

Vegetation Analysis of Tree and Pole Community as Part of Succession in Turgo Hill, Yogyakarta

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Submitted December 24th 2023 and Accepted February 24th 2024


Abstract

Vegetation analysis is the primary method of ascertaining the structure of the vegetation. This paper aims to analyze the diversity of tree and pole found on Turgo Hill, Sleman Regency, Yogyakarta Special Region following primary succession due to Mount Merapi eruption. Data collection was conducted by sampling plots with a total of 16 sampling plots consisting of 8 plots of 20x20m for trees and 8 plots of 10x10m for poles. A total of 91 individuals composed of 60 trees and 31 poles, were observed in the sampling area. Based on Importance Value (IV), the most dominant tree species is *Swietenia mahagoni* (IV 116,38%), followed by *Artocarpus heteropyllus* (IV 32,7%), and *Meiopsis eminii* (IV 24,12%). The most dominant pole species is *Swietenia mahagoni* (IV 60,78%) followed by *Durio zibenthilus* (IV 37.16%) and *Albizia chinensis* (IV 36.38%). It can be concluded that *Swietenia mahagoni* is the most dominated tree and pole species.

Keywords: Merapi, Pole, Succesion, Tree, Vegetation



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 <https://doi.org/10.36987/jpbn.v10i1.5330>

INTRODUCTION

The Indonesian archipelago's insular ecosystems, including the Java island, have developed many endemic species over time (Irl et al., 2019). These species once roamed the vast rain forests of Java; however, with the onset of industrialized human development, the natural habitat of the endemic Javanese species has dwindled with the receding forests. This habitat loss has led to the endangerment and extinction of certain significant species, such as the Java tiger (*Panthera tigris sondaica*) and recently the Java stingray (*Urolophus javanicus*) and the classification of others as critically endangered (Higginbottom et al., 2019). The loss of these species and conservational

efforts led to the establishment of nature reserves, usually set up around unique geological formations, such as Mount Merapi, Mount Gede Pang Rango, and Mount Sanggabuwana National Parks (Higginbottom et al., 2019). The rugged mountain terrain of these mountains has created ecological islands within the insular ecology of Java. From the search, plant types with high ethnobotanical index values have been highly researched for their bioassay content.

Mount Merapi National Park, located at the northernmost point of Sleman Regency within the Yogyakarta Special Region, is a unique opportunity to study the ecology of lifeforms living around the foothills of an active volcano. Considered to be Indonesia's most active volcano, it has erupted every roughly five years with some regularity since the 16th century, with the last major eruption in 2010 (Nakada et al., 2019) following the last significant eruption Mount Merapi undergoes by daily phreatic eruptions. The frequent lahars and volcanic pyroclastic density currents flowing the slope of Mount Merapi create mass devastation and often wipe out all life forms in its wake, creating the conditions necessary for primary succession, the re-establishment of lifeforms, and the complex interspecific species affiliation inherent to a healthy ecosystem (Irl et al., 2019).

Located on the southern edge of Mount Merapi National Park, Turgo Hill is of particular note due to the primary ecological succession following the 1994 and 2010 eruptions of Mount Merapi (Sutomo 2018; Sutomo et al., 2011). These significant eruptions completely wiped out the preexisting ecosystem, followed by a restart by primary succession (Haryadi et al., 2019). The changed environment and climate gradually influence the process of ecological succession until the ecological system achieves a stable condition known as the climax (Sutomo et al., 2011; Wijayani et al., 2019).

Vegetative analysis is necessary to study the progress and development of succession. Vegetative analysis is the systematic quantitative study of the composition and structure of vegetative communities within a particular area (Figueira-Branco et al., 2019; Haryadi et al., 2019; Joshi, Chhetri, & Yadav, 2019). The community, in turn, is influenced by environmental factors such as ground and air temperature, pH levels, and humidity. These factors are critical to those areas that are geologically active (Hidayat, 2018). The vegetative structure is the vertical composition, distribution, and layering of plants and other life forms (Santhyami et al., 2021, Roziaty & Pristiwi, 2020). Special note is given to the type, diameter, and height of individual plants to provide a comprehensive picture of the community (Sutomo et al., 2011).

Vegetative density, expressed in percentages, is the number of individual plants within a specified area. Vegetative density influences the characteristics and development of the community (Hartini et al., 2022). Species dominance, demonstrated by a high relative density of the species, is the ability to influence the species within the community, thus controlling the area (Wijayani et al., 2019). In the interest of conservation and monitoring the development of the Turgo Hill ecosystem, it is, therefore, necessary to conduct periodic studies into vegetative diversity, density, dominance, and spread. For these reasons, the authors aim to study the necessary vegetative structure and species domination of the tree and pole community of Turgo Hill, Sleman Regency, Yogyakarta Special Region, post-primary succession.

