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THE LOCAL COMMUNITY UNDERSTANDING OF THE FACTORS INFLUENCING THE DECLINE OF SANINTEN (*CASTANOPSIS ARGENTEA* (BLUME) A.DC.) AND TUNGURUT (*CASTANOPSIS TUNGURRUT* (BLUME) A.DC.) IN THE BUFFER VILLAGES OF THE GUNUNG HALIMUN-SALAK NATIONAL PARK

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ABSTRACT
PENIDDA, E. I., JUMARI, BASKORO, K., SAHRONI, D., PENIWIDIYANTI, SUJARWO, W. 2024. The local community understanding of the factors influencing the decline of saninten (*Castanopsis argentea* (Blume) A.DC.) and tungurut (*Castanopsis tungurrut* (Blume) A.DC.) in the buffer villages of the Gunung Halimun Salak National Park. *Reinwardtia* 23(1): 15–32. — *Saninten* (*Castanopsis argentea*) and *tungurut* (*Castanopsis tungurrut*) are plant species belonging to the family Fagaceae, native to the mountainous forest ecosystem within the Gunung Halimun-Salak National Park (GHSNP). These species are currently classified as endangered according to the IUCN Red List due to their significance in providing seeds for consumption and wood for construction materials. This research aims to examine the local community's knowledge concerning the presence, scarcity, and underlying causes of the decline of both species in the buffer villages of GHSNP. In this study, we employed survey methods and semi-structured interviews conducted with various informants. The data collected were meticulously described and analyzed descriptively. The findings revealed that the local community, in general, holds knowledge about the scarcity of species primarily based on field observations rather than legal or conservation status. Currently, both species are challenging to locate in the buffer villages of the GHSNP. According to the local community's knowledge, the causes of species scarcity can be categorized into internal and external factors. Internal factors include both species having a slow natural regeneration pattern, difficulties in germination, and vulnerability of seedlings to environmental conditions. Meanwhile, external factors encompass seed and timber exploitation, habitat loss, climate changes, limited knowledge, skills, and understanding of forest plants, and the current perception among locals that *C. argentea* and *C. tungurrut* offer limited economic benefits, leading to the gradual neglect of these species' existence.

Key words: Conservation, edible fruit, ethnobotany, slow regeneration, threatened species.

ABSTRAK
PENIDDA, E. I., JUMARI, BASKORO, K., SAHRONI, D., PENIWIDIYANTI, SUJARWO, W. 2024. Pengetahuan masyarakat lokal mengenai penyebab kelangkaan saninten (*Castanopsis argentea* (Blume) A.DC.) dan tungurut (*Castanopsis tungurrut* (Blume) A.DC.) di desa penyangga Taman Nasional Gunung Halimun Salak. *Reinwardtia* 23

(1): 15–32. — Saninten (*Castanopsis argentea*) dan tungurut (*Castanopsis tungurrut*) merupakan jenis tumbuhan dari suku Fagaceae yang menjadi salah satu komposisi penyusun hutan pegunungan di Taman Nasional Gunung Halimun Salak (TNGHS). Kedua jenis ini kini termasuk ke dalam kategori tumbuhan terancam punah (*Endangered*) berdasarkan IUCN Redlist. Kedua jenis tersebut dimanfaatkan bijinya untuk dikonsumsi dan kayunya untuk bahan bangunan. Tujuan penelitian ini adalah untuk mengkaji pengetahuan masyarakat terkait keberadaan dan kelangkaan kedua jenis, serta penyebab kelangkaan kedua jenis di desa penyangga TNGHS. Penelitian ini dilakukan menggunakan metode survei dan wawancara semi terstruktur pada sejumlah informan. Data yang diperoleh diuraikan dan dianalisis secara deksriptif. Hasil studi mengungkapkan bahwa masyarakat lokal secara umum memiliki pengetahuan mengenai kelangkaan jenis berdasarkan fakta di lapangan, bukan berdasarkan undang-undang atau status konservasi, bahwa keberadaan kedua jenis tersebut saat ini sudah sulit ditemukan di desa penyangga TNGHS. Berdasarkan pengetahuan masyarakat lokal, penyebab kelangkaan jenis dapat dikelompokkan menjadi faktor internal dan faktor eksternal. Faktor internal diantaranya adalah kedua jenis memiliki pola regenerasi alami yang lama, sulit berkecambah hingga anakan yang rentan terhadap kondisi lingkungan. Faktor eksternal meliputi eksploitasi biji dan kayu, hilangnya habitat, adanya perubahan iklim, keterbatasan pengetahuan, keterampilan, dan pemahaman terhadap tumbuhan hutan, serta keberadaan saninten dan tungurut yang dinilai masyarakat kurang dapat memberikan manfaat ekonomi, sehingga menyebabkan eksistensi saninten dan tungurut mulai dilupakan.

Kata kunci: Buah konsumsi, etnobotani, jenis terancam, konservasi, regenerasi lambat.

INTRODUCTION

The Gunung Halimun-Salak National Park is one of the national parks established by Indonesia's Minister of Forestry Decree No. 175/Kpts-II/2003, aimed at conserving the conservation area (Kurniawan *et al*., 2018). This area boasts high biodiversity, particularly in plant species. According to the Gunung Halimun-Salak National Park Authority (2022), explorations conducted have documented over 700 species of flowering plants, comprising 391 genera from 119 families. *Castanopsis argentea* (*saninten*) and *C. tungurrut* (*tungurut*), commonly referred to as forest rambutans, are among the species that can be found in the Gunung Halimun-Salak National Park. The International Union for Conservation of Nature (IUCN) categorized *C. argentea* and C. *tungurrut* as endangered species in 2018 (Barstow & Kartawinata, 2018a; Barstow & Kartawinata, 2018b). It is no surprise that *C. argentea* is now a rare and protected species according to Indonesia's Minister of Environment and Forestry Regulation No. 106/2018, as this species has become increasingly challenging to find in Indonesia (Harapan *et al*., 2022). The knowledge held by communities living around forest areas becomes crucial information in determining subsequent solutions for sustainable biodiversity management.

