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BIODIVERSITY OF TREE SPECIES: COMPOSITION AND STRUCTURE IN RADEN SOERJO GRAND FOREST PARK, BATU, EAST JAVA, INDONESIA

BIODIVERSITAS SPESIES POHON: KOMPOSISI DAN STRUKTUR DI TAMAN HUTAN RAYA RADEN SOERJO, BATU, JAWA TIMUR, INDONESIA

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Abstract

Raden Soerjo Grand Forest Park is a conservation area in East Java with moderate tree diversity. This study analyzed the diversity, composition, and structure of trees in three vegetation types: open forest, closed forest, and post-fire forest. Data collection used a systematic sampling method with random start. Data in the form of tree species names and numbers of individuals were analyzed to determine the ecological index and Canonical Correspondence Analysis (CCA). A total of 25 species from 21 families were identified, with *Fagaceae* and *Lauraceae* dominating in open and closed forests, and *Casuarinaceae* in post-fire forest. *Lithocarpus sundaicus* showed the highest Importance Value Index in open and closed forests, while *Casuarina junghuhniana* dominated the post-fire forest. Pioneer species such as *Homalanthus populneus*, *Ficus hispida*, and *C. junghuhniana* were present in all vegetation types. The diversity index showed moderate diversity (1.79 and 2.09), low species richness (2.22 and 3.45), and high evenness (0.69 and 0.71) in open and closed forests. Tree distribution is dominated by the 61–80 cm diameter class in open and closed forests, and 41–60 cm in post-fire forests. CCA showed that light intensity, soil moisture, air temperature, and soil pH influence species distribution. Four species are endemic to Indonesia, with three species of conservation concern: *Lithocarpus korthalsii* and *Canthiumera glabra* (near threatened), and *Saurauia bracteosa* (vulnerable).

Keywords: *Casuarinaceae*; Conservation; Diversity indices; *Fagaceae*; *Lauraceae*

Abstrak

Taman Hutan Raya Raden Soerjo merupakan kawasan konservasi di Jawa Timur dengan keanekaragaman pohon dalam kategori sedang. Penelitian ini menganalisis keanekaragaman, komposisi, dan struktur pohon pada tiga vegetasi: terbuka, tertutup, dan pascakebakaran. Koleksi data menggunakan metode systematic sampling with random start. Data berupa nama spesies pohon dan jumlah individu dianalisis untuk menentukan indeks ekologi dan Analisis Korespondensi Kanonik (CCA). Sebanyak 25 spesies dari 21 famili teridentifikasi, Fagaceae dan Lauraceae mendominasi di vegetasi terbuka dan tertutup serta Casuarinaceae di vegetasi pascakebakaran. Lithocarpus sundaicus menunjukkan Indeks Nilai Penting tertinggi pada hutan terbuka dan tertutup, Casuarina junghuhniana mendominasi hutan pasca kebakaran. Spesies pionir seperti Homalanthus populneus, Ficus hispida, dan C. junghuhniana terdapat pada semua tipe vegetasi. Indeks keanekaragaman menunjukkan keanekaragaman sedang (1,79 dan 2,09), kekayaan spesies rendah (2,22 dan 3,45), dan kemerataan tinggi (0,69 dan 0,71) di hutan terbuka dan tertutup. Distribusi pohon didominasi oleh kelas diameter 61–80 cm di hutan terbuka dan tertutup, dan 41–60 cm di hutan pascakebakaran. CCA menunjukkan bahwa intensitas cahaya, kelembapan tanah, suhu udara, dan pH tanah memengaruhi distribusi spesies. Empat spesies endemik Indonesia, dengan tiga spesies yang menjadi perhatian konservasi: Lithocarpus korthalsii dan Canthiumera glabra (hampir terancam), dan Saurauia bracteosa (rentan).

Kata Kunci*: Casuarinaceae; Fagaceae; Indeks keanekaragaman; Konservasi; Lauraceae*

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INTRODUCTION

The trees are large, long-lived, woody plants. Trees provide food and habitat for other biota (Kozlowski & Song, 2022). Trees are a crucial component of a forest ecosystem. A forest is a land area larger than 0.5 ha with trees taller than five meters and more than 10% canopy cover (Food and Agriculture Organization (FAO), 2006). The tropical rainforest is an ecosystem in an area with high rainfall throughout the year, a warm climate, and is located around the equator (Dounias, 2018). Tropical rainforest vegetation types vary greatly depending on latitude, altitude, soil conditions, flooding, and climate (Poker & MacDicken, 2016). Mountain vegetation in Indonesia includes a range of types from lower montane (1,000–1,500 masl) to subalpine forests and snowy vegetation (4,884 masl) (Kartawinata, 2013; Kartawinata & Sudarmonowati, 2022).

Trees can lose their function due to climate change, selective logging, and alien species invasions (Garcia-Valdes et al., 2018; Jones et al., 2018; Liebhold et al., 2017). These factors can alter tree species composition, forest succession, biodiversity, nutrients, carbon, and water cycling, decreasing forest productivity (Liebhold et al., 2017). Tree species composition and abundance changes affect rainfall redistribution and hydrological processes and threaten faunal survival (Perez-Suarez et al., 2014; Costa et al., 2023). Reduced genetic diversity can increase susceptibility to pests and diseases, leading to mass tree mortality in the future (Marden et al., 2017). Therefore, trees are essential for the survival of living things.

