Status Review of Guinayangan Quezon Mangrove Forest: An Assessment of Species Diversity and Habitat Analysis

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Abstract. This study was conducted to determine the status of the Mangrove Walk located in Brgy. Calimpak, Guinayangan, Quezon. Three main procedures were undertaken: species identification; habitat analysis using percent crown cover, regeneration per m², and average height; and the computation of diversity indicators such as species richness, relative abundance, Shannon–Wiener diversity index, and species evenness using PAST software. A total of 183 mangrove trees were recorded across three transect lines and two quadrats. Seven (7) out of the 23 mangrove species listed by the Zoological Society of London (ZSL) for the Municipality of Guinayangan, Quezon were identified at the study site, representing three families: Acanthaceae, Lythraceae, and Rhizophoraceae. In the habitat analysis using the parameters by Deguit et al. (2004), the results showed that the average percent crown cover of 5.63 falls under the poor condition category, as it lies within the 0–25% crown cover range. The average tree height of 9.04 meters is classified as excellent, as it exceeds the 5-meter threshold. For regeneration density, the computed value of 0.83 individuals per m² is considered good, as it falls within the range of 0.7 to less than 1 individual per m². In terms of diversity indices, relative abundance across all sampling stations showed that the dominant species were *Sonneratia alba* (39%), *Avicennia marina* (16.5%), and *Rhizophora mucronata* together with *Sonneratia apetala* (11.0%). *Sonneratia alba* was observed to dominate all three transects and two quadrats. In contrast, species with lower relative abundance included *Bruguiera cylindrica* (9.9%), *Bruguiera parviflora* (9.9%), and *Rhizophora apiculata* (2.7%). In terms of species richness, Transect Lines 1 and 3 recorded the highest values with seven species each, followed by Transect Line 2 with six species. Quadrats 1 and 2 recorded the lowest species richness, each with five species. For the Shannon–Wiener diversity index, Transect Line 3 obtained the highest value (1.83), followed by Transect Line 2 (1.71), Transect Line 1 (1.64), Quadrant 1 (1.43), and Quadrant 2 (1.42). Based on the interpretation scale, all transects, and quadrats exhibited a poor Shannon–Wiener diversity status. However, species evenness across all sampling units was balanced. In terms of species

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richness, all sampling units recorded values above five, indicating an integrated mangrove community structure.

1 Introduction

The Philippine Islands are recognized as one of the world's top biodiversity hotspots, supporting approximately 1.9% of the world's endemic plant and vertebrate species [1] and is considered among the countries with the richest diversity of coastal plants globally [2].

Approximately 60–70 mangrove and mangrove-associated species belonging to 26 families are found in the Philippines. Of these, an estimated 40 species from 16 families are considered true mangroves [3]. True mangroves are species restricted to mangrove communities, while associated species may also occur in other habitats [4]. The most common mangrove genera in the Philippines include *Rhizophora*, *Avicennia*, *Bruguiera*, and *Sonneratia* with at least 14 species previously recorded on Negros Island [2].

Mangroves play a vital role within coastal ecosystems, forming an interconnected system with coral reefs and seagrass beds [5]. Mangrove ecosystems in the Philippines are highly diverse, hosting a significant number of the world's salt-tolerant mangrove species. Often described as the "rainforest of the sea," these coastal forests form part of an interconnected system with coral reefs and seagrass beds. They provide important ecological and economic benefits, including sustaining fisheries, supplying timber and non-timber resources, protecting coastlines from erosion and storm surges, and supporting ecotourism activities [5].

Mangrove forests are among the world's most vulnerable tropical ecosystems [6]. Historically, mangroves once covered more than 35% of the planet's coastal areas. However, in countries such as India, the Philippines, and Vietnam, mangrove forests have declined by as much as 50% over the past century [8]. In the Americas, mangrove loss has occurred at a rate even faster than that of tropical rainforests [7]. While natural disturbances pose threats, anthropogenic activities, particularly pollution and land conversion, remain the primary drivers of mangrove degradation [7] [8].

Mangrove loss in the Philippines has been largely associated with the conversion of coastal areas to alternative land uses, particularly the expansion of aquaculture. Over time, large portions of mangrove forests have been cleared, contributing to a significant reduction in mangrove coverage. This trend led to the implementation of policies aimed at conserving remaining mangrove areas and limiting further conversion. Despite these measures, the continued demand for fishpond development has resulted in ongoing pressure on mangrove ecosystems, with illegal conversions persisting in some areas [9].

