlos H. et al. [31]   | This research presents a two-dimensional mathematical model during the drying process of eucalyptus plants. Simulation models are used to assess biomass production, carbon content in eucalyptus plants, and wood volume.                                                                                                                                          | 2020  | Chile     |
| Alegria, et al. [32]             |                                                                                                                                                                                                                                                                                                                                               | 2019  | Portugal  |
Table 3. Literature reviews on various topics in modeling, and simulation for sustainable replanting eucalyptus

| Authors      | Research Focus                                                                 | Years | Country |
|--------------|--------------------------------------------------------------------------------|-------|---------|
| Caldeira, et al. [33] | This study uses an ecophysiological model to predict the productivity of plantation forests. | 2020  | Brazil  |
| Dehghani, et al. [34] | Experimental, and computational study models are used to see the effect of eucalyptus leaf extract inhibition on steel corrosion in HCL solution | 2019  | Iran    |
| Attia, et al [35] | Drivers of variability in production activities on regional scale plantations using the G'Day Model, where this model is based on an ecophysiological process that is useful for the production of biomass stems in eucalyptus plantations, and simulates carbon, and water budgets | 2019  | Brazil  |

After reviewing several journals from 2018 to 2020, and from various search keywords, it was obtained the results of the review that research on Modeling, and Simulation for Sustainable Replanting Eucalyptus was mostly carried out in Brazil in 2019. For more details, it can be seen in the graphs listed in figure 3, and figure 4.

Figure 3. Journal reviews based on research location

Figure 4. Journal reviews based on years
4. Conclusion
The conclusion drawn after reviewing some literature is that research with the theme of Modeling, and Simulation for Sustainable Replanting Eucalyptus was carried out in Brazil in 2019. The number of studies on this matter is due to the current trend in Europe, namely on how to do it transformed the natural, and semi-natural forests that are currently being ab, anonden to a wealthy plantation. Many factors affect it, one of them is climate change that is not certain. So that it can cause the plants to be short of water, and can cause the plants to be short of water, and can cause the plants to be short of water so that it can cause death to plants, and this poses a significant challenge in implementing the plan. Therefore the importance of the right decision from management in handling this. One of the most widely used models, and simulations is the APSIM, 3PG, and FAO models. After the establishment of an appropriate model for h, addressing the problem, it can be expected that the problem can be implemented for future forest management.

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References
[1] Vaz A S J P, and Lomba A H 2018 Effects arising from neglect of l, and, and implications for l, landscape management on tree diversity, and tree structure: Case study of pine replacement by eucalyptus plantations, Landsc. Urban Plan 185 pp 61–67
[2] Taylor C, Blair D, Keith H and Lindenmayer D 2019 Logging, and Climate Representative futures: Modeling water yields, Sci. Total Environ.
[3] Kumar I G K R and Kumar A 2020 Construction of Bidirectional Volume Tables for Eucalyptus Tereticornis: Case Study of the Middle Himalayan Region of Himachal Pradesh, Int. J. Bioresource Stress Manag 11(1) 046–050
[4] Maillard F 2019 Subterranean alteration for harvest residue processing practices in eucalyptus plantations: Case study of microbial enzymatic activity, and community-level physiological profile (CLPP) 78(2) 528–533
[5] D M S, andoal López M F Arturi A 2020 J. For. Res 31(2) pp 601–611
[6] R C Pinheiro et al 2019 Consequences for fertilizer practice are measured Distance from trunk, and depth of absorption of labeled nitrates for dominant, and oppressed trees in Brazil's Eucalyptus plantations, For. Ecol. Manage 447
[7] S Peleteiro L Penin J L Alonso V Santos, and J C Parajo 2019 Enzymatic hydrolysis, and selective fractionation of Eucalyptus nitens wood, "Cellulose 26(2) pp 1125–1139
[8] Tan and Sen 2020 Sep. Sci. Technol 55(6) pp 1036–1050
[9] L Vergütz D E McMahon S V I R da Silva Valadares, and R. B. Jackson 2019 Maintaining soil nutrient stock for several rounds in the Brazilian Eucalyptus plantatio, For. Ecol. Manage 448
[10] E C S de Freitas G E Marcatti, and H G 2019 Modeling productivity of eucalyptus using artificial neural networks Ind. Prod 146 pp 112149
[11] E Subhan Salampak A E Embang Masliani Y Ludang, and A Jaya 2019 Int. J. Adv. Res. Eng. Technol 11(1) pp 14–22
[12] M V Masson et al 2020 Gryllus assimilis (Orthoptera: Gryllidae), Bioecological aspects of cricket black field general case studies in the laboratory, and in the Eucalyptus (Myrtaceae) plantations, J. Res. (1) pp 83–89
[13] L J Gallego S Cardona V L A Rios Valencia E Martinez 2019 New method for process mass with the best torrefaction conditions, and balance: Torrefaction of eucalyptus tree residues, Sustain. Energy Technol. Assessments, 31
[14] Jonker M Junginger J G J Posada Faaij, and F van C S Ioiart A P C der Hilst 2019 Biofuels, Bioprod. Biorefining 13(4) pp 950–977
[15] J Dutra S A L Christoforo 2019 Investigations on sustainable honeycomb s, andwich panels containing Piassava, eucalyptus sawdust , and cement, *Journal International* 10