The presence of trees in the forest is variably distributed across different vegetation types. The diversity of trees in each vegetation type has significant differences. This is caused by several factors, such as climatic conditions, soil type, topography, altitude, and interactions between organisms in the ecosystem (Webb, 1968). In addition, canopy cover is also a factor that can affect forest vegetation types (Siswo et al., 2023), as in research by Syaufina and Hamzah (2021) showed a significant change in tree species diversity from 24 species (unburned area) to 2 species (burned area) in Teluk Meranti, Pelalawan, Riau Province, Indonesia. Similar research was conducted by López-álvarez et al. (2021) in the Humid Mountain Forest in the protected natural area of La Martinica, Veracruz, Mexico, which recorded 37 species (24 families), with high diversity in closed canopies. In addition, research by Ubaekwe et al. (2024) on two canopy types in Omo Biosphere Reserve, Ogun State, Nigeria, found a total diversity of 64 species (22 families) in the open canopy and 56 species (21 families) in the closed canopy.

Raden Soerjo Forest Park (Tahura) is located in East Java Province, as a Protected Forest and Arjuno-Lalijiwo Nature Reserve Area (PHPA), consisting of two types of vegetation based on altitude, namely sub-mountain forest and mountain forest. This makes Tahura Raden Soerjo have a very abundant level of flora and fauna diversity. This region has conducted many studies on herbaceous plants (Respitosari et al., 2016), liana plants (Puspita et al., 2016), shrubs (Widiarti et al., 2017), *Pteridophyta* (Pranita et al., 2017), lichen (Fatma et al., 2017), orchids (Soetopo et al., 2021), *Lepidoptera* (Khoiri et al., 2023), and bamboo (Sa'diyah & Indah, 2024). The tree species that have been found in this area are 16, with the dominant species being *Trema orientale* and *Ficus virens* (Rahadiantoro, 2021), and the tree as an orchid host is *Engelhardia spicata* (Nusantara et al., 2017; Soetopo & Utami, 2020). Although Tahura Raden Soerjo is a conservation area, it still experiences unavoidable ecological disturbances, such as fires during the dry season, especially in 2023, when there were four incidents. Given the importance of Tahura Raden Soerjo and previous research, this study aims to analyze tree diversity, composition, and structure in three vegetation types: open forest, closed forest, and post-fire forest. The study's results can be used as important data and information to support biodiversity conservation efforts in Tahura Raden Soerjo. This is supported by the statement of Hossen et al. (2021) that tree structure and composition are one of the parameters in conservation forest ecosystem management.

MATERIALS AND METHODS

This research was conducted in Pasinan and Cangar areas, Tahura Raden Soerjo, Sumber Brantas Village, Bumiaji District, Batu City, East Java. Data collection locations were carried out in three vegetation types, namely open forest (coordinates 7°44'55.68"S, 112°32'44.41"E dan altitude

1,500–2,000 masl), closed forest (coordinates 7°44'48.86"S, 112°32'24.29"E and altitude 1,600–1,800 masl), and post-fire forest (coordinates 7°44'42.4"S, 112°32'54.0"E and altitude 1,900–2,100 masl) (Figure 1). Forest fires in the study area occurred approximately five months before data collection, namely August-September 2023. The post-fire area was characterized by highly open canopy cover, exposed soil, and numerous dead or damaged trees.