Castanopsis argentea has experienced a 50% decline in population, while *C. tungurrut* has seen a 30% decrease in population over the last three generations. Within the conservation area of the Gunung Halimun-Salak National Park, *C. argentea* is scattered with populations ranging from seven to 13 trees per hectare, whereas *C. tungurrut* has a density of two to 35 trees per hectare (Barstow & Kartawinata, 2018a; Barstow & Kartawinata, 2018b). Research conducted by Bailey *et al*. (1995) as cited in Hidayat & Fijridiyanto (2002) observed a low presence of *C. argentea* saplings in the western part of the Gunung Halimun-Salak National Park. Additionally, Yumarni (2012) recommended the necessity for conservation efforts for both species within the Gunung Halimun-Salak National Park region.

Both species are extensively utilized by the local community surrounding the Gunung Halimun-Salak National Park. According to Rahayu & Harada (2004), the nearby communities utilize *C. argentea* and *C. tungurrut* as construction materials due to their high-quality wood. Wardah (2005) mentions that *C. argentea* fruits can be processed into flour used for making cakes. Research conducted by Hidayat & Fijridiyanto (2002) further suggests that there is an excessive use of *C. argentea* for natural medicinal purposes and its fruits can be consumed. The excessive exploitation of both species is suspected to be a reason contributing to their scarcity.

The management of endangered plant species often encounters various challenges, such as the lack of information regarding the causes of scarcity and extinction, as well as the absence of technical guidelines for effective planning (Primack, 1998). Exploitation of a species without considering conservation or sustainable management can lead to its endangerment and eventual extinction. Hence, exploring the knowledge of local communities, who coexist directly with *C. argentea* and *C. tungurrut*, becomes crucial in understanding the factors causing the scarcity of these species.

This research aims to assess the local community's knowledge regarding the presence and scarcity of *C. argentea* and *C. tungurrut*. Additionally, it seeks to understand the community's insights into the causes of scarcity for these species in the buffer villages surrounding Gunung Halimun-Salak

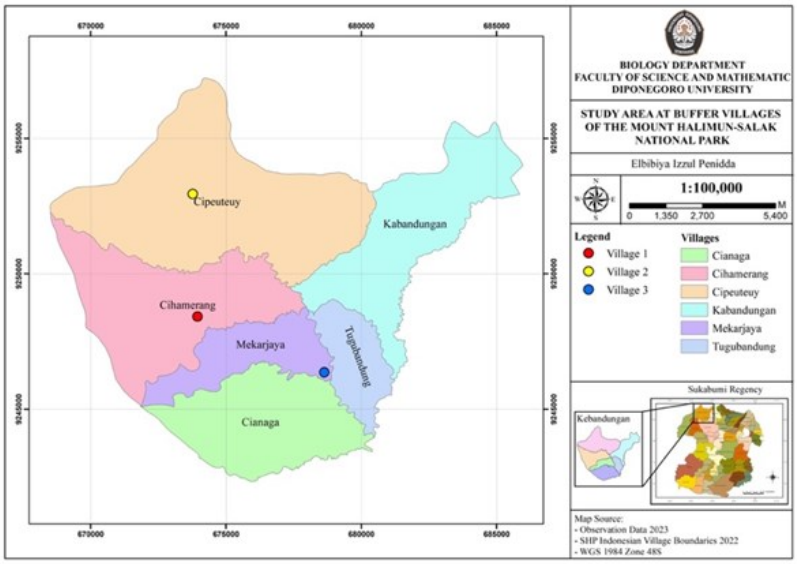

Fig. 1. Location of the study area in the buffer villages surrounding Gunung Halimun-Salak National Park.

National Park. Revealing the local knowledge from communities around the forest can serve as a reference and offer solutions to address issues related to scarcity, enabling the sustainable management of *C. argentea* and *C. tungurrut* to maintain their populations.

MATERIALS AND METHODS

Study Area

This research was conducted from December 2022 to March 2023 in the buffer zone of the Gunung Halimun-Salak National Park, which encompasses Cipeuteuy, Cihamerang, and Mekarjaya Villages within Kabandungan Sub-district, Sukabumi Regency, West Java (see Fig. 1). These villages were selected as research sites based on their proximity to the conservation area of the Gunung Halimun-Salak National Park and the local community's knowledge regarding the species and use of endangered plants, namely *Castanopsis argentea* (*saninten*) and *C. tungurrut* (*tungurut*).

Data Collection

Gentles *et al.* (2015) stated that the estimated number of informant to reach the saturated level in phenomological descriptive qualitative research is 12 participants. In this study, we employed survey methods and semi-structured interviews involving 22 informants knowledgeable about the causes of the scarcity of *C. argentea* and *C. tungurrut* species. The decision to limit the number of informants was based on the principle of data saturation, which occurs when no new information or themes emerge from additional interviews. In qualitative research, data saturation is an important criterion for determining sample size, as it indicates that we have obtained a sufficient depth and breadth of data to address the research questions. Additionally, this approach ensures that the research findings are based on a comprehensive understanding of the topic and are not influenced by potential bias or incomplete information. Our informants were directly engaged in utilizing both species in the buffer villages of Gunung Halimun-Salak National Park. Informants were purposefully selected based on recommendations from community leaders and individuals closely associated with both species. Additional informants were then identified using the snowball sampling method, relying on suggestions provided by already engaged informants within the researched villages. An overview of the specific questions can be seen in the Table 1.

Data Analysis

The data from informant interviews were analyzed descriptively (Tatlidil *et al*., 2009; Dawoe *et al*., 2012). Furthermore, the interview findings were quantified using a modified citation frequency (CF) presentation, adjusted to suit this research context. The employed formula is as follows:

$$CF = \frac{n}{N} \times 100\%$$

Here, "*n*" represents the quantity of information conveyed by informants, while "*N*" stands for the total number of informants. The percentage of

Table 1. Overview of the specific questions.

