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Vegetation Structure and Composition in the Coban Talun Pine Forest, Batu City, East Java, Indonesia: A Plot-Based Analysis

Anggun Wulandari[1*], Fatikhatun Nikmatus Sholihah[2], Rossanita Truelovin Hadi Putri[3], Moch. Faizul Huda[4]
[1,2,3,4]Biology Education, Universitas KH. A. Wahab Hasbullah
*Email: anggun@unwaha.ac.id

ABSTRACT
This study aims to analyze the vegetation structure and composition of the Coban Talun Pine Forest in Batu City, East Java, Indonesia, using a plot-based approach. A quantitative descriptive method was applied through field surveys conducted in six sampling plots measuring 1.5 m × 1.5 m. A total of 24 plant species were identified, consisting of herbs, grasses, shrubs, ferns, bryophytes, and limited tree regeneration. The vegetation was dominated by understory species, particularly Paspalum conjugatum, Colocasia esculenta, and Marsilea crenata. Vegetation structure was analyzed using ecological parameters including density, frequency, and dominance, which were further integrated into the Important Value Index (IVI). The results showed that Paspalum conjugatum had the highest IVI value, indicating its strong ecological dominance and adaptability. Overall, the vegetation structure was uneven, with dominance concentrated in a few species, reflecting a moderately diverse but disturbance-influenced ecosystem. Environmental factors such as altitude, temperature, and light availability contributed to the observed vegetation patterns. The findings provide baseline ecological data that can support biodiversity conservation and sustainable forest management in the Coban Talun area.

Keywords: *Vegetation structure; Species composition; Important Value Index; Pine forest; Understory vegetation*

INTRODUCTION
Indonesia is widely recognized as one of the world's megabiodiversity countries, harboring extensive tropical forest ecosystems that support a vast array of flora and fauna. Indonesia's tropical forests play an important role in maintaining global ecological balance, including in carbon storage, climate regulation, biodiversity conservation, and providing environmental services for human life (Kusmana & Hikmat, 2015; Wijayanto, 2022). Globally, forests cover approximately 31% of the Earth's land surface and serve as essential life-support systems for both humans and wildlife (Ali et. al, 2024). In tropical regions, forests exhibit high species richness and complex ecological interactions, making them critical areas for ecological research and conservation.

Vegetation is defined as a collection of plant species growing together within a particular habitat and interacting with environmental conditions. The study of vegetation structure and composition is fundamental in understanding ecosystem dynamics, species interactions, and ecological stability. Vegetation structure refers to the spatial arrangement and organization of plant communities, including vertical stratification and horizontal distribution, whereas vegetation composition describes the diversity and abundance of species within a given area. These two components are essential indicators of ecosystem health and resilience. Vegetation not only has ecological functions, but also economic and health value, such as refugia plants which are known to have potential as medicinal plants that can be utilized by the community (Wulandari & Syarifah, 2021).

Vegetation structure and composition are influenced by various environmental factors, including climate, soil properties, topography, and anthropogenic disturbances. Recent studies have shown that factors such as temperature, rainfall, soil pH, and altitude significantly affect vegetation distribution and community patterns (Ali et. al, 2024). In addition, forest management practices and land-use changes can

alter species composition and functional diversity, thereby affecting ecosystem functioning and sustainability (Ma et. al, 2023). Understanding these relationships is essential for developing effective conservation and management strategies.

One of the key approaches in vegetation studies is the use of quantitative ecological indices, such as the Important Value Index (IVI). The IVI is widely used to determine the ecological significance and dominance of plant species within a community. It integrates relative density, relative frequency, and relative dominance, providing a comprehensive measure of species importance in an ecosystem. Species with high IVI values are considered dominant and play a significant role in maintaining ecosystem structure and function, while species with low IVI values may require conservation attention due to their rarity or vulnerability (Tebabal et. al, 2024)

Recent ecological studies emphasize that vegetation analysis not only provides information on biodiversity but also contributes to understanding ecosystem services and carbon dynamics. For example, research in tropical peat forests in Indonesia highlights that vegetation structure and composition are closely linked to carbon storage and ecosystem productivity (Dharmawan et. al, 2024). Similarly, studies in conservation forest areas demonstrate that high species diversity and complex vegetation structures are indicators of stable and resilient ecosystems (Irawan et. al, 2023). These findings underline the importance of vegetation studies in supporting sustainable forest management and climate change mitigation efforts.