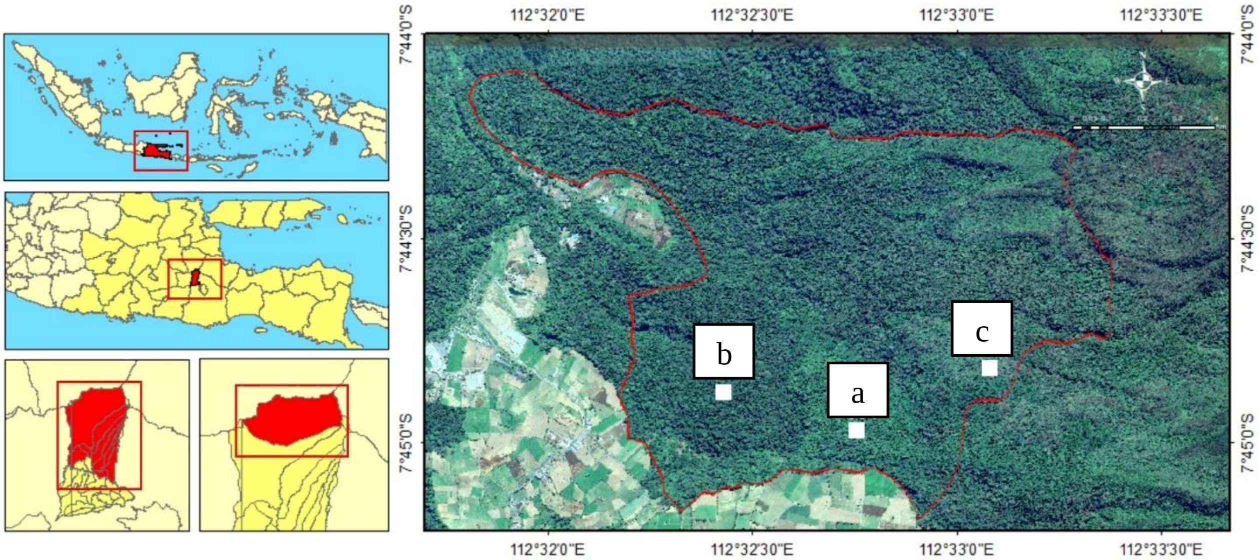

Figure 1. The research site was Tahura Raden Soerjo (Batu, East Java, Indonesia), open forest (a), closed forest (b), and post-fire forest (c)

Data collection of tree species was carried out using the systematic sampling method with random start, with a Sampling Intensity (IS) of 10% because the area is less than 1,000 ha (12 ha). This method systematically places measuring plots with the exact distance between measuring plots and determines the starting point using random numbers (Soerianegara & Indrawan, 2005). The number of observation plots was 30, with 10 plots for each vegetation type and a distance of 100 m between plots. The plot size for observation of tree species is 20 × 20 m, with a trunk diameter at breast height >20 cm (Soerianegara & Indrawan, 2005), using a soft tape measure 150 cm/60 inch. Environmental factors such as light intensity, soil moisture, and soil pH were measured using a 3 in 1 soil moisture tester; soil temperature using a soil thermometer with temperature range specifications: 0 + 100 C Div: 1 C; air temperature and humidity using a thermo-hygrometer model ST70TH. The data collected were the scientific names of species and the number of individuals. The identification of scientific names of trees used the references Steenis (2010), Backer and van den Brink (1965), and World Flora Online (WFO) (2024) Plant List (website: https://wfoplantlist.org/). Validation and updating of the latest scientific names refer to the Plants of the World Online (POWO) (2024). The conservation status of the species was checked on the International Union for Conservation of Nature's (IUCN) (2024) Red List of Threatened Species (website: https://www.iucnredlist.org/).

Data were analyzed using the Importance Value Index (IVI), a parameter that indicates the dominance of species in a vegetation community obtained from the values of density, relative density, frequency, relative frequency, dominance, and relative dominance (Nguyen et al., 2014). Several other ecological indices were used to describe the three vegetation types, including the Shannon-Wiener diversity index (H'), Margalef index (R), and evenness index (E), which refers to Magurran (2004). Canonical Correspondence Analysis (CCA) was used to show the relationship between tree species and environmental factors (Adel et al., 2014; Fatem et al., 2020) using the PAST 4.03 program.

RESULTS

In total, 21 families, 24 genera, and 25 species were found in the three vegetation types. In the open forest, 12 families with 13 species; in closed forest, 17 families with 19 species were obtained;

and in post-fire vegetation, only one family with one species was obtained. The open and closed forests were dominated by the *Fagaceae* family, but the closed forest was also dominated by the *Lauraceae* family, consisting of two species, and post-fire forests are dominated by the *Casuarinaceae* family (Figure 2).