Despite increased conservation initiatives and localized reforestation efforts, mangrove deforestation remains a significant environmental concern. In Southeast Asia and the Philippines, aquaculture development is widely recognized as a major driver of mangrove loss. In the Philippines, a substantial portion of mangrove deforestation has been associated with the conversion of mangrove areas into brackish-water fishponds. Continued degradation of mangrove ecosystems is still anticipated, highlighting the need for comprehensive assessment and monitoring of remaining mangrove forests to support effective conservation and protection strategies [10].

1.1 Objectives

This study generally aims to assess the status of the Mangrove Walk in Brgy. Calimpak, Guinayangan, Quezon. Specifically, the other objectives of this study are:

1. To identify the different mangrove species, present in the area.
2. To assess the current mangrove habitat through percent crown cover,

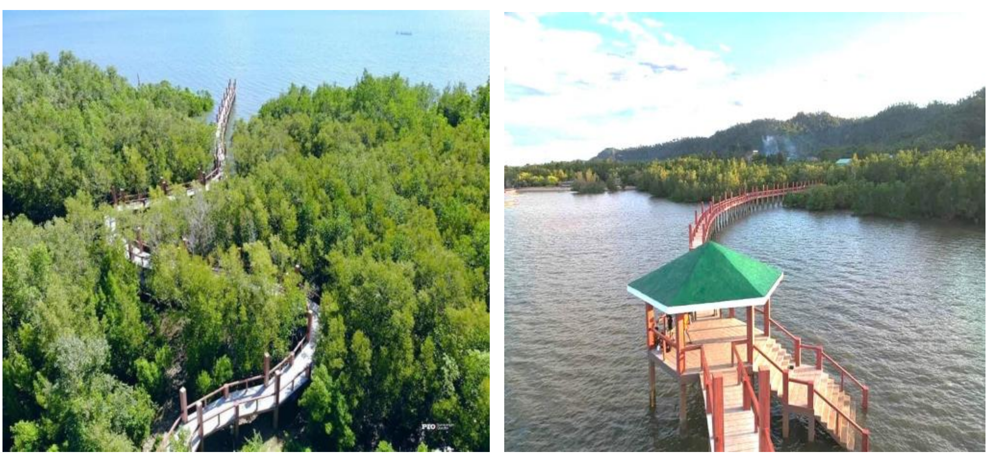
regeneration per m^2 and average height, and:
3. To calculate the present diversity indices such as species richness, relative abundance, Shannon-Weiner diversity index and evenness.

2 Methodology

2.1 Coordination with Guinayangan, Quezon Local Government Unit (LGU)

Five procedural steps were undertaken in this investigation. On March 11, 2023, a formal request letter was submitted to the Municipal Environment and Natural Resources Office (MENRO) of Guinayangan, Quezon, seeking permission to conduct the study, following coordination with the Sangguniang Bayan Secretary. Upon approval, an initial meeting was held on March 19, 2023, to discuss the criteria and process for finalizing the study site.

Subsequently, MENRO designated the final research location and assigned a staff member, along with the site caretaker, to assist during data collection. This arrangement was made as the MENRO representative was scheduled to travel to the Visayas the following week for a benchmarking activity. The Mangrove Walk as shown in Figure 1 (a) and (b) was selected as the study site because it was not included among the 14 sites under the ongoing Improving Coastal Resilience and Ecosystem Services through Biodiversity Restoration (ICORE) project, a collaborative initiative involving the Guinayangan Local Government Unit (LGU), the Zoological Society of London (ZSL), and the International Institute of Rural Reconstruction (IIRR).



a b

Fig. 1. Study Site aerial (a) and sea view (b)

2.2 Species Identification

Using the Field Guide Manual to Philippine Mangroves by Primavera [11] the mangrove species present at the site were identified and classified in situ. The distance between the gate and the Mangrove Walk was measured at 75 meters using an industrial measuring tape. A straw rope was then used to establish three 75-meter transect lines. Along these transects, two 15 × 15 meter quadrats were laid out, with each quadrat containing three 1 × 1 meter regeneration plots.

