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Research Article

Alternative Strategy to Improve the Conservation of Javan Deer in Pangandaran Nature Reserve, West Java, Indonesia

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ABSTRACT
The habitat of Javan deer in Pangandaran Nature Reserve (PNR) faced natural changes, particularly due to the succession process of vegetation community in grazing areas, and inadequate infrastructures that affected the deer to roam outside PNR. This study aimed to formulate strategies for the conservation of Javan deer in PNR, focusing on ecological aspects and conservation management. The methods were encountering Javan deer individuals; scan sampling and continuous recording to observe the behaviour of Javan deer; calculating the productivity of grazing area by defoliation experiment and vegetation analysis; reviewing documents, reports and interviews; and analysing strategy using SWOT-QSPM. Results showed there were 43 Javan deer encountered roaming in PNR and outside the conservation area, and nine individuals gathered in Cikamal grassland. The productivity of the grazing areas (5.61 ha) was 93,826 kg of feed annually and was only sufficient for 23 individuals. The grazing areas were dominated by *Cynodon dactylon*. Javan deer spent their time feeding. Javan deer herd in Cikamal is more intolerant to humans compared to the herd in Pangandaran Nature Tourist Park (PNTP). This study recommends: considering the management status of Javan deer in the conservation management of PNR and PNTP; improving the conservation management of Javan deer and its habitat; improving facilities and the management system of those facilities and conservation-supporting infrastructures;collaboration with researchers to perform some research and innovations for Javan deer conservation; improving the capability of PNR staff theoretically and practically; and educating and empowering the local people in terms of Javan deer conservation.

INTRODUCTION
Javan deer (*Rusa timorensis*, de Blainville 1822) or also called Timor deer, is a species that belongs to the Cervidae and is native to Indonesian islands, particularly Java and Bali, and had been introduced to other Indonesian islands and overseas (Hedges et al. 2015; Ali et al. 2021). Categorised as Vulnerable by IUCN in 2015, the Javan deer is protected by the Indonesian Government through the Regulation of Minister of Environment and Forestry No. P.20/Menlhk/Setjen/Kum.1/6/2018 concerning Protected Species of Plants and Animals. Javan deer have significant roles in ecology, economics, and socio-cultural, specifically since the species domesticated for commercial meat and antlers managed to be a game

-hunting animal and being invasive feral populations outside Indonesia (Hedges et al. 2015; Ali et al. 2021). However, Javan deer deal with extermination in many highly human-populated areas, including poaching, habitat loss, livestock competition, predator threats, diseases, and natural disasters (Rahman et al. 2020). In Pangandaran Nature Reserve (hereafter 'PNR'), Javan deer roam outside the conservation area, foraging on trashes, destructing public infrastructures, polluting the Pangandaran Beach tourist destination, disturbing local people's activities, and blocking transportation access that harms the deer themselves. The most robust hypothesis about the causal factors related to Javan deer roaming outside PNR are the scarcity of natural feed inside PNR (Firdaus et al. 2022) and the behaviour pattern changes of the species (Withaningsih et al. 2020).

PNR once comprised roughly 57 ha of five separated grazing areas as habitat for Javan deer and banteng (*Bos javanicus*), where three of them (Badeto, Batu Meja, and Karang Pandan) were abandoned to be secondary forests, and the other two (Cikamal and Nanggorak) still exist although only Cikamal being managed more intensively (Rosleine & Suzuki 2012). The alteration of grazing areas limited the sources of food for Javan deer. On the other hand damaged boundary walls between PNR and non-conservation areas allowed Javan deer to traipse outside the conservation site. As late as this research was conducted, we did not find any scientific data regarding the encounter and behaviour of Javan deer in Cikamal as the basic data to adapt the deer to roam only in the PNR, mainly in Cikamal.