METHOD

Study area

The research was carried out in the village of Turgo, located in the Purwobinangun Subdistrict of Sleman Regency. More particularly, the study took place at the base of Turgo Hill, with coordinates $S07^{\circ}35.285' E110^{\circ}25.337'$ (Figure 1). The research period spanned from December 2022 to February 2023. Turgo Hill is a little basaltic elevation situated on the southern inclines of Mount Merapi, a live volcano. In ecological terms, this area is classified as a submontane rainforest and is part of the Western Javanese Rainforest Ecoregion. It has a tropical monsoon climate, with temperatures ranging from 21°C to 24°C . The average humidity observed for this study was 83%. The northern portion of the hill is encompassed within the boundaries of the Merapi National Park, situated at coordinates $S07^{\circ}35.285'E110^{\circ}25.337'$ (Setyawan & Aminatun, 2018).

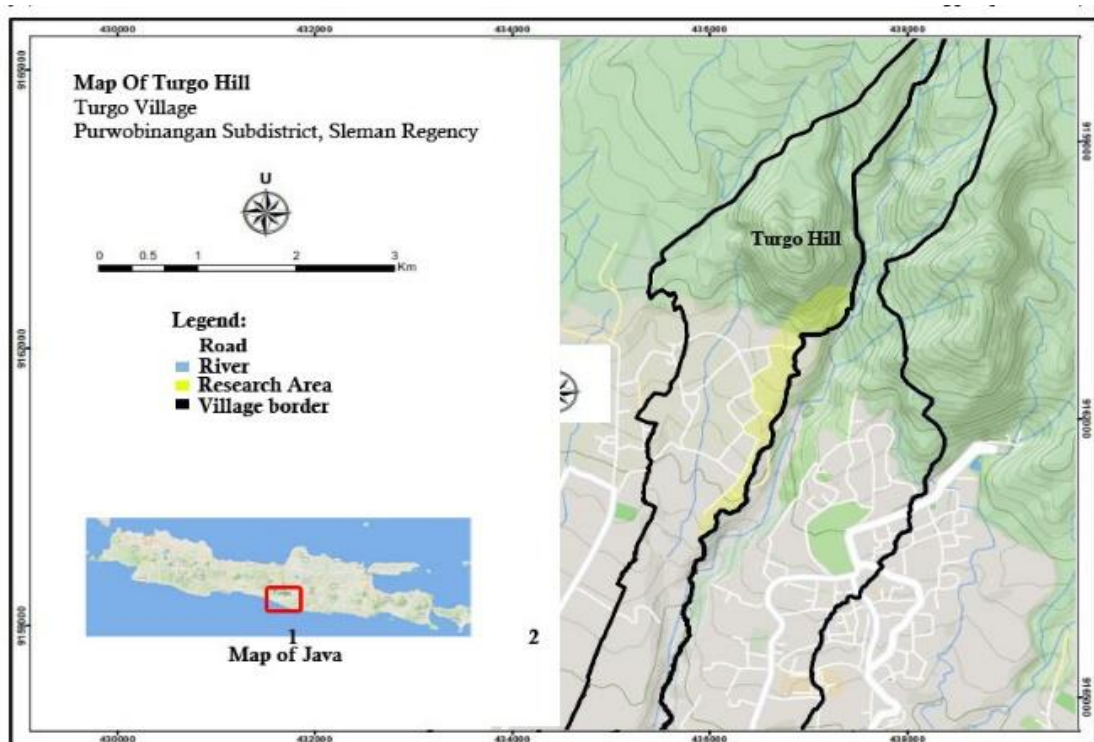


Figure 1. Research location

Method

After initial discussion and obtaining authorization from the local administration and permission from the Merapi National Park Authorities, surveys were carried out to delineate the research area and construct sampling sites. There was a total of eight sampling plots that were marked out. Each plot was $20\text{m} \times 20\text{m}$ and was used for trees. Additionally, there were eight sampling plots that measured $10\text{m} \times 10\text{m}$ and were specifically used for poles. A tree is a botanical organism that is considered fully mature when it reaches a diameter of 20 cm or larger. A pole is a young tree that typically measures between 10 cm and just under 20 cm in height.