Mangrove sampling along each transect line was conducted from the shoreline toward the landward direction. Individual mangrove trees encountered along the transects were recorded sequentially. Species identification was based on the examination of leaves, bark, and flowers to ensure accurate differentiation among individuals. For each tree, measurements of trunk diameter (cm), tree height (m), crown diameter (m), and crown height (m) were recorded. When morphological distinctions were evident but species identity was not immediately confirmed, individuals were temporarily labeled as Species A, B, C, and so on, following the mangrove field identification guide by Primavera [11].

Quadrat sampling was carried out using the 15 × 15 meter plots established between the transect lines. All mangrove species identified within the transects were also recorded inside each quadrat, and the same biometric parameters (trunk diameter, tree height, crown diameter, and crown height) were measured. In addition, the 1 × 1 meter regeneration plots within each quadrat were used to count and record the number of regenerating mangroves.

To further support and verify species identification, interviews and consultations were conducted during fieldwork with Mr. Zosimo Rom, the caretaker of the Mangrove Walk, and Mr. Aivan Lester Gonzales, a staff member of the Municipal Environment and Natural Resources Office (MENRO) of Guinayangan, Quezon.

2.3 Habitat Analysis

Habitat analysis was conducted using three parameters: percent crown cover, regeneration per square meter (m^2), and average tree height. Computations followed the standard procedures outlined in the habitat analysis guide. The condition of mangrove regeneration per square meter was evaluated using the criteria established by Deguit et al. [12].

$$\text{Percent crown cover} = \frac{\text{Total crown cover of all trees}}{\text{Total area sampled}} \quad (1)$$

$$\text{Regeneration per m}^2 = \frac{\text{Total regeneration count}}{\text{Total no. of regeneration plots}} \quad (2)$$

$$\text{Average height} = \frac{\text{Total height of all trees recorded}}{\text{Total number of trees recorded}} \quad (3)$$

2.4 Diversity Indices

Species diversity was assessed using the Shannon–Wiener diversity index (H′), along with species richness, relative abundance, and species evenness. These indices were computed using the Paleontological Statistical Software Package (PAST), a widely used free software for biodiversity analysis of flora and fauna, including mangrove ecosystems, developed by Hammer and colleagues [13]. Diversity index values were then interpreted using a rating scale sourced from ResearchGate as shown in Table 1.

Table 1. Criteria for determining the condition of mangrove

Condition	Criteria
Excellent	76% and above in % Crown Cover 1 Regeneration per m^2 Above 5m in Average Tree Height Undisturbed to negligible disturbance
Good	51% - 75% Crown Cover

	0.76 - <1 Regeneration per m^2 3m - <5m Average Tree Height Slight disturbance and few cuttings
Fair	26% - 50% Crown Cover 0.50 – 0.75 Regeneration per m^2 2m - <53 Average Tree Height Moderate disturbance and noticeable cuttings
Poor	0% - 25% Crown Cover <0.5 Regeneration per m^2 <2m Average Tree Height Heavy disturbance / cuttings / pollution, rampant conversion to other uses, nearly destroyed

3 Results and Discussion

Measurements were taken for trunk diameter (cm), tree height (m), crown diameter (m), and crown height (m) for individuals along the three transect lines and within the two quadrats, each containing three regeneration plots. Each mangrove was examined by observing its leaves, bark, and flowers to determine species identity and to distinguish it from previously recorded individuals, using the Primavera field guide as a reference. Field data were then recorded in tabular form after being transferred from data sheets or writing slates.

3.1 Species Identification

A total of 183 mangrove trees were recorded across the three transect lines and two quadrats established in the study site. Of the 23 mangrove species listed by the Zoological Society of London (ZSL) for the Municipality of Guinayangan, Quezon, seven species were identified, representing three families: Acanthaceae, Lythraceae, and Rhizophoraceae. The list of observed mangrove species is presented in Table 2.

As presented in Table 2, based on the International Union for Conservation of Nature (IUCN) Red List, all mangrove species documented in the sampling sites are classified as Least Concern (LC), indicating that they are relatively widespread and not currently at significant risk of extinction globally. Notably, the endangered species *Camptostemon philippinensis*, which has been reported in Guinayangan, Quezon, was not observed in the study site.