Data Type	No.	Aspects studied	Question overview
Respondent Characteristics	1	Name	What is your name?
	2	Age	How old are you?
	3	Gender	No need to ask.
	4	Education	What was the last education you received?
	5	Livelihood	What is your occupation?
Scarcity of *saninten* and *tungurut* species in the buffer villages of Gunung Halimun-Salak National Park	1	The existence of both species in the buffer villages of Gunung Halimun-Salak National Park	a. Do you know *saninten* and *tungurut*? b. How much do you know about these two species? c. Are you familiar enough with these two species? d. Are you aware of the existence of *saninten* and *tungurut*? e. Where are they distributed? f. Are their presence quite familiar around you?
	2	Community knowledge regarding the morphological differences between *saninten* and *tungurut*	a. Do you know the difference or could you differentiate between the two species? b. How do you differentiate the two species?
	3	Community knowledge about the rarity of both species	a. Do you know that these two species are protected and endangered plant species? b. How do you know that these two species are rare and protected? c. Has there ever been any outreach or counseling regarding endangered plant species in this area? d. Where does this socialization come from? e. When was the socialization held? f. Are you aware that there are sanctions for taking these species without permission? What is your response regarding this matter?
	4	Community knowledge regarding the causes of the scarcity of *saninten* and *tungurut*	a. What are the uses of these two species here? b. What are the majority used for? c. Which is more widely used, *saninten* or *tungurut*? d. Have you ever used these two species? e. Where did you get these species? From inside the forest or outside the conservation forest? f. What are these species used for? Selling or using them? Where are they sold? g. What is the reason behind selling these species?

information provided by respondents may exceed 100% as some individuals might share multiple crucial pieces of information. This variation in comprehension levels is due to differences in gender, age, education, and profession among the informants.

RESULTS

Community Knowledge of *Castanopsis argentea* and *C. tungurrut*

The ethnicity of the interviewed respondents was all Sundanese. The interviewed respondents were mostly male (81.82%) and were predomi-

Table 2. Local community knowledge regarding the morphological differences between *Castanopsis argentea* and *C. tungurrut.*

No.	Morphological characters	*Castanopsis argentea*	*Castanopsis tungurrut*
1	Tree canopy	Widened	Tall
2	Bark	Grayish brown	Greenish brown
3	Leaf	Smaller	Wider
4	Fruit's thorn	Shorter	Longer
5	Seed	Pyramid shape, in one fruit there are 3–5 seeds	Oval shape, in one fruit there is only one seed

nantly engaged in occupations, such as farming (54.55%) and construction work (13.64%). while female informants accounted for a lower percentage (18.18%) and were primarily involved in household activities (13.64%). In terms of age, over 50% of informants were aged over 56, followed by other productive age groups above 25. Regarding education, most informants had attended primary school (54.55%), with only 9.09% reaching a bachelor's degree level.

Castanopsis argentea and *C. tungurrut* trees have almost the same morphological characters. However, the locals in the study area (19 informants, 86%) can specifically differentiate the two species based on the morphological differences. The morphological differences between the two species are tabulated in Table 2 and shown in Fig. 2. Based on the knowledge of the local community, both species have several characteristics that can be simply differentiated. What can be seen clearly is that the canopy of *C. argentea* tree is wider than *C. tungurrut*. The tree of *C. argentea* has many branches and twigs, while *C. tungurrut* has a taller tree canopy and fewer branches and twigs. The trunks of *C. argentea* and *C. tungurrut* trees can be differentiated by the color of their bark, where the trunk of *C. argentea* is grayish brown bark, while *C. tungurrut* is brown, tending to greenish bark.

The leaves of the two species differ in leaf size. *Castanopsis argentea* leaves are smaller than *C. tungurrut*. The fruits of *C. argentea* and *C. tungurrut* can be distinguished by their spines, where the spines on the skin of *C. argentea* fruit are shorter compared to *C. tungurrut*, which are longer. In one *C. argentea* fruit there are 3–5 seeds which are slightly round and triangular (pyramid) and are smaller in size than *C. tungurrut*. In *C. tungurrut* fruit, there is only one seed, which is oval and larger in size than the seeds of *C. argentea*. The difference is that *C. argentea* cupule does not have branched spines and there are 3–5 seeds in one cupule, while *C. tungurrut* has one seed per cupule and the spines are slender and branched. The seeds of *C. argentea* can be eaten raw and have a sweeter taste, while *C. tungurrut* seeds must be cooked first before consumed and have a slightly bitter taste.

The analysis of the presence and scarcity of *C. argentea* and *C. tungurrut* in the buffer villages surrounding the Gunung Halimun-Salak National Park (see Table 3) indicates that a majority of the community members have a connection to these species through their forest activities and previous and current consumption of their fruits. Apart from using the fruits as snacks, the community also identifies these species through their wood usage. Additionally, people generally differentiate between *C. argentea* and *C. tungurrut* based on leaf size and fruit taste.

The community's knowledge of the presence and habitat of *C. argentea* and *C. tungurrut* generally indicates that both species are commonly found in the forest, although some have also encountered these endangered species growing around the village. The populations of *C. argentea* and *C. tungurrut* are relatively balanced. In addition, some informants believe that the populations of *C. argentea* and *C. tungurrut* in the forest have become more abundant than before due to the community's prohibition of logging wood from the forest. The community's response to the scarcity of these two species suggests the necessity for protective measures and refraining from harvesting them in their natural habitat.

Causes of Scarcity and Conservation Efforts

The scarcity of *C. argentea* and *C. tungurrut*, as revealed by the data, is primarily due to the utilization of their wood for construction purpo-ses and their fruits for consumption (see Table 4). The scarcity of these species is influenced by several factors, including challenges in germination (31.82%), infrequent fruiting periods (27.27%), and land use changes (22.73%). The involvement of local communities in forest areas has led to a decline in the populations of these species throughwood harvesting (45.45%) and the utiliza-

Table 3. Presence and scarcity of *Castanopsis argentea* and *C. tungurrut* in buffer villages of the Gunung Halimun-Salak National Park.

No.	Parameters	No.	Informants' Responses (%)	
1	Engagement with the species	1	Entering and exiting the forest	59.09
		2	Consuming the seeds	50.00
		3	Participating in species propagation	13.64
		4	Using plant parts for roofing or crafts	9.09
		5	Participating in reforestation or tree planting initiatives within the Gunung Halimun-Salak National Park	9.09
		6	Previously worked as a conservation area manager	9.09
		7	Participating in awareness programs	4.55
		8	No association	4.55
2	Community's knowledge of the species	1	Knows and consumes the seeds	68.18
		2	Does not know	18.18
		3	Knows and plants them beside the house	4.55
		4	Knows and utilizes their woods	4.55
		5	Knows but does not utilize them	4.55
3	Community's knowledge of species' differences	1	Can distinguish	81.82
		2	Does not know	18.18
4	Community's knowledge of species' presence	1	Knows; in the forest	36.36
		2	Knows; in the forest, but previously found in the village	36.36
		3	Does not know	22.73
		4	Knows; in the forest and around the house	4.55
5	Community's knowledge of species' population	1	*Castanopsis argentea* and *C. tungurrut* are equally abundant	45.45
		2	*Castanopsis argentea* and *C. tungurrut* are equally abundant, and now are more abundant than before	27.27
		3	Does not know	22.73
		4	*Castanopsis argentea* and *C. tungurrut* are equally abundant, but previously more abundant than now	4.55
6	Community's knowledge of species' scarcity	1	All plant species in the forest cannot be harvested, except for their fruits	45.45
		2	Does not know	22.73
		3	*Castanopsis argentea* and *C. tungurrut* cannot be harvested.	31.82
7	Community's response to species' scarcity	1	Does not know	54.55
		2	Should be protected	22.73
		3	Does not need to be harvested	22.73