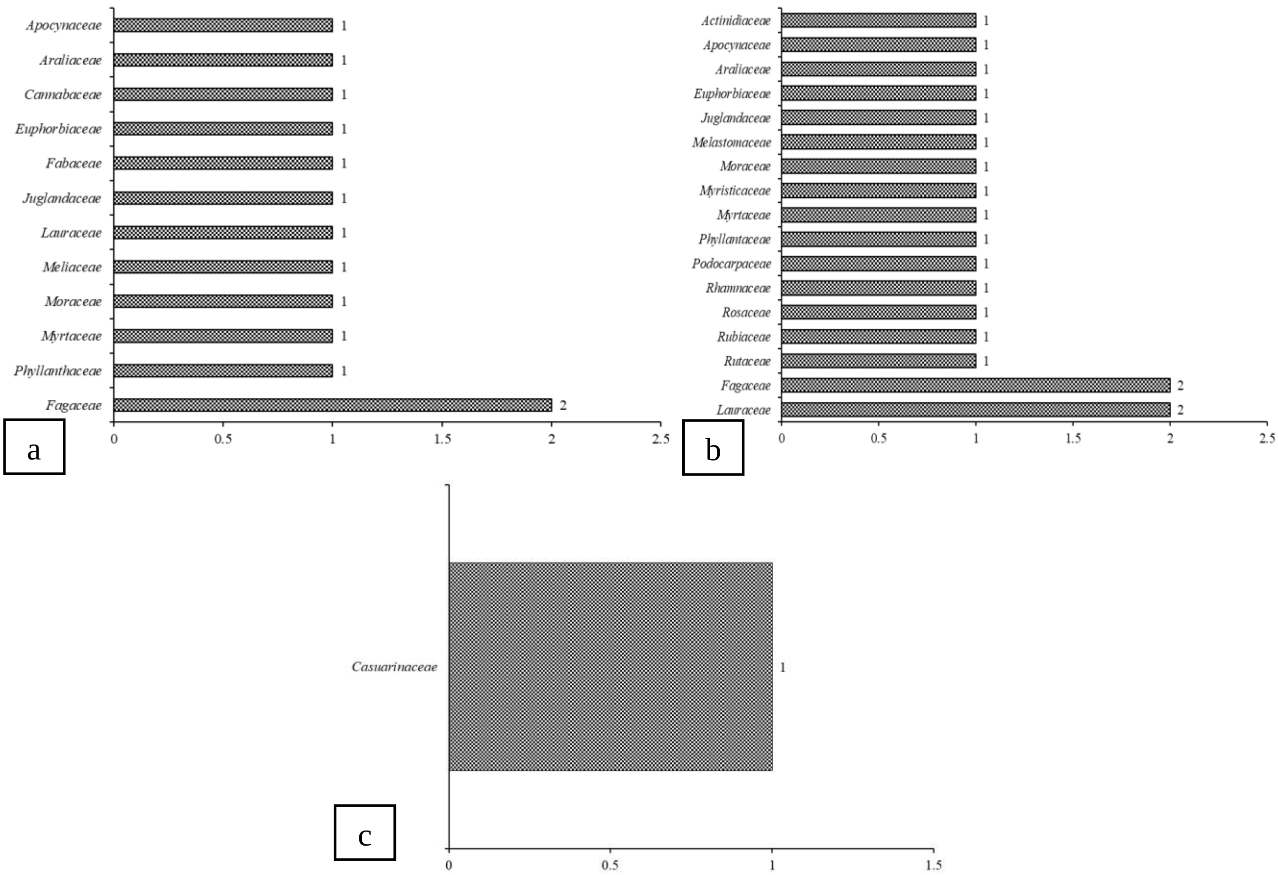

Figure 2. Number of species of each family in the three vegetation types in Tahura Raden Soerjo, open forest (a), closed forest (b), and post-fire forest (c)

Table 1. Five tree species have the highest IVI values in the three vegetation types

Vegetation types	Scientific name	Family	RD (%)	RF (%)	RDo (%)	IVI (%)
A	*Lithocarpus sundaicus* (Blume) Rehder	*Fagaceae*	25.68	17.54	32.88	76.11
	Engelhardia spicata Lechen ex Blume	*Juglandaceae*	1972	17.54	31.61	68.88
	Lithocarpus korthalsii (Endl.) Soepadmo	*Fagaceae*	21.55	14.03	22.97	58.56
	Homalanthus populneus (Geiseler) Kuntze	*Euphorbiacae*	11.46	8.77	4.66	24.90
	Litsea diversifolia Blume	*Lauraceae*	6.42	12.28	1.14	19.84
B	*Lithocarpus sundaicus* (Blume) Rehder	*Fagaceae*	22.40	16.12	31.50	70.03
	Engelhardia spicata Lechen ex Blume	*Juglandaceae*	18.03	16.12	25.96	60.13
	Lithocarpus korthalsii (Endl.) Soepadmo	*Fagaceae*	17.43	9.67	19.87	47.03
	Litsea diversifolia Blume	*Lauraceae*	14.20	12.90	8.07	35.18
	Ficus hispida L. f.	*Moraceae*	6.55	6.45	4.32	17.33
C	*Casuarina junghuhniana* Miq.	*Casuarinaceae*	100.00	100.00	100.00	300.00

Note: A= open forest; B= closed forest; C= post-fire forest; RD= relative density; RF= relative frequency; RDo= relative dominance; and IVI= importance value index

Based on the Importance Value Index, both in open and closed forests, there are four species in common, namely *Lithocarpus sundaicus*, *Engelhardia spicata*, *Lithocarpus korthalsii*, and *Litsea diversifolia* (Figure 3). The highest IVI values in the two vegetation types were *L. sundaicus* at 76.11% and 70.03%, *E. spicata* at 68.88% and 60.13%, and *L. korthalsii* at 58.56% and 47.03%. However, in the open forest, the relative density values are not sequential, with *E. spicata* having a smaller relative density value than *L. korthalsii* at 19.72%. In the post-fire forest, *C. junghuhniana* has the value of relative density, relative frequency, and relative dominance reaching the maximum, so the IVI value is 300% (Table 1).

Figure 3. Tree species with the highest IVI values in forest vegetation in Tahura Raden Soerjo, *Lithocarpus sundaicus* (a), *Engelhardia spicata* (b), *Lithocarpus korthalsii* (c), *Litsea diversifolia* (d), and *Casuarina junghuhniana* (e)

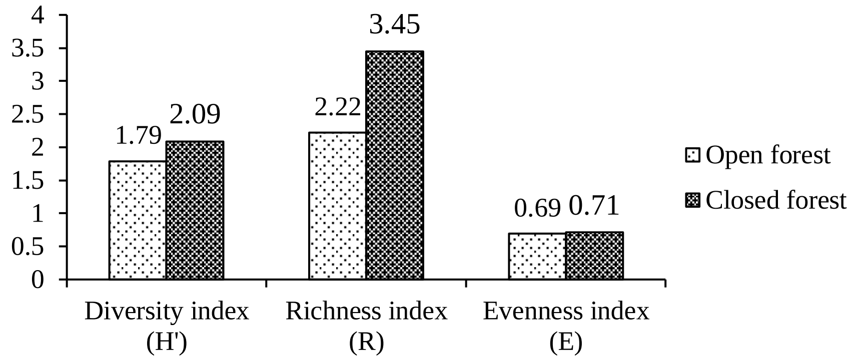

Figure 4. Diversity, richness, and evenness index values of species in two vegetation types of Tahura Raden Soerjo