Table 2. List of Identified Mangroves in the Study Site

Scientific Name	Common Name	Local Name	IUCN Status
Avicennia marina	Grey Mangrove	Miapi,Api-api	Least Concern (LC)
Sonneratia alba	Mangrove Apple	Pagatpat	Least Concern (LC)
Rhizophora mucronata	Red Mangrove	Bakhaw- Babae	Least Concern (LC)
Sonneratia apetala	Mangrove Apple	Pagatpat	Least Concern (LC)
Bruguiera cylindrica	Black Mangrove	Pototan,Busain	Least Concern (LC)
Bruguiera parviflora	Small-Leaved Orange Mangrove	Langarai	Least Concern (LC)

Rhizophora apiculata	Tall Stilt Mangrove	Bakhaw-Lalaki	Least Concern (LC)

3.2 Mangrove Zonation

Mangrove zonation refers to the occurrence of distinct biological groupings within a mangrove forest, where areas are dominated by species belonging to the same family, genus, or species [14]. Both natural and human-managed mangrove forests may exhibit such zoning patterns as shown in Figure 2.

Based on the data obtained from the three transects and two quadrats, the observed species distribution generally followed the typical zonation pattern of natural mangrove habitats. Species of *Avicennia* and *Sonneratia* were found in the fringing zone, while *Rhizophora* and *Bruguiera* species were more commonly observed in the inland zones.

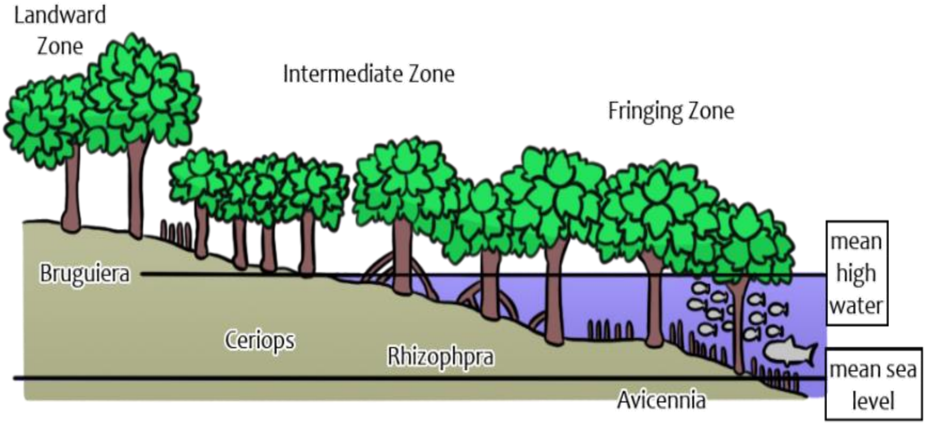


Fig. 2. Mangrove Species Zonation
Retrieved from: https://www.coast.ph/ccef-news/04/mangroves-a-link-between-the-land-and-the-sea/

3.3 Habitat Analysis

Based on the evaluation outcomes of the three criteria, percent crown cover, average height, and regeneration per m², the overall condition of the mangroves in the study area was determined.

Table 3. Average Percent Crown Cover and Average Height Summary

	Transect Line 1	Transect Line 2	Transect Line 3	Quadrant 1	Quadrant 2	Average
Percent Crown Cover (%)	5.21	4.85	7.00	4.83	6.26	5.63
Average Height (m)	8.97	10.92	8.76	8.35	8.20	9.04

Based on the parameters by Deguit et al. [12] presented in Table 1, the average percent crown cover of 5.63 falls under the *poor* condition category, as it is within the 0–25% crown cover range. Using the same reference, the average tree height of 9.04 meters is classified as *excellent*, since it exceeds the threshold of 5 meters in average tree height. For regeneration density, the computed value of 0.83 individuals per square meter is considered *good*, as it falls within the range of 0.7 to less than 1 individual per square meter. A summary of these results is presented in Table 3 and Figure 3.