Fig. 2. Morphological comparison between *Castanopsis argentea* and *C. tungurrut*. A. Bark of *C. argentea.* B. Bark of *C. tungurrut*. C. Fruit of *C. argentea.* D. Fruit of *C. tungurrut*. E. Seeds of *C. argentea.* F. Leaves of *C. argentea.* G. Seeds of *C. tungurrut*. H. Leaves of *C. tungurrut.* Photos by Peniwidiyanti (A-D, F & H) and Deni Sahroni (E & G).

Table 4. Causes of species scarcity.

No	Parameters	No.	Informants' Responses (%)	
1	Species utilization	1	Uses the wood for construction purposes	86.36
		2	Consumes the fruit	86.36
		3	Does not know	13.64
2	The community's knowledge regarding species scarcity causes	1	Difficulties in germination	31.82
		2	Infrequent fruiting periods	27.27
		3	Land use changes	22.73
		4	Wood harvesting	18.18
		5	Does not know	18.18
		6	Slow plant growth	13.64
		7	Seeds consumed by humans and animals	13.64
		8	Other growth disturbances	4.55
3	The community's role in species scarcity causes	1	Wood harvesting	45.45
		2	Seeds utilized by humans	31.82
		3	Does not know	9.09
		4	Slow growth	9.09
		5	Land use changes	4.55

tion of fruits and seeds (31.82%).

Castanopsis argentea and *C. tungurrut* are recognized for their wood, which serves as a construction material for houses. In fact, within the researched areas, several houses still utilize the wood from both species (see Fig. 3). These woods have a prolonged utility due to their classification as durable and of commendable strength. Generally, the local community in the buffer villages surrounding Gunung Halimun-Salak National Park uses *C. argentea* and *C. tungurrut* wood to support roof structures, such as roof trusses. Additionally, both types of wood are employed as door and window frames, as well as for house ceilings.

Gunung Halimun-Salak National Park has a long history of changing the area's status. Before Indonesia got its independence in 1945, the Dutch initially designated the area as a nature reserve. However, in 1961, it was altered and managed by the *Perusahaan Umum Kehutanan Negara* (Indonesia state-owned enterprise or Perum Perhutani) to harvest the woods. Then, in 1992, the Mount Halimun landscape was designated as Halimun National Park. The area of the national park changed again in 2003, when part of the Mount Salak landscape, which was managed by Perum Perhutani, was then included as part of the Gunung Halimun-Salak National Park area. The local people living in the buffer villages used to have access to harvest *C. argentea* and *C. tungurrut* woods. However, since 2016, they are no longer doing wood harvesting, because the entire area has become part of the national park with strict regulations.

The local community recognizes that *C. argentea* and *C. tungurrut* possess quality attributes due to their strong, water-resistant, and termite-resistant wood properties. Between 1980 and 1999, these woods were among the preferred choices, although their wood mass was heavy and challenging to transport from the forest. In the past, locals would generally obtain *C. argentea* and *C. tungurrut* woods for personal needs, while some would engage in selling them. The trade of these wood species within the buffer villages of the Gunung Halimun-Salak National Park involves consumers ordering wood from skilled wood workers familiar with navigating the forest. Wood sellers would then locate and fell *C. argentea* or *C. tungurrut* trees, processing them for immediate use in building houses or crafting tools based on the customers' requests.

One informant from Cipeuteuy Village used *C. argentea* wood to complete the ceiling, rafters, and frames in their house. This *C. argentea* wood was acquired by ordering it from a carpenter willing to retrieve it from the forest. The house, established in 1987, reached 35 years old in 2022. Despite its age, the building remains sturdy, showing no signs of decay or termite damage. Interestingly, even the house's rafters were made solelyof *C. argentea* wood without the use of iron. The *C. argentea* wood used in construction can be seen in Fig. 3. In 1987, *C. argentea* wood was

Fig. 3. The utilization of *C. argentea* and *C. tungurrut* wood. A & B. *Castanopsis argentea* wood is used for house ceilings. C. *Castanopsis argentea* wood for window frames. D. *Castanopsis argentea* wood for casings. E & F. *Castanopsis tungurrut* wood is used for roof rafters. Photos by Elbibiya Izzul Penidda.

Fig. 4. The expansion of intercropping (*tumpangsari*) farming areas in Cipeuteuy Village. Photo by Deni Sahroni.

Table 5. Local community's methods of propagation.

No.	Parameters	No.	Informants' Responses (%)	
1	Implementation of propagation techniques for the *C. argentea* and *C. tungurrut* species by the community	1	None yet	63.64
		2	Does not know	18.18
		3	Exists; natural propagation	9.09
		4	Exists; seed propagation	4.55
		5	Exists; cutting propagation but has not been successful	4.55
2	Local propagation techniques for other species	1	Does not know	63.64
		2	Propagation via seeds	27.27
		3	Natural propagation	9.09
3	Challenges encountered in local species conservation efforts	1	Does not know	72.73
		2	No initiative yet	13.64
		3	Plants easily perish	13.64

relatively expensive at 18,000.00 IDR per m^3 from the initial seller. Therefore, the use of *C. argentea* or *C. tungurrut* wood as construction materials was limited, considering the economic capabilities at that time.

