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Alarming call from Mursala Island, North Sumatra, Indonesia: The urgent task of conserving the previously reported extinct of *Dipterocarpus cinereus*

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Abstract. *Rachmat HH, Subiakto A, Wijaya K, Susilowati A. 2018. Alarming call from Mursala Island, North Sumatra, Indonesia*: *The urgent task for conserving the previously reported extinct of* Dipterocarpus cinereus. *Biodiversitas 19*: *399-405*. IUCN Red List (1998) declared that the Mursalan endemic *Dipterocarpus cinereus* was extinct in the wild, but brief exploration conducted in the first quarter of 2013 found that there were few numbers of *D. cinereus* still growing in the island. The objectives of this research were: to describe the current condition of the forest in Mursala island; and to determine the vegetation composition and association between *D. cinereus* and other major tree species in site. Identifying forest condition and the potential value of the non-timber product was done descriptively through direct observation and interview with local inhabitants. The vegetation analysis was carried out by a purposive stratified technique in three lines each consisting of 4-8 plots (quadrats). The size of each sampling plot was 1,000 m^2 (r= 17.8 m) with the total of 20 plots. The result showed that *D. cinereus* is still growing in the middle part until the top of the ridges. Importance Value Index (IVI) for the top five species were 32.37, 39.47, 17.43, 15.18 and 11.04 respectively for *D. cinereus, Shorea acuminata, Arenga pinnata, Shorea falcifera* and *Hopea sangal*. Among those five dominant species, only *D. cinereus* with *S. falcifera* and *D. cinereus* with *A. pinnata* had a significant association. Our study also determined that calling for species conservation is alarming rate and those not only needed for *D. cinereus* alone but island ecosystem as a whole.

Keywords: *Dipterocarpus cinereus*, extinct, vegetation analysis, conservation

INTRODUCTION

Mursala Island is the largest island in the District of Central Tapanuli and lies in the south-west of Sibolga Port. The island is located at 01°35'15" - 2°22'0" N and 98°38' - 37°12' E with total area ± 8000 ha. The topography is dominated by hilly and bumpy areas (43%) with an altitude 0-486 m asl. The average temperature was 26.7ºC while humidity was 75%. The area is a tropical region with the dry season comes in June through September, while the rainy season usually comes in November to March. A total number of the resident was only 250 families and identified as Nias ethnic (BPS Tapanuli Tengah 2017). The distance of Mursala Island from the mainland of Sumatra is around 23 km, and it takes 1-hour trip by speedboat. However, it takes a longer time of around 3 hours by local wooden boat.

Mursala Island harbors long history of timber extraction. The first commercial forest concession in Mursala Island was PT. Mujur Timber in around 1980s and held 25 years of land concession. However, the escalating conflict between the company and local peoples had made the company stopped its production and left from the island in the 1990s far before its concession's cycle finished. It was not automatically the island safe from timber extraction. Illegal logging and forest conversion keep happening as the demand for the timber from the island was not decreasing.

Mursala forest has been known for its richness in timbers species, especially Dipterocarpaceae such as *Dryobalanops*, *Shorea*, *Vatica, Hopea, Cotylelobium,* and *Dipterocarpus*. The extensive extraction of those timbers has led certain species to the brink of local extinction. IUCN Red List (1998) declared that *Dipterocarpus cinereus* Slooten, an endemic species in Mursala Island was extinct in the wild. Since then, the forest of the island took less attention both from the nation and local government. The richness of coral and ocean-related resources has been more attractive than those of the island and the timber itself. *D. cinereus* has high economical value and good quality of timber trees for making boats or construction. It is a large tree, twig arranges with leaf bud, stipule, petiole, leaf undersurface. Leaves size 6-8 by 1.7-2.5 cm, lanceolate, thinly coriaceous, distinctly persistently plicate. Inflorescences in a panicle; flower to 4 cm long, axillary simple or single-branched. Stamens c. 25, exceeding style when anthesis (Slooten 1927). The information of its natural regeneration, phenology and artificial propagation of the species has not been reported.

Brief exploration conducted in the first quarter of 2013 found that there were few numbers of *D. cinereus* still growing on the island. It is important to understand the existence of *D. cinereus* in the natural habitat and also its association with other plant species. This research was conducted to achieve some objectives, those: (i) To

describe the forest condition in Mursala island; and (ii) To determine the vegetation composition and association between *D. cinereus* and other major tree species in purposively selected site.