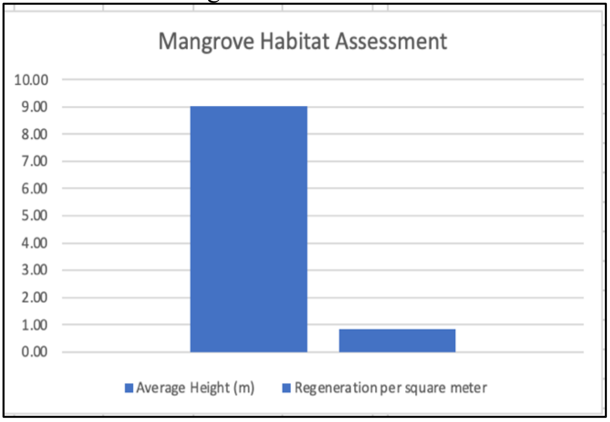


Fig. 3. Mangrove habitat assessment based on average height and regeneration per sqm

3.4 Diversity Indices

Based on Table 4, in terms of relative abundance across all sampling stations, the three most dominant species were *Sonneratia alba* (39%), *Avicennia marina* (16.5%), and *Rhizophora mucronata* together with *Sonneratia apetala* (11.0%). *Sonneratia alba* was observed to dominate all three transects and two quadrats, which may be attributed to the characteristics of its propagules. Its lightweight seeds are easily dispersed by water currents, contributing to its wide distribution within the study area [15].

Table 4. Relative Abundance Summary

		Transect Line 1		**Transect Line 2**		**Transect Line 3**		**Quadrant 1**		**Quadrant 2**		**In all sampling stations**	
		Count	% RA	Count	% RA	Count	% RA	Count	% RA	Count	% RA	Count	% RA
A	*Avicennia marina*	2	0.069	4	0.154	5	0.172	11	0.224	8	0.163	30	16.5%
B	*Sonneratia alba*	13	0.448	7	0.269	9	0.310	20	0.408	22	0.449	71	39.0%
C	*Rhizophora mucronata*	4	0.138	3	0.115	3	0.103	10	0.204	0	0.000	20	11.0%
D	*Sonneratia apetala*	2	0.069	6	0.231	4	0.138	4	0.082	4	0.082	20	11.0%
E	*Bruguiera cylindrica*	2	0.069	4	0.154	3	0.103	4	0.082	5	0.102	18	9.9%
F	*Bruguiera parviflora*	4	0.138	2	0.077	2	0.069	0	0.000	10	0.204	18	9.9%
G	*Rhizophora apiculata*	2	0.069	0	0.000	3	0.103	0	0.000	0	0.000	5	2.7%

In contrast, the species with lower relative abundance shown on Figure 4 included *Bruguiera cylindrica* (9.9%), *Bruguiera parviflora* (9.9%), and *Rhizophora apiculata* (2.7%), indicating comparatively less representation within the sampling sites.

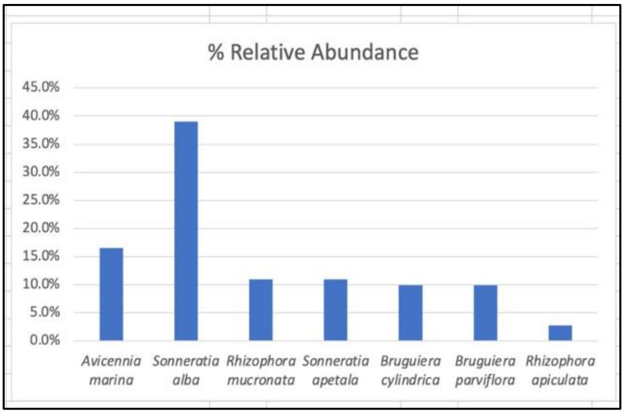


Fig. 4. Percent relative abundance of seven identified species

Table 5. Diversity Indices Data

Diversity Indices	Transect Line 1	Transect Line 2	Transect Line 3	Quadrant 1	Quadrant 2	Average
Shannon-Weiner	1.64	1.71	1.83	1.43	1.42	1.606
Evenness	0.845	0.957	0.939	0.891	0.881	0.9026
Richness	7	6	7	5	5	6

Based on Table 5 and Figure 5, Transect Lines 1 and 3 exhibited the highest species richness, each with seven species recorded. This was followed by Transect Line 2 with six species, while Quadrants 1 and 2 recorded the lowest species richness, each with five species observed.