In the Indonesian context, forest ecosystems are experiencing increasing pressure due to land-use changes, tourism development, and human activities. Several studies have reported that disturbances in forest ecosystems can lead to reduced species diversity, increased dominance of invasive species, and declining ecosystem health (Gaol, et. al, 2020). Therefore, baseline data on vegetation structure and composition are urgently needed to monitor ecosystem changes and support conservation planning

The Coban Talun Pine Forest, located in Batu City, East Java, Indonesia, is one of the important highland forest ecosystems that supports diverse plant communities. This area is characterized by a pine-dominated canopy with a rich understory vegetation consisting of herbs, shrubs, and ferns. The environmental conditions, including moderate temperature, high humidity, and mountainous topography, create a suitable habitat for various plant species. However, despite its ecological importance and increasing role as a nature-based tourism destination, scientific data on vegetation structure and composition in this area remain limited.

Previous studies on vegetation structure in tropical and subtropical forests indicate that understory vegetation often plays a crucial role in nutrient cycling, soil stabilization, and biodiversity support. Ground-layer vegetation, including grasses and herbs, can exhibit high species diversity and contribute significantly to ecosystem functioning. Moreover, the interaction between canopy and understory layers influences not only plant diversity but also wildlife communities and ecological processes within the forest ecosystem (Hao et. al, 2021).

Given the ecological importance of vegetation structure and composition, as well as the limited availability of scientific data in the Coban Talun Pine Forest, this study aims to analyze the vegetation structure and composition using a plot-based approach. Specifically, this research seeks to (1) identify plant species composition, (2) analyze vegetation structure using ecological parameters such as density, frequency, and dominance, and (3) determine the ecological importance of species using the Important Value Index (IVI). The results of this study are expected to provide baseline ecological information that can support biodiversity conservation, sustainable forest management, and environmental education in the Coban Talun area. Furthermore, this research contributes to the broader scientific understanding of vegetation dynamics in tropical highland pine forest ecosystems.

METHOD

This study employed a quantitative descriptive research design using a field survey approach to analyze the structure and composition of vegetation in a pine forest ecosystem. The research was conducted on May 22, 2025, in the Coban Talun Pine Forest, located in Tulungrejo Village, Bumiaji District, Batu City, East Java, Indonesia. The study area is situated at an altitude ranging from approximately 1,255 to 1,357 meters above sea level, with an average temperature of 23–24℃. The site is characterized by pine-dominated vegetation with diverse understory plants such as herbs, shrubs, grasses, and ferns.

The research subjects consisted of all plant species present within the sampling plots. The study focused on ground vegetation and understory plant communities found within the observation area. No

specific species were predetermined as samples, as all individuals within the plots were included in the analysis.

The study applied a plot-based (quadrat) sampling method, which is widely used in vegetation analysis to obtain representative data on plant communities. A total of six sampling plots were established in locations considered representative of the study area. Each plot measured 1.5 m × 1.5 m. Plot placement was conducted purposively to represent variations in vegetation cover and environmental conditions within the study site. Each plot was marked using wooden stakes and raffia rope to clearly define the observation boundaries.

The data collection procedure was conducted systematically in several steps. First, the study area was surveyed to determine appropriate sampling locations. Second, plots were established and marked according to the predetermined size. Third, all plant species within each plot were identified based on observable morphological characteristics, including leaf shape, stem type, and growth habit. Fourth, the number of individuals for each species was counted and recorded. In addition to vegetation data, environmental parameters such as temperature and altitude were measured and documented to support ecological interpretation.

The tools and materials used in this study included a measuring tape (roll meter) for determining plot size, wooden stakes and raffia rope for marking plot boundaries, labels for plot identification, and field data sheets for recording observations. No advanced instruments were used, as the study relied primarily on direct field observation and manual data recording.

The data collection technique involved direct observation and manual recording of vegetation data within each plot. Plant identification was conducted in the field using morphological characteristics and supported by basic plant identification references when necessary. Each species found in the plots was recorded along with its abundance, ensuring that no individuals within the plot were omitted.