MATERIALS AND METHODS

Location site

Situated between Nias Island and the town of Sibolga, Mursala Island is administratively part of Central Tapanuli Regency (Figure 1). Three transects have been made, two of which had an extremely steep slope with more than 45° thus we used ropes for climbing up at several points. The altitude ranged from 0 to 300 m asl. Mursala is surrounded by beautiful, uninhabited islands nearby, among which the Putri, Silabu Na Godang, Kalimantung, Silabu Na Menek, and Jambe Islands.

Methods

Identification of forest condition

Identification of forest condition was made descriptively through direct observation and interview with local inhabitants during a ten-days trip in April 2017 together with sampling and inventory activities. This section was conducted to determine the potential and current state of forest's threats in Mursala Island. Since the legal status of the whole island clearly and legally assigned as state-owned forest and those classified as protected and limited production forest, any form of utilization, conversion, and management should be under the approval of the government. Those, any activities are done without legal approval assigned to be illegal. This kind of activities will be identified and noted and will determine the potential and current threats level for the forest in the island.

Determining vegetation composition and association of the D. cinereus *- related sites*

In order to answer the research questions of the study, the necessary data of all tree species in the studied plant community were measured in sets 4-8 plots (quadrats) at each of the total three track lines of *D. cinereus*'s study site. The vegetation analysis was carried out as a purposive technique in which the tracks/lines were decided purposively based on local people information for the occurrence of *D. cinereus* in certain sites of the island (Jumawan et al. 2015). The starting point of the plot in each of the track line areas laid out at least 100 m after getting into the dryland of the forest edge adjacent to those of mangrove or wetland area, cut contour lines perpendicularly. The size of each sampling plot was 1,000 m^2 (r= 17.8 m). In each sampling plot, we assessed the following variables: i) Name of all tree species occurring in the sampling plots, GPS coordinate, altitude, topography condition; ii) Number of individuals of each occurring tree species; iii) Total height (H) and Diameter at breast height (DBH) of each stem. Those classified as the tree was planted that had more than 20 cm in diameter. These data were used to calculate relative density, frequency, abundance, and dominance of the species; and from those values, the Importance Value Indices (IVI) were calculated.