Another informant from Mekarjaya Village also utilized *C. argentea* wood for crafting roof trusses and casings (ceiling supports) for their house starting in 2012. By 2022, this construction wood had aged around 10 years (see Fig. 3). Unlike the previous informant, the *C. argentea* wood used by the Mekarjaya Village informants did not come from the forest; instead, it was sourced from *C. argentea* trees planted near their house. Planting *C. argentea* trees and later harvesting them after 25 years of growth is one approach the community adopts to utilize *C. argentea* wood without having to venture into the forest. This stems from the aspiration to construct homes using high-quality wood. During the 1980s, *C. argentea* wood was esteemed as the top-quality construction timber, commanding a relatively high market price. This made it more accessible for individuals with limited economic means to plant and later harvest the wood themselves. Alongside the use of *C. argentea* wood, the community in the buffer villages of Gunung Halimun-Salak National Park also utilized *C. tungurrut* wood. An informant from Cihamerang Village employed *C. tungurrut* wood as the roofing material for their house. Obtained from the forest around 20 years ago by felling a roughly 30-year old *C. tungurrut* tree, this wood was used for the house's rafters (see Fig. 3). Despite displaying minor decay along the edges caused by termite bites, the *C. tungurrut* wood has endured and remains robust and resilient. With the expansion of the Gunung Halimun-Salak National Park's working area in 2003, there has been no extraction of *C. argentea* or *C. tungurrut* wood from the forest area. This is due to regulations that prohibit individuals or community groups from harvesting wood in the forest. However, at the start of the transition phase when the entire operational area previously managed by the state-owned timber company (*i.e.* Perum Perhutani) transformed into a conservation zone, the Gunung Halimun-Salak National Park Authority still allowed local communities in the buffer villages to harvest one tree from the forest for personal use, prohibiting its sale. Additionally, the extraction of trees with small trunk diameters was forbidden to prevent a decline in the species population. Since 2011, the logging of trees for construction timber within the Gunung Halimun-Salak National Park has decreased compared to previous years due to the implementation of penalties and limitations on access to the conservation area.

The harvesting of *C. argentea* and *C. tungurrut* wood ceased in the early 2000s. However, locals still utilize the seeds of these species for consumption. *Castanopsis argentea* and *C. tungurrut* bloom and bear fruit once a year, typically during a prolonged dry season. When these species bear fruits, communities in the buffer villages of the Gunung Halimun-Salak National Park gather them, whether they have fallen to the forest floor or remain on the trees. Usually, locals collect *C. argentea* or *C. tungurrut* fruits for personal use. Additionally, one informant mentioned it is common for people to bring sacks and fill them with these fruits. The extensive fruit collection significantly reduces the chances of new *C. argentea* or *C. tungurrut* saplings growing, posing a severe threat to their natural population in the forest.

Given the substantial exploitation of *C. argentea* seeds, propagation efforts become crucial as a conservation measure. Seeds that can be germinated must be ripe, as indicated by the fruits

falling from the trees by themself with opening cracking peel. The community was still collecting *C. argentea* seeds to consume (see Table 3 and Table 4). Because the tree does not bear fruit every year. The seeds taste delicious, and the locals consider this quite special. Apart from that, in the past, the populations of *C. argentea* and *C. tungurrut* were abundant. However, based on current locals' perceptions, it is more abundant than before (see Table 3), so people do not worry about the regeneration of both species.

Land use conversion is one of the reasons for the scarcity of *C. argentea* and *C. tungurrut* species (see Table 3). When the forest corridor managed by Perum Perhutani shifted into a production forest, the management introduced a system of "*tumpangsari*" (intercropping). In 2003, the forest management responsibility was transferred to the Gunung Halimun-Salak National Park Authority. Following Indonesia's Minister of Forestry Regulation No. P.56/2006 regarding National Park Zoning, which served as the basis for establishing a specific zone, the area's utilization to support the livelihoods of local communities (before its official recognition as a national park). Due to the high demand from local communities to establish new "*tumpangsari*" farming plots for their livelihoods, the Gunung Halimun-Salak National Park Authority has opened new "*tumpangsari*" fields. However, the area surrounding the forest corridor is the native habitat of *C. argentea* and *C. tungurrut* (see Fig. 4). Additionally, some community groups have illegally expanded "*tumpangsari*" areas.

Due to the opening of intercropping(*tumpangsari*) areas around the forest corridor, the Gunung Halimun-Salak National Park Authority, together with the forest buffer zone communities, signed a cooperation agreement to manage the forest corridor. One of the agreements stated that areas implementing the "*tumpangsari"* system must be planted with native plants from the Gunung Halimun-Salak National Park. However, despite this, communities in the buffer zones of Gunung Halimun-Salak National Park continue to cultivate their land. The Gunung Halimun-Salak National Park Authority encourages these communities to also plant native species on their agricultural land. The commonly planted native tree species by communities are *rasamala* (*Liquidambar excelsa* (Noronha) Oken) and *puspa* (*Schima wallichii* (DC.) Korth.). These two plant species are highly sought after by the community due to their valuable wood and relatively rapid growth. Consequently, few, if any, farmers are cultivating *C. argentea* and *C. tungurrut* in their fields, despite these plants being native and currently facing extinction.

Informants from Cipeuteuy and Mekarjaya Villages reported that 10 to 20 years ago, *C. argentea* and *C. tungurrut* thrived in the forest corridor area. However, with the opening of new fields and given the slow growth and extensive regeneration period of these species, as they mature and their canopy spreads, shading the crops below, the community is compelled to cut them down and replace them with other tree species that offer greater economic benefits.

Based on interviews with the informants, the propagation methods for *C. argentea* and *C. tungurrut* are still unknown to many people (63.64%), despite some starting to use methods like natural propagation, seeds, and cuttings (see Table 5). Harvesting wood and seeds and a lack of knowledge about the growth of these two endangered species have become serious problems for current propagation and cultivation efforts. Moreover, conservation efforts for *C. argentea* and *C. tungurrut* face obstacles due to community unawareness about available actions (72.73%), a lack of initiative to start conservation activities (13.64%), and a perception that these species are prone to easy mortality (13.64%).