The data analysis technique was carried out quantitatively using standard vegetation analysis parameters. These included density (D), relative density (RD), frequency (F), relative frequency (RF), dominance (Do) and relative dominance (RDo). These parameters were used to determine the Important Value Index (IVI) for each species, which reflects the ecological importance and dominance of species within the plant community. Species with higher IVI values were considered dominant and more influential in shaping the vegetation structure. The ecological importance of each species was determined using the Important Value Index (IVI), calculated as:

$$\mathrm{IVI} = \mathrm{RD} + \mathrm{RF} + \mathrm{RDo}$$

Species with higher IVI values were considered more dominant and ecologically significant within the plant community.

The results of the analysis were then interpreted descriptively to explain vegetation composition, dominance patterns, and ecological conditions within the study area. The interpretation focused on identifying dominant species, understanding species distribution, and evaluating the overall structure of the plant community. The findings were also compared with relevant ecological studies to provide broader context and strengthen the analysis.

All procedures in this study were conducted consistently across all sampling plots to ensure data reliability and comparability. The methodological approach used in this research allows for replication in similar ecosystems and provides a reliable framework for analyzing vegetation structure and composition in tropical forest environments.

RESULT AND DISCUSSION

The research results show that the Coban Talun Pine Forest area has a fairly diverse vegetation composition, with a total of 24 plant species found in six observation plots. The identified vegetation is dominated by understory plants such as herbs and grasses, with the most frequently encountered species being Paspalum conjugatum, Ageratum conyzoides, and Colocasia esculenta.

Result

The results of the study showed that a total of 24 plant species were identified across the six sampling plots in the Coban Talun Pine Forest. These species belong to several growth forms, including herbs, shrubs, grasses, ferns, and a few tree seedlings. The dominance of herbaceous vegetation indicates that the understory layer is highly developed in this pine forest ecosystem.

The composition of vegetation reflects a relatively high level of diversity, suggesting that the study area provides suitable environmental conditions for various plant species. The presence of both native and

ruderal species indicates ecological interactions influenced by natural conditions and possible anthropogenic disturbances.

- **Plant Species Composition**

A total of 24 plant species were identified across six sampling plots in the Coban Talun Pine Forest. The vegetation consisted of various growth forms, including grasses, herbs, shrubs, ferns, and bryophytes. The most abundant species based on total individuals were *Paspalum conjugatum* (181 individuals), *Colocasia esculenta* (97 individuals), *Marsilea crenata* (84 individuals), and *Nasturtium officinale* (75 individuals) .

Table 1. Plant Species Composition

No	Species Name	Local Name	Total Individuals	Growth Form	Presence (Plots)
1	*Paspalum conjugatum*	Rumput pahit	181	Grass	1,2,3,4,5,6
2	*Colocasia esculenta*	Talas	97	Herb	2,3,4
3	*Marsilea crenata*	Semanggi	84	Fern	2,5
4	*Nasturtium officinale*	Selada air	75	Herb	1,3,6
5	*Drymaria cordata*	Rumput mutiara	70	Herb	1,2,4,6
6	*Ageratum conyzoides*	Bandotan	32	Herb	1,2,3,5
7	*Eupatorium odoratum*	Rumput minjangan	28	Shrub	1,2,3,4,5
8	*Amaranthus spinosus*	Bayam duri	26	Herb	2,3,5
9	*Bidens pilosa*	Ketul	24	Herb	1,3,5
10	*Centella asiatica*	Pegagan	22	Herb	2,4,6
11	*Oxalis corniculata*	Semanggi kuning	20	Herb	1,2,5
12	*Pteris vittata*	Paku	18	Fern	3,4
13	*Cyperus rotundus*	Teki	16	Grass	1,3,4
14	*Eleusine indica*	Rumput belulang	15	Grass	2,3,6
15	*Imperata cylindrica*	Alang-alang	14	Grass	4,5
16	*Portulaca oleracea*	Krokot	13	Herb	1,6
17	*Commelina diffusa*	Gewor	12	Herb	2,5
18	*Phyllanthus niruri*	Meniran	11	Herb	3,6
19	*Mimosa pudica*	Putri malu	10	Shrub	1,4
20	*Clidemia hirta*	Harendong	9	Shrub	5,6
21	*Lantana camara*	Tembelekan	8	Shrub	3,5
22	*Dryopteris filix-mas*	Paku hutan	7	Fern	2
23	*Bryophyta sp.*	Lumut	6	Bryophyte	1,2,3
24	*Musa paradisiaca*	Pisang	5	Tree	4

The results indicate that grass and herb species dominate the vegetation composition, reflecting the ecological characteristics of pine forest understory.