[16] K Sen J K Datta , and Mondal 2019 Optimization through response surface modeling: Glyphosate adsorption by charcoal mediated by Eucalyptus camaldulensis bark, *Journal International* 9

[17] V Alex, Andre et al 2019 Forest 44(2) pp 1115–1128.

[18] L D Tuffi-Santos F A O Tanaka S A dos Santos F de Á Rodrigues B F Sant’Anna-Santos, and A. C. Alfenas 2019 Pest. Manag. Sci 75(1) pp 53–62

[19] M Vale et al 2019 Substitution of diol derived from petroleum by biopoly in a continuous component polyurethane foam, *J. Clean. Prod* 5

[20] S Chu et al 2019 Effects of planting native tree species that are rich in benefits on sediments, surface runoff, and nutrients in eucalyptus plantations in southern China, *Sci. Total Environ* 675

[21] M Voigtlaender et al 2018 Nitrogen turnover in single , and mixed species plantations: Case Study of Acacia mangium , and Eucalyptus in 4 locations in Brazil,” *For. Ecol. Manage* 436 pp 56–67

[22] Medauar S 2020 To identify vegetative forces , and measure the area occupied by eucalyptus shoots after weeding chemicals by using unmanned aerial vehicles in the state of Bahia, Brazil *Agric 171*

[23] P C Sentelhas E F Ellí C H de R L Carneiro Freitas , and C A Alvares 2019 Structural , and performance of Eucalyptus simulation models for estimation of results 450 pp 117

[24] H F Scolforo J P McTague H Burkhart J Roise O Campoe, and J L Stape 2019 *For. Ecol. Manage* 432 pp 1–16

[25] J V N Carrijo et al 2019 The growth, and production modeling of individual trees of Eucalyptus urophylla plantations,” *J. For. Res*

[26] P C Sentelhas E F Ellí de Freitas R L C H Carneiro, and Alvares 2019 451 p 117464

[27] M Tabatabaei majd G Bahlakeh A Dehghani B Ramezanadeh , and M Ramezanadeh 2019 *J. Mol. Liq* 294 p 11155

[28] C H Salinas C A Chávez N PérezPeña H Vargas , and R A Ananías 2020 *Wood Sci. Technol* 54(1) pp 187–201

[29] C Alegria N Pedro M do Carmo Horta N Roque , and P Fern, andez 2018 *For. Ecol. Manage* 432 pp 327–344

[30] D R M Caldeira et al 2019 Multisite evaluation of the 3-PG model for the highest phenotypic plasticity Eucalyptus clone in Brazil, *For. Ecol. Manage* 462 p 117989

[31] Misran E, Sarah M, Irvan, Dina SF, Harahap SAA, and Nazar A 2020 *IOP Conf. Ser.: Journal of Physics* 1542(1) 012068

[32] Ginting MHS, Irvan, Misran E, Maulina S. 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* 801(1) 012045

[33] Sidabutar R, Trisakti B, Husin A, Irvan 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* 801(1) 012053

[34] Irvan, Suharmanto A, Sidabutar R, Ashari M 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* 801(1) 012127

[35] Haryani N, Harahap H, Taslim, Irvan 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* 801(1) 012051