DISCUSSION

Local Community Knowledge of *Castanopsis argentea* and *C. tungurrut* Population Status

The residents living around the villages adjacent to Gunung Halimun-Salak National Park generally understand *C. argentea* and *C. tungurrut* plants. Furthermore, some informants can explain the morphological differences between these two endangered plant species. Based on Murna *et al.* (2020), the canopy type on the wide and round *C. argentea* tree can be interpreted as globular, while the canopy type on the tall and slender *C. tungurrut* is called columnar. Heriyanto *et al.* (2007) stated that the wood of *C. argentea* tree is gray-brown to pink, the sapwood or middle wood is white, light yellow and sometimes reddish. In contrast, according to Putri & Suhendri (2018), the wood of *C. tungurrut* is covered with greenish bark. Other differences between *C. argentea* and *C. tungurrut* can be seen in the leaves and cupules. Heriyanto *et al.* (2007) stated that *C. argentea* has elongated pointed leaves (lanceolate), measuring 7–12 cm, 2–3.5 cm wide, 5–6 cm thick. Based on Harapan *et al.* (2022), *C. argentea* has leaves that are shiny on the top and have a slightly silvery colour on the bottom, while based on Barstow & Kartawinata (2018), *C. tungurrut* has leaves with golden brown hair when young, the surface of the leaves is colored dark green on top and brownish on the bottom when old. Harapan *et al.* (2022) informed that *C. argentea* and *C. tungurrut* have similar sharp spiny cupules.

Knowledge regarding the existence of both species is widespread among individuals in the late

Table 6. Factors contributing to the scarcity of *Castanopsis argentea* and *Castanopsis tungurrut*

No.	Internal Factors	No.	External Factors
1.	A slow natural regeneration pattern	1.	Excessive exploitation of seeds
2.	Difficulties in germination	2.	Timber exploitation in the past
3.	Vulnerability of saplings of both species to environmental conditions	3.	Habitat loss due to land use changes leading to their diminishing presence
		4.	Climate change
		5.	Limited knowledge, skills, and understanding of forest plants

adult age category (36–45 years old) up to the elderly (65 years and above). Their past and current activities involving forest expeditions and consumption of *C. argentea* and *C. tungurrut* seeds have made them easier to distinguish between the two. Additionally, informants who have attempted to propagate mountainous plant species or have been involved in conservation management also possess knowledge about *C. argentea* and *C. tungurrut* trees.

Among the younger generation in the study area, only a few informants in the late adolescent (17–25 years old) and early adulthood (36–45 years old) categories are familiar with both species. The prohibition of activities or resource extraction from the forest is a significant factor contributing to the current generation's limited knowledge of *C. argentea* and *C. tungurrut*. Moreover, the populations of these species are now scarce in the vicinity of the villages. As a result, their understanding of *C. argentea* and *C. tungurrut* is mainly derived from stories passed down by elders or occasional educational sessions conducted by the Gunung Halimun-Salak National Park Authority. Another reason why the younger generation is less acquainted with *C. argentea* and *C. tungurrut* is the shift in social behavior due to technological advancements. The rise in technology can be observed through the increased engagement of the community in television programs and the widespread use of gadgets. Suryono (2019) explains that changes in social behavior can result from external factors, such as innovations in technology. The younger generation, who have never entered the national park area, certainly do not have sufficient knowledge to recognize and differentiate between *C. argentea* and *C. tungurrut*. The reduced interest and attention of the younger generation towards both species needs a serious concern because this does not only happen around the Gunung Halimun-Salak National Park but also in many other areas, such as community groups in Gayo Highland (Navia *et al.,* 2020), the Minangkabau and the Mandailing ethnic groups (Pawera *et al.,* 2020), and Batak Karo ethnic group (Lavenia & Dewi, 2020), due to limited access and opportunities for the younger generation to further explore forests and the current convenience of foods, so they do not need to enter the forests to collect food sources.

The utilization of *C. argentea* and *C. tungurrut* seeds by the local community has been known for ages, although most informants nowadays find consuming both seeds challenging. The seeds of *C. argentea* boast a sweeter and softer taste compared to *C. tungurrut*. They can be consumed directly or processed beforehand. In the past, certain community groups even used *C. argentea* seeds to produce flour. This aligns with research conducted by Wardah (2005), which mentions that *C. argentea* seeds can be processed into flour for making cakes. Apart from being used as a raw material for processed foods, consuming *C. argentea* seeds is believed to help maintain bodily health and is used as a natural remedy (Hidayat & Fijridiyanti, 2002). In contrast to *C. argentea* seeds, *C. tungurrut* seeds require various processing methods like boiling, grilling, frying, or roasting before consumption. Additionally, *C. tungurrut* seeds have a slightly bitter taste. Harada (2004) highlighted the utilization of *C. argentea* and *C. tungurrut* by communities surrounding the Gunung Halimun-Salak National Park, not only as food and construction materials for homes but also as fuel sources, such as firewood to cook traditionally. Even today, residents near Cikaniki—a research station managed by the Gunung Halimun-Salak National Park Authority—occasionally indulge in *C. argentea* and *C. tungurrut* seeds as snacks during their fruiting seasons (Dewi *et al.*, 2023), despite *Castanopsis* spp. having a notably low regeneration rate (Nurdiana & Buot, 2021).

Generally, the community is aware that *C. argentea* and *C. tungurrut* can be found growing within the forest area. In fact, after several years of restrictions on resource extraction from the forest, they understand that the populations of *C. argentea* and *C. tungurrut* should be more plentiful now. The community's awareness of refrain-

ing from taking wood from the forest has developed due to regular socialization activities held every year. Tinambunan (2011) explains that the Gunung Halimun-Salak National Park Authority communicates the regulations enforced among the community. These regulations include prohibitions, such as entering areas designated as nature reserves (1953–1992), logging within the Gunung Halimun-Salak National Park zone, land cultivation, and selling forest products. However, the interview results in this study indicate that, specifically, the community lacks knowledge about the specific protected plant species, their conservation status, and the penalties for violating these regulations. The community generally perceives that all plant species within the forest area are protected and should not be harvested. Moreover, concerning the community's response to the scarcity of *C. argentea* and *C. tungurrut*, only a few are aware of potential actions to take, while others believe that plants within the forest area should be conserved and left undisturbed.

The Threat of Extinction to *Castanopsis argentea* and *C. tungurrut*

Castanopsis argentea and *C. tungurrut*, both belonging to the family Fagaceae, are plant species that dominate mountainous forests. The silvicultural lifespan of these species is relatively long; *C. argentea* can live up to 75 years (Barstow & Kartawinata, 2018a), while *C. tungurrut* can survive for up to 100 years (Barstow & Kartawinata, 2018b). They are primarily used for construction timber, and their seeds are consumed by both humans and animals. The community's awareness of the scarcity of these species in the buffer villages of Gunung Halimun-Salak National Park can be divided into two factors: internal and external (see Table 6). Internal factors originate from the physiology and environmental conditions in which these species grow, while external factors are human-induced causes contributing to their scarcity.