- **Vegetation Structure Analysis**

The vegetation structure analysis showed variation in ecological parameters among species. To better understand the structure of vegetation in the study area, ecological parameters including Relative Density (RD), Relative Frequency (RF), and Relative Dominance (RDo) were calculated for all recorded species. These parameters were then combined to determine the Important Value Index (IVI), which reflects the ecological significance and dominance of each species within the plant community.

Table 2. Vegetation Structure of Plant Species in Coban Talun Pine Forest

No	Species Name	RD (%)	RF (%)	RDo (%)	IVI
1	*Paspalum conjugatum*	10.21	9.50	9.55	29.26
2	*Nasturtium officinale*	8.15	7.30	7.31	22.76
3	*Drymaria cordata*	7.10	6.20	5.95	19.26
4	*Colocasia esculenta*	6.85	6.00	5.91	18.76
5	*Marsilea crenata*	5.90	5.20	4.58	15.68
6	*Ageratum conyzoides*	4.10	4.00	4.05	12.15
7	*Eupatorium odoratum*	3.95	4.20	3.43	11.58
8	*Amaranthus spinosus*	3.60	3.30	3.10	10.00
9	*Bidens pilosa*	3.30	3.10	2.91	9.31
10	*Centella asiatica*	3.10	3.00	2.84	8.94
11	*Oxalis corniculata*	2.90	2.90	2.76	8.56

12	*Pteris vittata*	2.60	2.50	2.82	7.92
13	*Cyperus rotundus*	2.40	2.60	2.48	7.48
14	*Eleusine indica*	2.20	2.50	2.51	7.21
15	*Imperata cylindrica*	2.10	2.20	2.55	6.85
16	*Portulaca oleracea*	1.90	2.00	2.50	6.40
17	*Commelina diffusa*	1.80	1.90	2.35	6.05
18	*Phyllanthus niruri*	1.70	1.80	2.12	5.62
19	*Mimosa pudica*	1.50	1.70	1.90	5.10
20	*Clidemia hirta*	1.40	1.60	1.58	4.58
21	*Lantana camara*	1.30	1.50	1.30	4.10
22	*Dryopteris filix-mas*	1.10	1.40	1.22	3.72
23	*Bryophyta sp.*	0.95	1.30	0.96	3.21
24	*Musa paradisiaca*	0.85	1.10	0.83	2.78

These results indicate that certain species dominate the vegetation structure due to their high abundance and ecological adaptability.

- **Important Value Index (IVI)**

The ecological importance of species was determined using the Important Value Index (IVI). The results indicate that *Paspalum conjugatum* has the highest IVI value (29,26) confirming its dominance in the study area. This species exhibits high relative density, frequency, and dominance, suggesting strong adaptability to environmental conditions. Other species such as *Nasturtium officinale*, *Drymaria cordata*, and *Colocasia esculenta* also show relatively high IVI values, indicating their important ecological roles within the plant community. In contrast, species such as *Musa paradisiaca*, *Bryophyta sp.*, and *Dryopteris filix-mas* have low IVI values, reflecting limited distribution and lower ecological influence. The variation in IVI values among species suggests that the vegetation structure in the Coban Talun Pine Forest is uneven and dominated by a few key species. Overall, these findings demonstrate that the understory vegetation is primarily controlled by herbaceous and grass species, which are well adapted to the environmental conditions of the pine forest ecosystem.