Measurements were taken for the diameters of all trees and poles at breast height (dbh). The identification, categorization, and subsequent analysis were conducted in the Biology Laboratory of the Faculty of Teacher Training and Education at Universitas Muhammadiyah Surakarta.

Analysis

Following identification and classification of taxonomic data, further quantitative analysis was conducted to ascertain the components of vegetative analysis which include the following indexes: Relative Species Density (RD), Relative Species Dominance (RDo), Relative Species Frequency (RF) and Importance Value (IV) (Mueller-Dombois et al., 2016).

RESULT AND DISCUSSION

Tree community

The Turgo hill has experienced several substantial eruptions of Mount Merapi, with the most recent large eruption taking place in 2010 (Sadono et al., 2017). The most recent volcanic explosion on Turgo Hill resulted in the complete extinction of all living organisms and established the requisite circumstances for primary succession. Subsequently, there has been a restoration of the ecological system, reaching a state of ecological climax (Jinarto, 2023; Vaverková et al., 2019). The data obtained from field observations reveals the presence of 61 distinct trees distributed over the eight sampling plots. The vegetative analysis of these individual specimens is provided in table 1, including the Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), and Importance Value (IV) (Figueira-Branco et al., 2019; Sutomo et al., 2011).

Tabel 1. Tree community of Turgo Hill Sleman, Yogyakarta

| Local Name | Scientific Name | D | RD (%) | RF (%) | RDo (%) | IV (%) |
|-------------|---------------------------------|-----------|------------|------------|------------|------------|
| Sengon | <i>Albizia chinensis</i> | 3 | 5.00 | 8.69 | 4.57 | 18.26 |
| Nangka | <i>Artocarpus heterophyllus</i> | 5 | 8.33 | 13.03 | 11.34 | 32.70 |
| Mahoni | <i>Swietenia mahagoni</i> | 30 | 50.00 | 17.39 | 48.99 | 116.38 |
| Awar-awar | <i>Ficus septica</i> | 1 | 1.67 | 4.35 | 1.17 | 7.19 |
| Damar | <i>Agathis dammara</i> | 1 | 1.67 | 4.35 | 2.18 | 8.20 |
| Melinjo | <i>Gnetum Gnetum</i> | 1 | 1.67 | 4.35 | 0.98 | 7.00 |
| Durian | <i>Durio zibethinus</i> | 1 | 1.67 | 4.35 | 1.11 | 7.13 |
| Akasia | <i>Acacia mangium</i> | 5 | 8.33 | 4.35 | 6.96 | 19.64 |
| Lamtoro | <i>Leucaena leucocephala</i> | 2 | 3.31 | 8.69 | 2.11 | 14.11 |
| Vismia | <i>Vismia baccivera</i> | 1 | 1.67 | 4.35 | 1.01 | 7.03 |
| Hinau | <i>Elaeocarpus dentatus</i> | 1 | 1.67 | 4.35 | 0.98 | 7.00 |
| Pucuk Merah | <i>Syzygium paniculatum</i> | 1 | 1.67 | 4.35 | 1.01 | 7.03 |
| Ketapang | <i>Terminalia catappa</i> | 1 | 1.67 | 4.35 | 1.50 | 7.52 |
| Waru | <i>Hibiscus tiliaceus</i> | 1 | 1.67 | 4.35 | 1.39 | 7.41 |
| Trembelu | <i>Meiopsis eminii</i> | 5 | 8.33 | 4.35 | 11.44 | 24.12 |
| Alangium | <i>Alangium Chinenses</i> | 1 | 1.67 | 4.35 | 3.26 | 9.28 |
| Total | | 61 | 100 | 100 | 100 | 300 |

The sampling areas contained 61 tree individuals of the following species: sengon (*Albizia Chinenses*), nangka (*Artocarpus heterophyllus*), mahoni (*Swietenia mahagoni*), awar-awar (*Ficus septica*), damar (*Agathis dammara*), melinjo (*Gnetum Gnemon*), durian (*Durio zibethinus*), akasia (*Acacia mangium*), lamtoro (*Leucaena leucocephala*), vismia (*Vismia baccivera L*), hinau (*Elaeocarpus dentatus*), pucuk merah (*Syzygium paniculatum*), ketapang (*Terminalia catappa*), waru (*Hibiscus tiliaceus*), trembelu (*Meiopsis eminii*), dan alangium (*Alangium Chinenses*).