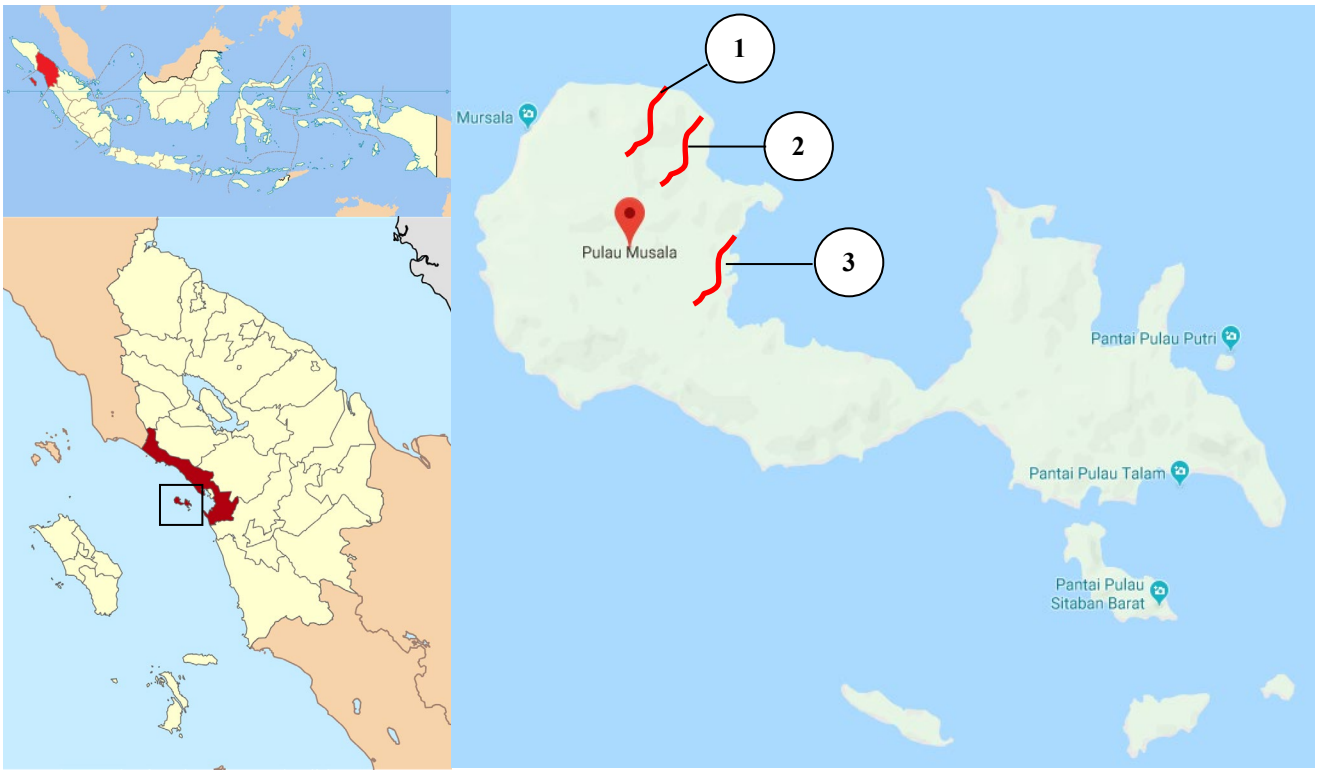

Figure 1. Mursala Island, Central Tapanuli District, North Sumatra, Indonesia. Red lines showed transect during vegetation analysis study

Data analysis

To express the dominance and biological success of any species with a single value, the concept of Importance Value Index (IVI) have been developed by Curtis and McIntosh (1950), Phillips (1959) and Misra (1968). Rastogi (1999) and Sharma (2003) have reported the IVI as a better expression of the relative ecological importance of a species than an absolute measure such as frequency, density or dominance. IVI of each species was obtained by summing the three relative values, i.e. relative density (RD), relative frequency (RF) and relative dominance or relative basal area (RBA), in which IVI = RD + RF + RBA (1). Importance percentage is obtained by dividing the IVI-value by 3.

Relative density

Density denotes the average number of individuals of a given species out of the total of samples examined in a study area (Oosting 1942; Rastogi 1999; Sharma 2003). The Relative Density (RD) is calculated using the formula:

RD =

Relative frequency

Frequency indicates the number of sampling plots (sites) in which a given species occurs as a percentage of all sampling plots and based on the presence or absence of a species (Raunkaier 1934; Rastogi 1999; Sharma 2003). Relative Frequency (RF) is calculated using the formula:

RF =

Relative basal area

Dominance is defined as the sum of basal areas of all individuals of a species. The basal area refers to the ground covered by the stems (Rastogi 1999; Sharma 2003). Relative Basal Area (RBA) is calculated using the formula:

RBA =

Species association

Species association was generated by making contingency table 2 × 2 followed by chi quadrat test. For each pair of species A and B, we can obtain the following: a = the number of samples in which species A and B co-occurred; b= the number of samples in which species A occurs, but not B; c= the number of samples in which species B occurs, but not A; d= the number of samples in which neither A nor B are found; N= the total number of samples. Further, we tested for the Jaccard Index. A positive association was determined where a> E (a) and negative association when a< E (a). Association present if x^2test< x table, when x table is 3.84. Jaccard Index test was used to show the association level, as the value approaching 1, it showed maximum association (Ludwig and Reynold 1988).

RESULTS AND DISCUSSION

Current forest condition in Mursala Island

Since legal forest concession of PT. Mujur Timber stopped its operation in the 2010s (BPS Tapanuli Tengah 2012), the island was left by its legal inhabitants. However, the situation triggered surroundings community to come and stay on the island. Along the time, numbers of inhabitants were escalated and those also the need for land occupancy. Based on our direct survey and observation, we evaluated several threats to the pristine condition of the island. Each of the threat is described as follow:

Logging

Timber extraction is the most livelihoods of people in Mursala Island. We identified many spots where timber extraction took place. The people work in a group consisting of 3-5 peoples. Based on personal communication with local people, there were no distinct target species to cut down as long as the trees were big and healthy (no inner hole). The loggers left the area occupied only by the small tree because all the trees with 50 cm in diameter were cut down. We also found that *D. cinereus* grows naturally in the middle of the ridges until the top of ridges. Moreover, the logging activity seemed to put the situation of the *D. cinereus* extinction in the middle part. This condition could be identified by the occurrence of the stump within our track of the observation and measurement plots. When lower and middle parts were intensively changed by human activity, the top part of the ridges still has little impact from such activities and that is why we can find trees with a diameter bigger than 50 cm. Our study suggests that the extreme slope with very rough topography has made *D. cinereus* maintain their occurrence in the top of the ridges of the island because it is less accessible to human to be commercially logged. Forman (1995) stated that human activities such as logging and urbanization consequently affected species distribution. Furthermore, Elgueta et al. (2014) also stated that low-intensity human activity would prevent tree species from disturbance and maintenance it's natural regeneration.

Forest conversion

When the number of inhabitants increased, the need for land occupancy is also high (Repetto 1990; Chima and Ihuma 2014). We identified that the lowland area of the islands had been transformed into several types of gardens, those may take form as monoculture and also mixed plantation. Monoculture plantations using palm oil and rubber dominate the landscape in Sumatra. The lowland conversion into garden or palm oil/ rubber plantation was also occurred in many parts of Sumatra Island, not only in Mursala Island. Allen et al. (2015) described that lowland rainforests are especially vulnerable to degradation and conversion because of easy access and a majority of those forests have been converted to economically viable agricultural systems to keep up with the world's growing population and consumption needs.

The forest conversion began by cutting big trees and followed by a slash and burn activity. The monoculture gardens may take the form of rubber plantation and coconut tree plantation, while mixed garden may have rubber as perennial trees and cash crop as above ground plant. The forest conversion began from the area located at the backside of the village; however current condition found that the garden may spread to those that far from the house in the other part of the island. In that case, they go by their boat. We determined that one household may manage to more than two sites of the garden and each of the gardens may cover up to one hectare. Their garden's products (e.g., banana, coconut, sweet potato, cassava) usually send and sell to Sibolga.

It is likely that logging activity contributes to explain the presence of smaller trees on this island especially in lower to the middle part. Further research is required in this island, given its importance as a reservoir of great diversity and endangered species, and that can be used to assess the real impact of high deforestation occurring on the island.

Vegetation composition

Vegetation analysis is a powerful tool employed for several purposes, including communication, data reduction and synthesis, interpretation, and land management and planning. It also provides one way of summarizing our knowledge of vegetation patterns (Dalle et al. 2005). Each forest has a distinct floristic composition which varies in its species richness and the abundance of different species. Environmental variability regarding climatic factors, social resources, grazing by herbivores and human interference are the critical factors which regulated the spatial and temporal patterns of the vegetation of an ecosystem (Chapin et al. 1993). Steenis (1950) also stated that many islands in Indonesia have been isolated for millennia and consequently show a high level of species endemism those also have never been developed and their vegetation types mostly never described (Sukardjo 2006). This study was also one of the initial efforts on studying vegetation composition of the Mursala Island. Vegetation study of Mursala Island has not been reported before.

Our vegetation analysis was designed to determine the occurrence of *D. cinereus* in the island. Based on that purpose, the method was as purposive stratified sampling where the decision of choosing line transects based on the suspected location where *D. cinereus* still might be found on the island. The locations were decided based on local people information. A total of 50 tree species were identified belonging to 40 genera. Our study revealed that the island is home to many dipterocarps. We determined at least six genera of dipterocarps with 17 species were recorded, those *Shorea bracteolata, S. ovalis* ssp. *sericera, S. leprosula, S. acuminata, S. falcifera, S materialis, Dipterocarpus cinereus, D. elongates, D. fagineus, D. kunstlerii, Hopea sangal, Dryobalanops aromatica, Vatica umbonata, V. stabfiana*, *Vatica* sp. (resak batu group), and *Cotylelobium melanoxylon*. Compare to that of island's size, high richness of dipterocarps has made the island as one of the hotspots for dipterocarps biodiversity. Based on the vegetation analysis of our study, it identified five species with highest Importance Value Index those were *D. cinereus*, *S. acuminata, H. sangal*, *S. falcifera* and *A. pinnata* (Table 1). The five dominant species morphological appearance were shown in Figure 2.