Animal behaviour research is one of the main factors for animal management planning (Singh & Kaumanns 2005; Caro 2007; Pairah et al. 2014). Animal behaviour research could be applied to manage both domesticated animals (e.g. Venter et al. 2019; Orihuela 2021; Herrera et al. 2022; Lardy et al. 2022) and wild animals (e.g. Koirala 2021; Laguna et al. 2021; Miglioli & Vasconcellos 2021; Lardy et al. 2022; Rose et al. 2022). Behavioural research was also performed to reduce human-animal conflict (Silk 2007). For free-ranging wild Javan deer, behavioural research was rarely conducted due to time-consuming of observing Javan deer in their home range, and most of the research was concentrated in captivity. Yet, observing Javan deer in their natural home range would give information to conserve the species in their natural habitat (Pairah et al. 2015). Additionally, behavioural research on Javan deer was usually run due to the conservation priority in the conservation area. In Wan Abdul Rachman Forest Park, Javan deer was bred to be a tourist attraction, and behavioural research was used to analyse the deer behaviour to improve tourist-based conservation (Sofyan & Setiawan 2018). However, in Komodo National Park, Javan deer behaviour research was aimed at sustaining the population of the komodo dragon (Ariefiandy et al. 2019).

Javan deer in PNR was a priority species to protect since it is the remaining large herbivore and is an iconic animal for a tourist attraction. Moreover, the conservation of Javan deer has been declared as a primary conservation management plan of PNR since 2015 through PNR's Strategic Planning 2015-2020, followed by the next period of year 2021-2025. Nevertheless, the 2015-2020 conservation efforts to conserve Javan deer have insignificant results.

This study aimed to recommend alternative strategies for Javan deer conservation in PNR based on ecological and management aspects. The ecological aspects covered Javan deer population, behaviour patterns, and the potency of their habitat. The management aspects included the current programs implemented by PNR. Strength-Weakness-Opportunity-Threat (SWOT) analysis and Quantitative Strategic Plan-

ning Matrix (QSPM) were applied in this study. The SWOT-QSPM has been used to solve issues in many fields, including conservation management as it was applied in Baluran National Park (Siswanto 2020). SWOT -QSPM is dynamically adapted following the condition of internal and external factors in a management.

MATERIALS AND METHODS

Materials

The research was carried out in PNR and PNTP (Pangandaran Nature Tourist Park). Behavioural research on Javan deer was conducted in Cikamal, PNR. Cikamal is the primary feeding ground for Javan deer in PNR (Figure 1).

Methods

Javan Deer Encounter

We observed Javan deer population and their behaviour patterns from 06.00 to 17.00 in seven days continuously, dated December 23-29, 2021, in Cikamal. Javan deer population data was acquired using manual counting according to Javan deer encountered at the site. We identified Javan deer individuals into: fawn, juvenile male, juvenile female, adult male, and adult female, based on visual characteristics. The age of Javan deer was classified according to the size of their physical appearance. Big-sized deer are assumed to be older (Yuliawati 2011; Pairah et al. 2014). Meanwhile, the sex was classified by antler characteristics which only male Javan deer have antlers on their heads whether they are juvenile or adult (Yudha et al. 2019).

Javan deer commonly lived in groups called herds (Ali et al. 2021). Therefore, the behavioural observation was conducted using the scan sampling method, which observed most individuals' animal behaviours in a herd of deer (Altmann 1974). The scan sampling was modified and combined with the continuous-time recording that simultaneously observed the object and stopped when they moved out of sight (Altmann 1974; Oliveira et al. 2018). We recorded Javan deer behaviour in seconds and limited minimum duration for the behaviour to be recorded as 10 minutes. This Javan deer behavioural observation was conducted by F.I.F. solely to use the method consistently (Lemos de Figueiredo et al.