Table 1 illustrates that *Swietenia mahagoni* exhibited the maximum number of individuals (30 individuals), resulting in the highest relative density (50%) (RD). This species exhibits the highest RF value, indicating an equitable distribution of mahogany trees, and also has the highest RDo value, signifying the most basal area cover in comparison to other species. Given that *Swietenia mahagoni* is not indigenous to Java, it suggests that this species has the ability to quickly adjust and establish itself in the region during the initial stages of ecological succession. The swift establishment of an invasive species may have detrimental effects on natural selection and the biodiversity during the early stages of ecological succession (Lopez et al., 2019; Susilowati et al., 2020).

A species's importance value (IV) reflects its dominance within a community. The IV is calculated by adding the relative density, base area, and relative frequency (Fajri & Garsetiasih, 2019; Joshi et al., 2019). It is also evident from Table 1 that the importance value of *Swietenia mahagoni* (116.38%) is much higher than all other species, demonstrating the dominance of the species. Although the species with the highest IV may not always have the highest density (Susilowati et al., 2023; Turkyilmaz et al., 2023), *Swietenia mahagoni* is also shown to have the highest density within the sampling areas. The species with the second highest IV is *Artocarpus Heteropyllus* (32.70%), followed by *Meiopsis eminii* (24.12%). The species with the lowest IV are *Elaeocarpus dentatus* (7%) and *Gnetum Gnemon* (7%). Various environmental factors such as air, water, and light scarcity; humidity and ground temperature; and human intervention such as pruning, clearing, burning, and the introduction of exotic or invasive species have the potential to change the community composition and structure over time (Hartini et al., 2022).

Pole community

Data collected from field observations demonstrate 31 individual poles spread throughout the 8 sampling plots. The vegetative analysis, namely the Relative Density (RD), Relative Frequency (RF), relative dominance (RDo) and Importance Value (IV) (Figueira-Branco et al., 2019; Sutomo et al., 2011) of these individual specimens are described in table 2.

Table 2 described the 31 pole individuals observed in the field. These poles are divided into 13 species including: nangka (*Artocarpus Heteropyllus*), damar (*Agathis dammara*), mahoni (*Swietenia mahagoni*), kopi (*Coffea arabica*), durian (*Durio zibenthinus*), alpukat (*Persea americana*), puring (*Codiaeum variegatum*), sengon (*Albizia chinensis*), asam duku (*Dacryodes rostrata*), takalis (*Pentace laxiflora*), lubang tikus (*Myoporum laetum*), cacao (*Theobroma cacao*), dan kelengkeng (*Dimocarpus longan*). As with the tree community, *Swietenia mahagoni* dominates (756.31) the pole community and is also the

densest pole population (22.58%) with the highest relative frequencies (20%). It is noted that the tree community is considered normal with a higher number of poles compared to adult trees (Sutomo et al., 2011). *Swietenia mahagoni* dominates the pole community with the highest IV (60.78%), followed by *Durio zibenthilus* (37.16%) and *Albizia chinensis* (37.16%). The lowest IV was *Codiaeum variegatum* (8.23%).

Tabel 2. Pole community of Turgo Hill Sleman, Yogyakarta

| Local Name | Scientific Name | N | RD (%) | FR (%) | DR (%) | IV (%) |
|--------------|--------------------------------|-----------|------------|------------|------------|------------|
| Nangka | <i>Artocarpus Heteropyllus</i> | 4 | 12.90 | 5.00 | 16.26 | 34.16 |
| Damar | <i>Agathis Dammara</i> | 2 | 6.45 | 5.00 | 9.56 | 21.01 |
| Mahoni | <i>Swietenia mahagoni</i> | 7 | 22.58 | 20.00 | 18.20 | 60.78 |
| Kopi | <i>Coffea arabica</i> | 1 | 3.23 | 5.00 | 3.53 | 11.76 |
| Durian | <i>Durio zibenthilus</i> | 1 | 3.23 | 5.00 | 28.93 | 37.16 |
| Alpukat | <i>Persea americana</i> | 2 | 6.45 | 10.00 | 8.00 | 24.45 |
| Puring | <i>Codiaeum variegatum</i> | 1 | 3.23 | 5.00 | 0.09 | 8.32 |
| Sengon | <i>Albizia chinensis</i> | 4 | 12.90 | 15.00 | 8.48 | 36.38 |
| Asam Duku | <i>Dacryodes rostrata</i> | 1 | 3.23 | 5.00 | 0.55 | 8.78 |
| Takalis | <i>Pentace laxiflora</i> | 2 | 6.45 | 10.00 | 0.88 | 17.33 |
| Lubang Tikus | <i>Myoporum laetum</i> | 1 | 3.23 | 5.00 | 2.76 | 10.99 |
| Cacao | <i>Theobroma cacao</i> | 4 | 12.90 | 5.00 | 1.90 | 19.80 |
| Kelengkeng | <i>Dimocarpus longan</i> | 1 | 3.23 | 5.00 | 0.85 | 9.07 |
| Total | | 31 | 100 | 100 | 100 | 300 |