Table 1. Five dominant species along the transect lines in Mursala Island

Local name	Species	RD	RF	RBA	IVI
Lagan beras	*Dipterocarpus cinereus*	8.33	10.7	13.34	32.37
Meranti merah	*Shorea acuminata*	16.67	14.27	8.53	39.47
Merawan	*Hopea sangal*	1.77	4.46	4.81	11.04
Meranti	*Shorea falcifera*	6.55	6.24	2.39	15.18
Aren	*Arenga pinnata*	10.71	4.46	2.26	17.43

Note: RD= Relative Density; RF= Relative Frequency; RBA= Relative Basal Area; IVI= Important Value Index

A B C D

Figure 2. The Five dominant species in research site. A. *Shorea acuminata* (right) standing near *Dipterocarpus cinereus* (left), B. *Arenga pinnata*, C. *Shorea falcifera,* D. *Hopea sangal*

Shorea acuminata or locally known as meranti merah is the species with the highest RD, RF, and IVI. The species is widespread and distributed in a mixed dipterocarp forest in Malaysia, Sumatra, Lingga and Borneo Islands (Ashton 1982; Appanah and Chan, 1981; Sakai et al. 1999). In Indonesia, it is known locally as meranti bunga, and belongs to the light red meranti timber group (Newman et al. 1996). The highest value of RD, RF, and IVI for this species indicated that this species denotes their range of niche preferences and capability to establish over a large area. Its IVI also depicts the phytosociological structure of meranti merah in the natural habitat and getting an overall picture of the ecological importance of a species.

Hopea sangal has widespread distribution from India, Peninsular Malaya, Java, Borneo to New Guinea (Symington 1943). The species is listed as Critically Endangered in IUCN Red List (Ashton 1998a), then Pooma et al. (2017) has revised the status of this species to Vulnerable. *Shorea falcifera* is known as balau kuning. The tree is commonly found in lowland to coastal hill forests in Indonesia (Kalimantan, Sumatra), Peninsular Malaysia and Sarawak (Ashton 1998b). *Arenga pinnata* is an economic plant native to tropical Asia, from eastern India, Malaysia, Indonesia, and the Philippines (Uhl and Dransfield 1987). *H. sangal* and *S. falcifera* have owned lower IVI, RD and RV than *S. acuminata*. This result is indicated that distribution adaptability and regeneration pattern of both species has been facing certain constraints. It might be a consequence from disrupted seed dispersal, the vulnerability of the seed from decaying or even because of the isolation process and soil characteristics changes (Ashton 1982). Other possibility, it was the high frequency of timber extraction by illegal loggers those decreasing population size in relatively short time.

Frequency and density is a measurement of distribution uniformity of a species. Thus a low frequency indicates that a species is either irregularly distributed or rare in a particular stand or forest (Kharkwal and Rawat 2010). The higher IVI of *D. cinereus*, *S. acuminata, H. sangal*, *S. falcifera* and *A. pinnata* than other species indicate that most of the available resources are being utilized by those species and residual resources are being trapped by the competitor and/or associate species. According to Erenso et al. (2014), species with high IVI could adapt to high pressure of disturbance, natural and environmental factors, and effect of local communities. In contrast, almost all species in this study showed variation regarding their IVI, showing the different ecological importance of each species in The natural habitat.

Plants diversity of Mursala Island still reflects most of the species that commonly grows in lowland forest. Vegetation analysis showed that tree components of the island were dominated by those widespread species that also existed in Sumatra mainland (e.g. *S. acuminata*, *S. falcifera*, *H. sangal* and *A. pinnata*). It means that biodiversity management could occur within the anthropometric ecosystem. Ramos et al. (2016) stated that human activities were a dominant driver for changing biodiversity and disruption of the tropical forest ecosystem, so that synergistically management based on conservation and human need should be conducted.

It could be concluded in general that forest vegetation in Mursala Island represent a national treasure and should be managed continuously. The report of tree composition in Mursala Island is the first step to review conservation problems then followed by growing of recognition for resource sustainable utilization and management coordination between government and stakeholders.