Internal Factors

1. A Slow Natural Regeneration Pattern

The communities in the buffer villages of the Gunung Halimun-Salak National Park previously utilized *C. argentea* and *C. tungurrut* wood for house construction, which could be harvested around 20 to 35 years of age. This suggests that both species have a long lifespan. Typically, *C. argentea* and *C. tungurrut* only bear fruit once a year, following a prolonged dry season. The fruits produced annually often contain seeds that are not always viable, as commonly found seeds tend to rot or be empty. *Castanopsis argentea* sometimes flowers from August to October, followed by fruiting from November to February. However, locating natural saplings of these tree species is challenging as fallen fruits easily decay or get damaged due to consumption by animals or humans (Heriyanto *et al*., 2007). *Castanopsis argentea* exhibits a clustered distribution pattern and a low regeneration capacity, although its vertical density typically demonstrates an inverted J-curve in the forested areas of the Gunung Gede Pangrango National Park (Hilwan & Irfani, 2018). On the other hand, regarding the *C. tungurrut* species, Simbolon (2001) elaborates that the regeneration of *C. tungurrut* in the submontane forests of Mount Halimun is notably poor and experiences a high mortality rate.

2. Difficulties in Germination

More than 30% of the respondents indicated that the scarcity of *C. argentea* and *C. tungurrut* is due to difficulties in germination. This is supported by various research endeavors aimed at propagating these endangered species. *Castanopsis argentea* propagation has been experimented with using in vitro methods due to the challenges of propagating the species from seeds (Surya *et al*., 2017). In addition, the methodology for propagating *C. tungurrut* is currently unknown.

3. Vulnerability of C. argentea and C. tungurrut Saplings to Environmental Conditions

Another challenge in increasing the population of *C. argentea* and *C. tungurrut* is the threat of seedling damage due to their surrounding habitat. Disruptions and potential damage to *C. argentea* seedlings can result from drought, being shaded, or competing with other plants. The presence of wildlife also poses a threat to the growth of both *C. argentea* and *C. tungurrut* seedlings, such as wild boars. Typically, seedling trees lack sufficient woody structure, thus lacking the resilience necessary for their survival (Raharjo *et al*., 2017). Survival rate tests of *C. argentea* and *C. tungurrut* seedlings in restoration areas indicated a low percentage, with 66.67% for *C. argentea* and 33.33% for *C. tungurrut*, primarily due to stem breakage or disruptions caused by weeds (Handayani *et al*., 2019).

External Factors

1. Excessive Exploitation of Seeds

Castanopsis argentea and *C. tungurrut* are two plant species classified as endangered, yet Indonesia's Minister of Environment and Forestry Regulation No. 106/2018 only designates *Castanopsis argentea* (*saninten*) as a protected plant species in Indonesia. Additionally, Minister of Environment and Forestry Regulation No. 35/2007 regarding Non-Timber Forest Products specifies that *Cas-*

tanopsis spp. species can only utilize the bark, as it can be processed into natural dye. This demonstrates the government's commitment to reducing potential disturbances and the extinction of *Castanopsis* species in Indonesia. Therefore, excessive collection of fruits and seeds from *C. argentea* or *C. tungurrut* should be avoided, except when the trees of these species are outside conservation areas and are specifically cultivated for fruit, seed, or timber utilization. The past excessive utilization of fruits and seeds by the community has undoubtedly contributed to the decline in the population of both *C. argentea* and *C. tungurrut* seedlings and trees today.

2. Timber Exploitation in the Past

The challenge akin to the utilization of fruits and seeds involved the overharvesting of *C. argentea* and *C. tungurrut* wood, leading to a significant decline in their populations. Between 1978 and 2003, before the expansion of the Gunung Halimun-Salak National Park into the surrounding villages, such as Cihamerang, Cipeuteuy, and Mekarjaya, the forest corridor within these villages was managed as a production forest by Perum Perhutani (State-owned enterprises of Indonesia). In 2016, the entire area, which was managed by Perum Perhutani, became part of the Gunung Halimun-Salak National Park area (BTNGHS, 2022). An informant mentioned that during this period, the state-owned timber company (*i.e.* Perum Perhutani) extensively harvested fully grown trees in the forest corridor, including the species of *C. argentea* and *C. tungurrut*. In addition to being excessively harvested by timber company, the logging of *C. argentea* and *C. tungurrut* wood in the past was also carried out by communities for various purposes, such as house construction, bridge building, and firewood. *Castanopsis argentea wood* is classified under durability class III, and strength class II (Kemen-PUPR 1977), while *C. tungurrut* wood falls within durability class III-IV, and strength class I-II (Krisdianto, 2007). The exploitation of *C. argentea* and *C. tungurrut* wood was a significant factor contributing to the scarcity of these species. This assertion is supported by Barstow & Kartawinata (2018a, 2018b), who stated that the populations of both species in Java Island have drastically decreased, likely due to their utilization as construction timber and their excessive exploitation.

3. Habitat Loss Due to Land Use Changes Leading to Their Diminishing Presence

The conversion of land use poses a threat to the habitats and populations of *C. argentea* and *C. tungurrut* in the Gunung Halimun-Salak National Park. Tinambunan (2011) stated that communities are not allowed to cultivate production forest land after the conversion of production forests by Perum Perhutani. Although, Gunung Halimun-Salak National Park Authority designating the zones surrounding the forest corridor as "*tumpangsari*" forests (Supriyanto *et al*., 2010). So that, opening up fields and employing mixed land use around the forest corridors inevitably diminish and harm the habitat conditions for these species. While 10–20 years ago, *C. argentea* and *C. tungurrut* were commonly found around villages and forest corridors, the increasing shift in land use and the high economic needs of the communities have gradually displaced these two endangered plant species. They have been substituted by other tree species that grow faster and can be cultivated in their agricultural areas. Knowledge about *C. argentea* and *C. tungurrut* has also dwindled from generation to generation due to the difficulty in encountering and utilizing these endangered trees in village areas. Additionally, the community has not fully adhered to the conservation area management's advice to plant native trees within the Gunung Halimun-Salak National Park (Tinambunan, 2011).