Based on Figure 4, diversity index values in open and closed forests were 1.79 and 2.09, the species richness index values were 2.22 and 3.45, and the value of the species evenness index was 0.69 and 0.71. Based on Figure 5, the distribution of diameter classes is divided into four groups, from 20–40 cm to 80–100 cm. The diameter class of trees in the open and closed forests is dominated by 61–80 cm diameter, while in the post-fire forest, it is dominated by 41–60 cm diameter. In the open forest, the number of trees decreased dramatically in the large diameter class (81–100 cm), while in the closed forest, the number of trees decreased markedly in the small diameter class (20–40 cm).

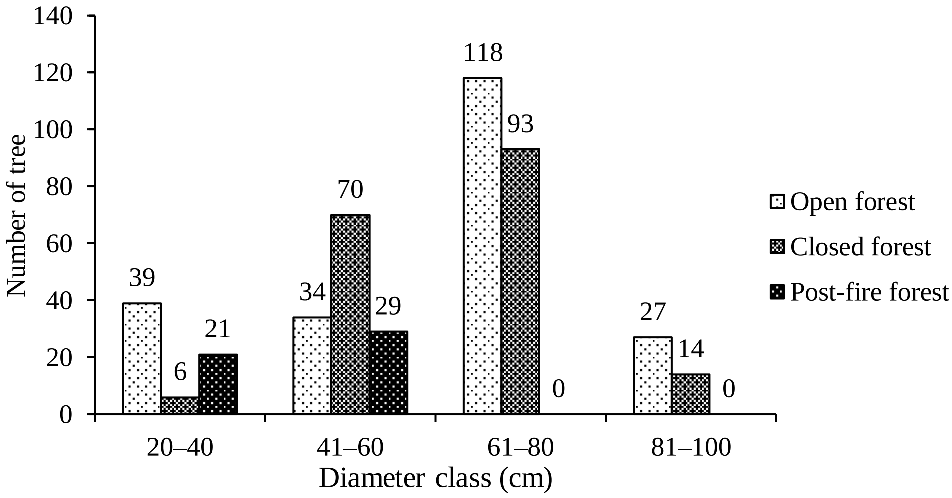

Figure 5. Distribution of tree diameter class in three vegetation types in Tahura Raden Soerjo

Table 2. Eigenvalue and percentages of Canonical Correspondence Analysis (CCA) results in three vegetations in Tahura Raden Soerjo

Axis	Eigenvalue	%
1	0.9256	82.76
2	0.19276	17.24

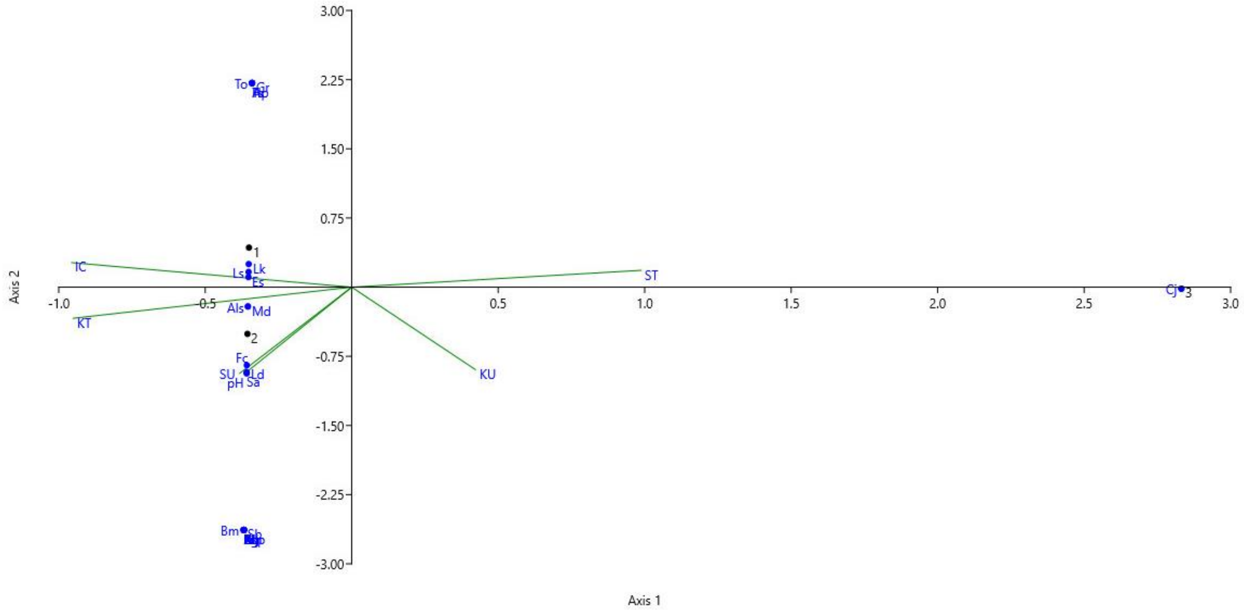

Figure 6. Result of Canonical Correspondence Analysis (CCA) analysis in three vegetations. 1= open forest; 2= closed forest, and 3= post-fire forest. IC= light intensity; KT= soil moisture; ST= soil temperature; KU= air humidity; SU= air temperature; and pH= soil pH