In terms of the Shannon–Wiener diversity index, Transect Line 3 had the highest value (1.83), followed by Transect Line 2 (1.71) and Transect Line 1 (1.64). Quadrant 1 recorded a value of 1.43, while Quadrant 2 had the lowest diversity index of 1.42.

The Shannon–Wiener diversity index typically ranges between 1.5 and 3.5 and rarely exceeds 4.5. Its primary purpose is to provide a quantitative measure of biological diversity that allows comparison across different sites or over time. Using the scale presented in the methodology, the obtained diversity index values were interpreted accordingly.

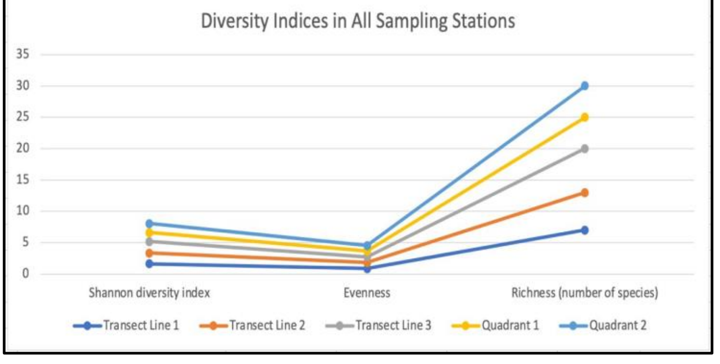


Fig. 5. Diversity indices in all sampling stations

Based on the interpretation table, all transects and quadrats were classified as having a *poor* status in terms of the Shannon–Wiener diversity index. In terms of species evenness, all transects and quadrats exhibited a *balanced* distribution. Lastly, for species richness, all sampling sites recorded values above five, indicating an *integrated* condition.

4 Recommendation

Overall, the assessment of the Mangrove Walk in Brgy. Calimpak, Guinayangan, Quezon provides valuable information that can support appropriate management, conservation, and rehabilitation efforts aimed at maintaining and improving the biological condition of the site.

Despite the relevance of the findings, several recommendations are proposed to strengthen future studies and management initiatives. First, the low percent crown cover and Shannon–Wiener diversity index values may be partly attributed to the limited number of transect lines and quadrats used in the methodology. Increasing the number of transects and establishing additional quadrats between existing lines may yield a more comprehensive representation of vegetation structure and species diversity.

Second, the use of advanced technologies such as high-resolution cameras with zoom lenses would improve documentation of flowers, propagules, and other elevated plant structures. The integration of unmanned aerial vehicles (drones) could also provide aerial imagery for more accurate assessment of crown cover and spatial distribution.

Third, the results of this study can serve as baseline data for long-term management interventions, including informed decisions on suitable mangrove species for future planting and rehabilitation programs.

Fourth, the findings may assist the Municipal Environment and Natural Resources Office (MENRO) and the Tourism Office of Guinayangan, Quezon in planning the sustainable development of the Mangrove Walk as an ecotourism destination, potentially incorporating a minimal entrance fee to support site maintenance and conservation.

Lastly, future research may incorporate additional parameters such as water and soil quality analysis, hazard assessment, and conservation and sustainability evaluations to provide a more comprehensive understanding of the mangrove ecosystem and further support effective resource management.

5 Conclusion

Based on the results and findings of the study, the following conclusions are drawn:

Seven (7) of the 23 mangrove species listed by the Zoological Society of London (ZSL) for the Municipality of Guinayangan, Quezon were recorded at the study site. These species belong to three families: Acanthaceae, Lythraceae, and Rhizophoraceae.

The dominant mangrove species identified were *Sonneratia alba*, *Avicennia marina*, *Rhizophora mucronata*, and *Sonneratia apetala*. The observed mangrove zonation pattern generally followed the typical natural zonation characteristic of mangrove ecosystems.

Habitat analysis based on the criteria of Deguit et al. [12] indicated contrasting structural conditions. The average percent crown cover of 5.63% was classified as *poor*, while the average tree height of 9.04 m reflected an *excellent* condition. Regeneration density, with a mean value of 0.83 individuals per m^2, was classified as *good*.

Analysis of diversity indices showed that all transects and quadrats exhibited a *poor* Shannon–Wiener diversity index. However, species evenness across all sampling units was *balanced*, and species richness values exceeded five species in all cases, indicating an *integrated* mangrove community structure.

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