4. Climate Change

Information gathered from interviews indicates that over the past five years (2018–2022), both *C. argentea* and *C. tungurrut* trees within the forest area of the Gunung Halimun-Salak National Park have not produced flowers or fruits. Kurni (2024, personal communication) said that there is absence of fruiting observed for both species for nearly 5–6 years in the Cibodas Botanical Gardens.. This situation is likely due to Indonesia's general experience of La Niña, which prolonged the rainy season beyond its usual duration. The La Niña event from 2020–2022 caused an unusual rainfall anomaly, extending its impact not only in Indonesia but also across the Pacific region (Hasan *et al*., 2022; Gao *et al*., 2022). The La Niña phenomenon leads to increased rainfall, which can hinder the flowering process. When there is high rainfall and sufficient nutrients, plants may prioritize shoot growth, leading to increased levels of GA and endogenous auxin, affecting the initiation of flowering (Sarvina & Sari, 2017). Climate change, causing weather instability in a region, results in changes in temperature and other environmental conditions. This can potentially influence the flowering induction process and photoperiod for each plant. Prolonged periods of high rainfall and lower temperatures than usual can be factors contributing to the lack of flowering and fruiting in both *C. argentea* and *C. tungurrut*. Boudreau (2008) cited in Hamzah (2010) states that cold nighttime temperatures hinder or delay flowering in certain plants. Hamzah (2010) mentions that the altitude above sea level also affects plant flowering, with plants grown at

lower altitudes flowering earlier than those planted at higher elevations. Excessive rainfall is linked to prolonged sunlight exposure, which has an impact on the gene that regulates flowering, called the *CONSTANS* (CO) gene (Darwati, 2018).

5. Limited Knowledge, Skills, and Understanding of Forest Plants

Local knowledge regarding the cultivation and propagation of *C. argentea* and *C. tungurrut* is limited in the study area. The study on propagating *C. argentea* was carried out in vitro (Surya *et al.*, 2017), while the propagation of *C. tungurrut* has never been carried out. Propagation activities using the stem-cutting technique have also been carried out on *Castanopsis buruana*, but the results were unsuccessful because the experimental activities could not produce the roots (Arif *et al.*, 2021). Limited knowledge and skills in cultivating forest plants, such as *C. argentea* and *C. tungurrut*, make it challenging to restore forest ecosystems. The low natural regeneration of *C. argentea* and *C. tungurrut* should be balanced by ex-situ cultivation skills to preserve Indonesia's native plant species. One of the propagation methods that is currently being developed is using the KOFFCO (Komatsu-FORDA Fog Cooling System) by testing various plant parts, such as shoot cuttings and stem cuttings, especially from the Dipterocarp species (Rachmat *et al.*, 2018). Meanwhile, methods for propagating the *Castanopsis* species that have been considered successful include the stem cuttings method by adding potassium (K) salt of IBA (KIBA) with a success rate of up to 90% for *Castanopsis sclerophylla* (Conden & Blazich, 2003), and *C. hystrix* in China with in vitro regeneration technique that uses stem segments of the species as explants (Zhang *et al.*, 2022). Currently, with limited knowledge and skills in cultivating *Castanopsis* spp. in Indonesia, attention needs to be paid to creating propagation methods that are effective, efficient, low production costs, and easy to use so that communities around the forest can apply these propagation techniques.

Conservation and Sustainable Management Efforts

Conservation efforts—aimed at slowing the decline of *C. argentea* and *C. tungurrut* populations, especially within the Gunung Halimun-Salak National Park—involve gaining support from communities in the buffer villages. Several alternative conservation and management measures that can be implemented include enforcing rules to protect endangered plant species, efforts to propagate and reintroduce endangered plant species in ecosystem recovery areas and increasing dissemination and socialization about the importance of preserving flora and fauna in the forests of the Gunung Halimun-Salak National Park among the communities in the buffer villages.

The presence and role of communities in the buffer villages surrounding Gunung Halimun-Salak National Park in preserving the habitat and populations of endangered plants are crucial. Conservation efforts in the forest significantly affect the socio-cultural lives of these village communities. Residents living near the forest have a strong connection to it, creating a reciprocal relationship between the forest and the people (Yanto, 2013). The primary factor in community participation in collaborative conservation area management should be the close relationship between the community and the forest. This includes the community's reliance on forest resources, historical and socio-cultural ties of the local community, and the livelihoods of those living around the forest. When the community's reliance on these resources is acknowledged and met, it fosters an awareness among them to protect the forest and encourages a commitment to conserving the area (Qodriyatun, 2020). Therefore, effective communication and coordination between conservation area managers and the forest-dwelling community are essential. Furthermore, sharing information, functions, roles, and responsibilities fosters a healthy and productive partnership.

Improving the skills and proficiency of communities in cultivating rare plants, such as *C. argentea* and *C. tungurrut*, is a crucial step in preserving endangered plant species. The current challenge lies in the lack of information and success in propagating these species, posing a significant hurdle that requires an immediate solution. Enhancing the community's understanding and knowledge regarding the importance of *C. argentea* and *C. tungurrut* within the forest ecosystem chain is essential. This can encourage them to willingly plant these endangered plant species in the agricultural areas they tend around the forest corridor.

CONCLUSIONS

The communities in the buffer villages of Gunung Halimun-Salak National Park recognize the presence of *Castanopsis argentea* (*saninten*) and *C. tungurrut* (*tungurut*) in their surroundings. They can even distinguish between these two species. Their understanding and utilization of *C. argentea* and *C. tungurrut* stem from past activities involving frequent entries and exits from the forest and previous and current use of their parts, such as wood and fruits. Generally, their awareness of the species' scarcity is based on practical observations rather than legal regulations or conservation statuses. According to local knowledge, the causes of species scarcity can be categorized into internal and external factors. Internal factors include both

species having a slow natural regeneration pattern, difficulties in germination, and vulnerable seedlings due to environmental conditions. External factors encompass seed and wood exploitation, habitat loss, climate changes, limited knowledge, skills, and understanding of forest plants, and the perceived lack of economic benefits from *C. argentea* and *C. tungurrut*, leading to the gradual neglect of their existence.

All related stakeholders, *i.e.* academics, businesses, governments, and communities, must be responsible hand-by-hand to the existence of *C. argentea* and *C. tungurrut* as native plants of Gunung Halimun-Salak National Park. Apart from that, there is also a need to educate the local people in the study area regarding current regulations of collecting plant species in the Gunung Halimun -Salak National Park. It would be a good step if all related stakeholders could raise awareness among the public by informing them of the protected plant species, the urgency, and the sanctions imposed.

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