Table 3. Conservation status of tree species in the three vegetation types in Tahura Raden Soerjo

Scientific name	Family	Vegetation types	IUCN status
Lithocarpus sundaicus (Blume) Rehder	*Fagaceae*	A, B	LC
Lithocarpus korthalsii (Endl.) Soepadmo	*Fagaceae*	A, B	NT
Engelhardia spicata Lechen ex Blume	*Juglandaceae*	A, B	LC
Casuarina junghuhniana Miq.	*Casuarinaceae*	C	LC
Toona Sureni (Blume) Merr.	*Meliaceae*	A	LC
Albizia chinensis (Osbeck) Merr.	*Fabaceae*	A	LC
Ficus hispida L. f.	*Moraceae*	A, B	LC
Machilus rimosus (Blume) Blume	*Lauraceae*	B	N.A
Litsea diversifolia Blume	*Lauraceae*	A, B	LC
Syzygium acuminatissimum (Blume) DC.	*Myrtaceae*	A, B	LC
Ziziphus sp.	*Rhamnaceae*	B	N.A
Alstonia scholaris (L.) R.Br.	*Apocynaceae*	A, B	LC
Melicope latifolia (DC.) T.G.Hartley	*Rutaceae*	B	LC
Homalanthus populneus (Geiseler) Kuntze	*Euphorbiaceae*	A	LC
Trema orientale (L.) Blume	*Cannabaceae*	A	LC
Glochidion rubrum Blume	*Phyllanthaceae*	A	LC
Podocarpus neriifolius D.Don	*Podocarpaceae*	B	LC
Canthiumera glabra (Blume) K.M.Wong & Mahyuni	*Rubiaceae*	B	NT
Astronia spectabilis Blume	*Melastomaceae*	B	N.A
Prunus grisea (Blume ex Mull.Berol.) Kalkman	*Rosaceae*	B	LC
Knema globularia (Lam.) Warb.	*Myristicaceae*	B	LC
Claoxylon longifolium (Blume) Endl. Ex Hassk.	*Euphorbiaceae*	B	LC
Breynia microphylla (Kurz ex Teijsm. & Binn.) Mull.Arg.	*Phyllanthaceae*	B	LC
Saurauia bracteosa DC.	*Actinidiaceae*	B	VU
Macropanax dispermus (Blume) Kuntze	*Araliaceae*	A, B	LC

Note: A= open forest; B= closed forest; and C= post-fire forest. LC= least concern; NT= near threatened; VU= vulnerable; N.A= not available

Based on the Canonical Correspondence Analysis (CCA) results it showed a variation of 82.76% on the first axis (Axis 1) and 17.24% on the second axis (Axis 2) (Table 2). In the open forests, there is a relatively close relationship between light intensity and some soil moisture. In contrast, in the closed forests, there is a closer relationship between air temperature and soil pH. In the post-fire forests, there is a close relationship with soil temperature. Species affected by these factors, exceptionally light intensity, were *L. sundaicus* (Ls), *L. korthalsii* (Lk), and *E. spicata* (Es). The presence of *Alstonia scholaris* (Als) and *Macropanax dispermus* (Md) species is influenced by soil moisture. The presence of *Litsea diversifolia* (Ld), *Ficus hispida* (Fc), and *Syzygium acuminatissimum* (Sa) is influenced by air temperature and soil pH (Figure 6).

Based on the origin of the distribution of trees on the Plants of the World Online site, four tree species are only found on several islands in Indonesia, namely *L. korthalsii*, native to Java and Sumatra; *C. junghuhniana*, native to Java to the Lesser Sunda Islands; *Astronia spectabilis*, native to Java to the Lesser Sunda Islands, and *Breynia microphylla*, native to Northern Sumatra, Java to the Lesser Sunda Islands, and Southern Sulawesi. These four species are only native to Indonesia and can, therefore, be categorized as Indonesian endemic trees.

Based on Table 3, 22 species were identified with conservation status on the IUCN Red List of Threatened Species. The status of Least Concern (LC) species totalled 13 species; two Near Threatened (NT) species were *L. korthalsii* (open and closed forests) and *Canthiumera glabra* (closed forest), and one Vulnerable (VU) species was only found in closed forest, *Saurauia bracteosa*.