The domination of *Swietenia mahagoni* in both the tree and pole communities can be considered a unique phenomenon because this species was not significant before the 2010 eruption. Although *Swietenia mahagoni* is an invasive species to the Javanese ecosystem, it is considered a pioneer species in its native environment of neotropical rainforests of the Neotropical (Joseph et al., 2022; Joseph et al., 2020; Villa-Galaviz et al., 2022). *Swietenia mahagoni* was not observed in the immediate aftermath of the 2010 eruption or within ten years, covered by Sutomo et al., (2023) It is noted that the previous dominant species was *Homalanthus giganteus*, locally known as *Waru Gunung*.

The drastic transformation of the tree community is due to secondary succession and human intervention. As was observed, the three most dominant species within the tree community: *Swietenia mahagoni*, *Artocarpus Heteropyllus*, and *Meiopsis eminii*; and, the three most dominant species within the pole community *Swietenia mahagoni*, *Durio zibenthilus*, and *Albizia chinensis* all have high economic value to the local villagers. It can be assumed that human intervention in the form of clearing and the introduction of invasive species has led to the eradication of the previously dominant species *Homalanthus giganteus* and the steep decline of other native species within the sampling locations (Qin et al., 2020; Susanto, 2019; Sutomo, 2018).

The eradication of native pioneer species is detrimental to the stability of the ecosystem as a whole. The concept of interspecific species affinity describes the preference of certain species to form strong bonds that either encourage or discourage the development of other species (Roziaty & Farisi, 2022). Species that show strong positive interspecific specific affinity are local pioneer species that share commensal relationships with other local species. It is assumed that the loss of pioneer species due

to human intervention is the cause of the loss of biodiversity post 2006 (Agnes et al., 2019; Sutomo et al., 2011). The loss of biodiversity noted by Kurniawan et al., (2020) following the 2010 Merapi eruption has been exacerbated by human intervention on the borders of the Merapi National Park, and includes the loss of species endemic to the Merapi montane rainforest previously observed on Turgo.

The loss of biodiversity due to primary succession exacerbated by human intervention can also be overserved in multiple locations (Aryani, 2017; Fernández-Palacios et al., 2021; Lavigne & Gunnell, 2006; Medd & Bower, 2019; Hidayah & Roziaty, 2022). The inevitability of local interventions within the nature reserves, nominally to forage for food and firewood, is allowed, but without further education and incentives, the large-scale destruction of unique ecological environments such as Turgo is inevitable, as was the case in Nevado de Toluca (González-Fernández et al., 2022).

CONCLUSION

To summarize, the vegetative environment of Turgo Hill exhibits a flourishing community of trees and poles, with *Swietenia mahagoni* being the dominant species. Despite the apparent vitality of the forest, characterized by a well-balanced distribution of poles and trees, it is worth mentioning that the specific species found in the Turgo area were intentionally imported due to commercial motivations. The decline in biodiversity on Turgo Hill, documented in 2006, occurred before the eruption of Mount Merapi in 2010, which subsequently led to a secondary succession event on Turgo Hill.

ACKNOWLEDGMENTS

We would like to acknowledge the village administration of Turgo and especially the Village Elder Mr. Misran for his support. We also thank Universitas Muhammadiyah Surakarta for funding and supporting this paper. We extend special acknowledgement to the students who served as enumerators for the duration of fieldwork as follows; Saraswati Anggraeni, Aflah Ikromi, Adhi Warsito, Fito Zuhud Abdillah, Duta Saksena Mahatama, Mumtaza Mandarasy, Herviana Yessykasari, Firma Aryanti, Siwi Pratiwi, Saila Nabila, and Hana Novitasari.

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How To Cite This Article, with APA style :

Santhyami, S., & Aryani, I. (2024). Vegetation Analysis of Tree and Pole Community as Part of Succession in Turgo Hill, Yogyakarta. *Jurnal Pembelajaran dan Biologi Nukleus*, 10(1), 63-73. <https://doi.org/10.36987/jpbn.v10i1.5330>

Conflict of interest : The authors declare that they have no conflicts of interest.

Author contributions : All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submitted by [Santhyami]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.