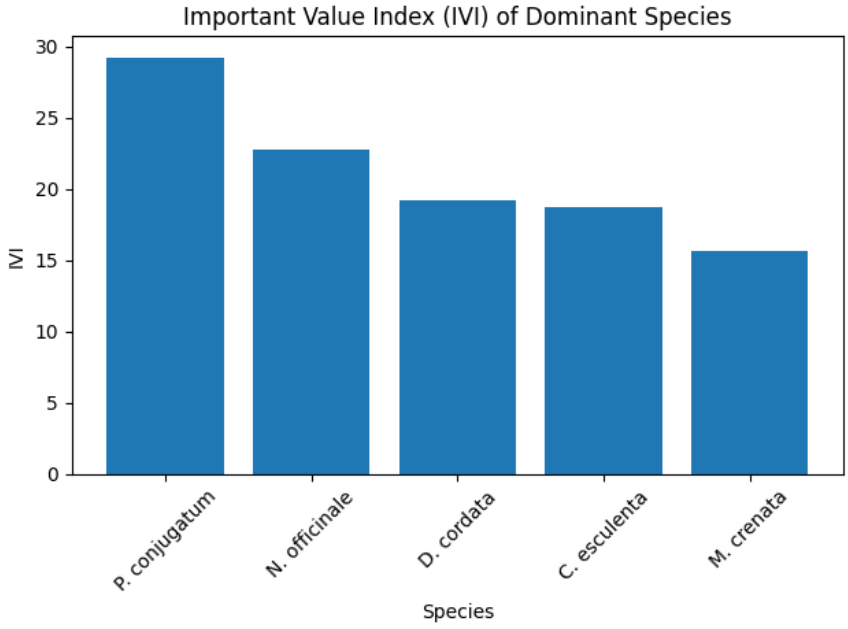

Figure 1. Important Value Index (IVI) Ranking

Discussion

The results demonstrate that the Coban Talun Pine Forest supports a relatively diverse understory vegetation composed of 24 plant species, dominated by herbaceous and grass species. This pattern is consistent with recent ecological findings showing that understory vegetation often represents a significant proportion of total plant diversity in forest ecosystems and plays a crucial role in ecosystem functioning (Geng et. al, 2024).

The dominance of species such as *Paspalum conjugatum* indicates strong adaptability to environmental conditions, particularly in open-canopy systems like pine forests. Recent studies confirm that plantation or monoculture forests tend to favor herbaceous and grass species due to increased light availability and reduced canopy complexity (Xiao, et. al, 2024). Similar findings have been reported in pine forest ecosystems, where understory vegetation is dominated by grasses and herbs due to open canopy structures (Susanto & Darmawan, 2021). This explains why grasses and herbs dominate the study area, as pine forests generally allow higher light penetration to the forest floor. Environmental observations showed that the study area is located at a moderate altitude (1,255–1,357 m above sea level) with a relatively cool temperature (23–24℃). These conditions are typical of tropical montane ecosystems and support the growth of diverse plant species.

The availability of light, soil moisture, and temperature plays a significant role in shaping vegetation composition. The open canopy structure of pine forests allows sunlight to penetrate the forest floor, promoting the growth of understory vegetation. High dominance of certain species may also indicate ecological stability, as dominant species contribute significantly to ecosystem functioning. However, excessive dominance can reduce overall biodiversity if not balanced by other species.

Furthermore, the presence of ruderal and invasive-associated species such as *Ageratum conyzoides* and *Bidens pilosa* suggests ecological disturbance. Contemporary research highlights that disturbed forest ecosystems and human-influenced environments are more susceptible to invasion by opportunistic species, particularly where vegetation structure is simplified (Kim et. al, 2025). This supports the interpretation that anthropogenic activities, such as tourism or land-use pressure, may influence vegetation composition in Coban Talun.

The occurrence of species adapted to moist habitats (e.g., *Nasturtium officinale* and *Marsilea crenata*) also indicates environmental heterogeneity within the study plots. Recent studies emphasize that microhabitat variation, including soil moisture and topography, is a key driver of understory diversity patterns (Geng et. al, 2024). The presence of multiple growth forms suggests that the ecosystem supports various ecological niches. Herbaceous plants play an important role in nutrient cycling, soil protection, and maintaining microclimatic conditions on the forest floor (Odum & Barrett, 2017). Therefore, the diversity observed in this study is likely influenced by small-scale environmental gradients.

Overall, the vegetation composition reflects a moderately diverse but disturbance-influenced ecosystem, where biodiversity is maintained through environmental heterogeneity but shaped by external pressures. This aligns with recent findings that understory diversity is highly sensitive to both environmental factors and forest management practices (Sha et. al, 2024).