Association of the previously reported extinct dipterocarp of *D. cinereus* with other dominant species

The IVI of five species is exceeding the value of 10% (Table 2). Later, we test the association between *D. cinereus* with other four dominant species within the research site. This information is important to conserve *D. cinereus* in the future. A negative association pattern between two species might be as result of competition or differences in habitat preference. A positive pattern might be the result of facilitation or neutrality and similarity in habitat preference (Kent and Coker 1992). Contingency test showed that there were only two significant associations, there was *D. cinereus* with *S. falcifera* and *D. cinereus* with *A. pinnata*. Calculation of association index was carried out to support the contingency result. The positive relationship between *D. cinereus* and *A. pinnata* was supported by high association Index (0.65). It means that positive association between a pair of species has been common in Indonesian tropical forest, such as: *Cananga odorata* and kayu kapur (Kurniawan et al. 2008), *Ficus benjamina* and *Artocarpus elastica* (Martono 2012), *Eusideroxylon zwageri* and *Shorea leprosula* and *Ficus Albipila* (Sari and Maharani 2016). This positive association was simply translated as when one certain species is found in a certain site will be followed by the finding of its pair.

The current state of association index did not reflect factual association. Habitat alteration and anthropogenic threats of the islands have modified the vegetation composition. Our study found that the absence of the top layer of the canopy, which should be composed of big mature trees both in lower and middle part of the ridges, would have affected the calculation of the associated index value. Thus, the forest landscape composition has changed much from its original. From what we revealed in the field, the best example is shown by *Dryobalanops aromatica*, a very high economically value tree. The big mature trees of the species are almost disappeared from the island; this condition leads to the extinction of the seedlings. As a result, the current composition of the species mainly is made up from saplings and poles. When calculation only took account of tree stage, certain species of trees with similar cases such as *D. aromatica* may not be included in the calculation, and those would lead to a biased result. As the island experienced mechanical timber extraction under a forest concession company, the extinction of the high valuable species such as *D. cinereus, D. aromatica*, and several *Shorea* species happened earlier than those of less valuable ones. However recent study determined that species association may not exist and the pattern of spatial

Table 2. Association between *D.cinereus* and other dominant species in Mursala Island

Species	x^2m	a	E (a)	Assoc. type	Assoc. index
D. cinereus with *S. acuminata*	0.47ns	9	9.6	na	0.65
D. cinereus with *H. sangal*	0.8ns	4	3.0	na	0.52
D. cinereus with *S. falcifera*	4.64**	2	4.2	-	0.22
D. cinereus with *A. pinnata*	4.44*	5	3.0	+	0.65

species distribution described as a result of the stochastic geometry of biodiversity. Species placement in species-rich communities approximates independence (Wiegand et al. 2012).

Conservation action

Forest Research Center in coordination with the focal point of species conservation authority in Indonesia, Directorate General of Forest Resources Conservation and Indonesian Institute of Sciences (LIPI) has initiated a meeting to propose species ratification to IUCN. When declared extinct from the wild, there will be nothing to carry out to conserve the species, since it has been stated long disappeared in their natural range. But, when new finding determined that the species is still growing with the high risk of extinction and further declared as Critically Endangered, there will be several conservation actions could be taken.

Plant conservation of single species seems not to be the most effective effort, but *in situ* conservation is ideal conservation strategy to be implemented. Current status of the island as Protected Forest does not give proper protection for conserving *D. cinereus*. The status of the Island needs to be increased to the higher level that can accommodate conservation action. The best choices could be proposed for the island is an establishment Essential Ecosystem or Forest with Special Purposes (KHDTK) by submitting a proposal submitted by local government to the Ministry of Environment and Forestry. In this case, local academic institution (e.g., University of Sumatera Utara) may take its role as the scientific advisory board for local government. When the new status approved, all stakeholders should make collaboration and work together to established conservation actions needed for *D. cinereus*.

Effort on revisiting the existence of *D. cinereus*, followed by collecting of seed/seedling for propagation material, then implementation of reintroduction program should be fruitful to increase its population in the natural habitat. Besides that, series of meeting among related stakeholders (e.g. Forestry Research and Development Center, Indonesian Insitute of Sciences, NGOs) triggered the re-assessment of the species. Ratification of the species status has been successfully achieved as now we can see that Barstow and Kusuma (2017) in IUCN, rates the status of this species as Critically Endangered. This ratified status will put forward the conservation effort of the species in the front line together with the island itself. However, ratification status would be work best if only there is also effort to protect the island as a whole.

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