DISCUSSION

The *Fagaceae* and *Lauraceae* family in this study was found at around 1,500–2,000 masl. *Fagaceae* in Indonesia can grow at altitudes of more than 1,500 masl (Purwaningsih & Polosakan, 2016). *Fagaceae* commonly grow in tropical montane rainforests and are considered an essential component of montane forests (700–1,500 masl, especially 1,200–1,500 masl) in Malaya (Whitmore, 1988; Whitmore, 1990). According to Fadhila et al. (2023), members of the *Lauraceae* family are distributed in all altitude ranges of 1,400–1,700 masl. This family also has an important role ecologically and economically (Giraldo-Kalil et al., 2023). *Lauraceae* species can thrive in areas that have experienced significant deforestation and land use (Alkishe et al., 2022). The *Fagaceae* and *Lauraceae* families dominate the tree composition, one of the characteristics of the montane rainforest (Culmsee et al., 2011). The *Casuarinaceae* family in this study was found at of around 1,900–2,100 masl. *Casuarinaceae* (*C. junghuhniana*) in Southeast Asia can grow at altitudes ranging from 550–3,100 masl (Khairunnisa et al., 2023). According to Rahardi et al. (2020), this species in Indonesia grows in highland areas at altitudes between 2,000–3,000 masl.

The important value index in open, closed, and post-fire forests indicates that these species dominate the forest community in Tahura Raden Soerjo and have adapted well to the surrounding environmental conditions. According to Hou et al. (2023), a high IVI value indicates the dominance of species in a forest area. In addition, a high IVI value proves that the species grows according to the habitat, thus successfully adapting to the local environment (Lillo et al., 2024; Solfiyeni et al., 2024a). *Lithocarpus sundaicus* and *Engelhardia spicata* had the highest IVI values in open and closed forests because both were found in almost every observation plot. The *Lithocarpus* genus dominates in the tropics and at higher latitudes, although it is not freezing-resistant (Chen et al., 2020). According to Hidayat et al. (2022), *L. sundaicus* includes climax trees in natural forests. This is supported by the statement of Solfiyeni et al. (2024b) that species with high IVI values should consist of climax trees because they play an essential role in maintaining the structural integrity of the ecosystem. *E. spicata* can control environmental temperature (Senoputri et al., 2016), so it can grow in open and closed forests. This species is mainly found in primary forests and rarely in secondary forests (Kozlowski et al., 2018). Meanwhile, *C. junghuhniana* had the highest IVI value in post-fire forests because only one tree species covered the area. This is due to its ability to grow in dry and semi-dry regions, supported by genetic diversity and high heritability of growth and quality traits, especially branch thickness (Garg et al., 2022; 2024). *Casuarina junghuhniana* can grow in dry and nitrogen-deficient environments, especially at high altitudes (Golam & Araki, 2010). According to

Eze and Ahonsi (1993), this species is essential for conservation efforts as it is a unique and distinct lineage. According to Gojamme (2024), the composition and species in a community are influenced by several environmental factors.

Based on several species with high IVI values in three vegetation types, which contained pioneer species, namely *Homalanthus populneus*, *Ficus hispida*, and *C. junghuhniana*. Pioneer plants show that they can adapt to disturbed environmental conditions. Pioneer plants can be associated with Plant Growth Promoting Rhizobacteria, allowing them to survive and adapt to degraded habitats (Andriani et al., 2019). The presence of pioneer species in this study was caused by low canopy cover and human activity, namely, tree felling. According to Rahayu et al. (2017) and Silvestrini et al. (2015), the growth of pioneer species is caused by low canopy cover and human disturbances that can affect genetic diversity and structure. *Homalanthus populneus* is typically found in lowlands to highlands at elevations of about 2,000 masl, as well as logged-over woods, secondary forests, and riparian forests. Only open spaces and occasionally open areas of intact woods are home to populations of the genus (Zuhud et al., 2013). *Ficus hispida* is not only found in open forests but also in closed forests. The *Ficus* genus grows in nearly every vegetation type, including rocky regions, primary or secondary forests, and wet or dry ground (Hendrayana et al., 2019). This genus can grow in tropical and subtropical areas and is essential for fruit-eating animals, so it is considered a critical species in tropical forests (Shi et al., 2018). This genus, referred to as the ‘fig’, can survive in a wide range of habitats and plays a vital role in ecological restoration due to the density and diversity of its saplings being twice that of other genera (Hendrayana et al., 2019). *Casuarina junghuhniana* is found in post-fire forests with open, extreme environmental conditions and dry soil due to fire. According to Yulianto et al. (2019), this species has a high tolerance to areas that lack oxygen, so it can grow in dry areas. The *Casuarina* clan associates with ectomycorrhizal and endomycorrhizal fungi and can fix nitrogen through an endosymbiotic relationship with *Frankia Actinomycetes* (Luechanimitchit et al., 2017).

The diversity index of trees in open and closed forests was moderate, indicating that species diversity is abundant and abundance is relatively evenly distributed. Other studies also showed similar diversity indices in Medha Kachapia National Park, Cox's Bazar, Bangladesh (1.16) (Uddin et al., 2020), unburned areas in Teluk Meranti, Pelalawan, Riau, Indonesia (2.86) (Syaufina & Hamzah, 2021), and Bung Hatta Grand Forest Park, West Sumatra, Indonesia (2.32) (Solfiyeni et al., 2024b). According to Solfiyeni et al. (2024b), the diversity index describes species diversity in a vegetation community. The higher the diversity index value, the more diverse the species in a community tends to be, and the more stable it is. Species diversity indicates that a species can survive environmental changes (Rahman et al., 2023).