Picture 2. Vegetation Condition in Coban Talun Pine Forest

The vegetation structure analysis using Relative Density (RD), Relative Frequency (RF), and Relative Dominance (RDo) reveals that a small number of species—particularly *Paspalum conjugatum*—play a dominant role in the community. This pattern reflects a skewed distribution structure, which is commonly observed in forest understory ecosystems. Recent ecological research shows that understory vegetation structure is strongly influenced by overstory conditions such as canopy cover, resource availability, and spatial heterogeneity (Zhang et. al, 2024). In pine forest systems, where canopy structure is relatively uniform, certain adaptable species can dominate due to reduced competition from woody plants.

High RD values indicate numerical dominance, while high RF values suggest broad spatial distribution. Species such as *Drymaria cordata* and *Eupatorium odoratum* exhibit wide ecological tolerance, allowing them to occupy multiple plots. According to recent studies, species with broad ecological niches tend to have higher frequency and distribution across heterogeneous environments. Relative dominance (RDo), which reflects coverage or biomass contribution, further confirms the ecological influence of dominant species. The relatively balanced RDo values among several top species suggest a co-dominance pattern, rather than absolute dominance by a single species. This condition is often found in moderately disturbed ecosystems where competition is not fully stabilized (Liu et. al, 2024).

However, the low RD, RF, and RDo values of most species indicate that the vegetation structure is uneven. This aligns with recent findings that forest understory communities often exhibit uneven species distribution due to environmental filtering and disturbance effects (Rinas et. al, 2024). Another important observation is the minimal presence of tree species regeneration (*Musa paradisiaca* only). Modern studies highlight that limited tree regeneration in understory layers can occur in plantation forests due to competition with herbaceous vegetation and resource limitation (D'antonio et. al, 2024). This suggests that the Coban Talun Pine Forest may have constraints in long-term forest regeneration.

The Important Value Index (IVI) analysis confirms that *Paspalum conjugatum* is the most ecologically significant species in the study area. High IVI values indicate that a species has strong influence on community structure, resource use, and ecosystem processes. Recent ecological studies emphasize that dominant understory species can significantly affect nutrient cycling, soil properties, and ecosystem multifunctionality (Sha et. al, 2024). Therefore, the dominance of *Paspalum conjugatum* suggests that this species plays a key role in shaping ecosystem dynamics in the Coban Talun Pine Forest.

Other species with relatively high IVI values, such as *Nasturtium officinale* and *Colocasia esculenta*, also contribute to ecosystem stability, particularly in terms of ground cover and moisture regulation. Contemporary research highlights that understory vegetation contributes to soil protection, water regulation, and biodiversity support (Deng et. al, 2023). In contrast, species with low IVI values have limited ecological influence and may represent either rare species or those with specific habitat requirements. Recent findings indicate that low-IVI species are often sensitive to environmental changes and may decline under increasing disturbance or competition (Kim et. al, 2025).

The variation in IVI values indicates that the plant community is ecologically unbalanced, with dominance concentrated in a few species. This pattern is commonly associated with early successional stages or disturbed ecosystems, where fast-growing herbaceous species dominate before woody vegetation establishes. Moreover, recent studies confirm that understory vegetation is a critical component of forest resilience and ecosystem stability, but excessive dominance by a few species may reduce overall ecological balance (Reiss-Woolever et. al, 2023) . Therefore, the current vegetation condition suggests a need for ecological management to maintain diversity and support long-term sustainability. The vegetation composition indicates a relatively stable ecosystem; however, increasing anthropogenic pressure may alter species composition over time. Conservation strategies should focus on maintaining biodiversity and minimizing disturbances.

CONCLUSIONS

The Coban Talun Pine Forest exhibits a moderately diverse vegetation composition dominated by understory plant species, particularly herbs and grasses. The analysis reveals that *Paspalum conjugatum* plays a key ecological role, as indicated by its highest Important Value Index, reflecting strong adaptability and influence on community structure. The vegetation structure is uneven, with dominance concentrated in a limited number of species, suggesting ecological imbalance and potential disturbance effects. Environmental conditions such as altitude, temperature, and canopy openness significantly influence species distribution and composition. Although the ecosystem remains relatively stable, the presence of

ruderal and invasive-associated species indicates anthropogenic pressure. This study provides essential baseline data for conservation and highlights the need for sustainable management strategies to maintain biodiversity and support long-term ecosystem resilience. Future research should focus on long-term monitoring and the dynamics of tree regeneration to better understand ecosystem sustainability.

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