The number of species in open forests was less than in closed forests. In some observation plots, human activities disturb the forest ecosystem, namely, tree felling. According to Oktavia et al. (2021), changes in diversity can occur due to natural or human processes. Only one species was in the post-fire forest, indicating a low diversity index due to forest fires. Wildlife poaching caused the fire, and this vegetation had the worst disturbance compared to the other two. According to Syaufina and Hamzah (2021), sites that experience high-severity disturbance and low recovery have a slow response to seed conditions and environmental factors. This is supported by Chang and Turner's (2019) statement that the severity of disturbance drives the level of community change and the various mechanisms that mediate community dynamics. Recurrent fires can be a threat that results in the decline of forest ecosystems, loss of biodiversity, and significant amounts of carbon emissions (Dohong et al., 2017).

The richness index in open and closed forests was low, indicating that some species are more abundant than others. Other studies have higher values in East Kalimantan, Indonesia (6.09) (Karmini et al., 2021), Mertelu Purba Nature Reserve, North Sumatra, Indonesia (4.5) (Rangkuti et al., 2023), and Batam Island, Indonesia (7.09) (Susilowati et al., 2024). According to Khumbongmayun et al. (2005), species richness is one of the parameters in determining an area's importance for biodiversity conservation.

The evenness index in open and closed forests was high, indicating that individuals' distribution between species is relatively even. Similar research was also found in Fakim Wildlife Sanctuary, Nagaland, Northeast India (0.92) (Ao et al., 2020) and Gunung Gede Pangrango National Park, West Java, Indonesia (0.82–0.85) (Sadili et al., 2023). According to de Mazancourt et al. (2013), there is a high correlation between the stability of the associated community and tree evenness and diversity. Numerous individuals and varying natural forest components govern species evenness and plant community improvement (Susilowati et al., 2021).

Based on Figure 5, the decrease in the number of large-diameter trees in open vegetation is due to tree felling. This is in line with the research of Hossen et al. (2021), where the number of species and individuals decreases with increasing diameter and vice versa. An increase in the diameter class indicates the successful recruitment of some native species, indicating that mature trees are being cut down. In both open and closed forests, 61–80 cm diameter was dominated by *L. sundaicus* and *L. korthalsii*, while in post-fire forests, 41–60 cm diameter was dominated by *C. junghuhniana.*

The environmental conditions affect the presence of tree species. Previous research noted that *L. sundaicus* can grow in areas with high light intensity, and *Engelhardia* habitats are mostly in sunny and open areas (Kusmana & Suwandhi, 2019; Meng et al., 2022). However, research by Irawan et al. (2021) revealed that *A. scholaris* is more sensitive to light intensity, while *M. dispermus* is more responsive to soil conditions (Fathia et al., 2019). Air temperature and soil pH in the study area tend to be optimum, namely 21–28 °C and 7.25–7.5. The optimum temperature for plant growth is 10–38 °C (Sudarmono, 1997), while the optimum soil pH is 6–7.5 (Xu et al., 2014). According to Srinivas and Krishnamurthy (2019), low temperature, high humidity, and soil pH around 5.6–6.0 affect the diversity and distribution of the genus *Litsea*. The presence of the *Ficus* genus in Pattunuang Resort and Bantimurung Resort is also influenced by air temperature and soil pH (Yelastri et al., 2023). However, the presence of the *Syzygium* genus is mainly influenced by altitude (Mudiana, 2017; Damas et al., 2022). Soil factors (soil physical and chemical properties) can influence the distribution of tree species (Nguyen et al., 2015). Environmental factors can describe ecological niches under current and future environmental conditions (Alkishe et al., 2022).

According to the IUCN Red List of Threatened Species, *L. korthalsii* and *C. glabra* are near threatened due to local logging, massive habitat conversion, and land conversion for agriculture and urbanization (International Union for Conservation of Nature (IUCN), 2024). *Saurauia bracteosa* has a natural distribution in the Andaman Islands, Java, the Lesser Sunda Islands, and the Nicobar Islands. This species is vulnerable to habitat destruction, land loss, and forest fires (Soemarno & Girmansyah, 2012; Helmanto et al., 2020).

CONCLUSION

This research resulted in a reasonably abundant tree diversity of 25 species from 21 families in three vegetation types, including several pioneer species that signalled the recovery of damaged or degraded forest ecosystems. The results also found that Tahura Raden Soerjo has a suitable habitat for *L. sundaicus* and *E. spicata*. However, according to conservation status, *L. korthalsii* and *C. glabra* are near-threatened species, and *S. bracteosa* is vulnerable to threats, which requires increased protection to prevent the loss of tree diversity. This study recommends conserving and sustainably managing the natural habitats of *L. sundaicus*, *E. spicata*, and other native species. It is a big responsibility for managers to determine appropriate and sustainable conservation strategies, such as giving strict sanctions to perpetrators and ensnaring them in an integrated manner, using a forest fire detection system. In addition, education from the government to the surrounding community is an effective way to stop the destruction of forest ecosystems in Tahura Raden Soerjo, such as campaigns through social media, a forest management strategy workshop, and inviting people to participate actively in tree planting.

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