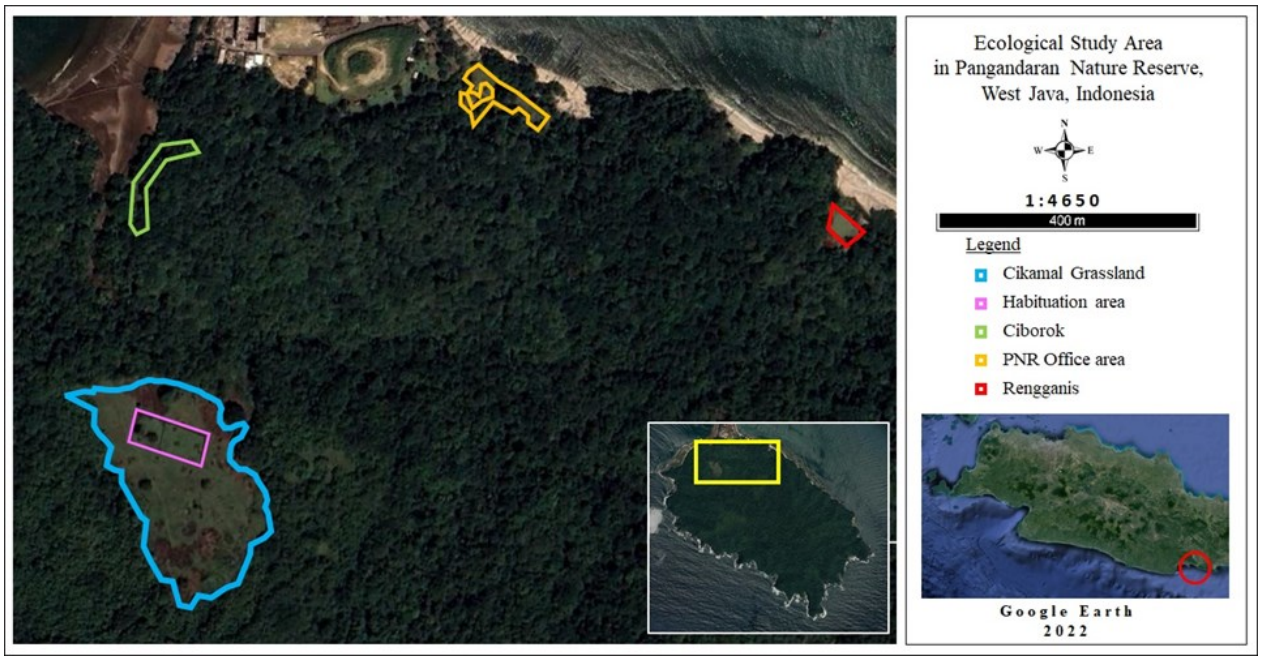


Figure 1. Study area in Cikamal.

2021). The Javan deer behaviour pattern was classified according to Pairah et al. (2014):

1. Feeding, including foraging, digesting, ruminating, drinking, and suckling (for adult females with fawn);
2. Locomoting, including moving, stampeding, and jumping;
3. Inactive, including standing still, resting, and wallowing in mud or pond;
4. Alerting, including anti-predator adaptations, detecting threats, and alarming to evade predators;
5. other activities, including interaction amongst individuals, fighting, rutting, grooming, urinating and defecating.

The Javan deer behavioural data was compiled in hour intervals (06.00-17.00). We calculated the mean of the seven-day observation data and transformed it into an hour-interval ethogram to illustrate the percentage of Javan deer daily time budget (Jakopin et al. 2021).

Potency of Javan Deer Habitat

This research uses plots for undergrowth measuring 1 m^2 (Kusmana 1997; Nurjaman et al. 2017) as many as 12 pieces, lawn mowers, and digital kitchen scales with an accuracy of 1 gram. We used PlantNet and Google Lens to identify the vegetation species encountered and asked PNR staff. The identification was then verified using website-based Plants of the World Online by Royal Botanic Garden Kew. Research on the potential of Javan deer habitat was primarily carried out in PNTP, totally from December 19, 2021 to February 8, 2022, in three locations: Rengganis, PNR Office area, and Ciborok

The 1 m^2 plot used to analyze the vegetation under the forage of the Javan deer was determined using a simple random sampling method to suit field conditions and regulations from PNR. Three plots were installed in Rengganis, five plots were installed at the PNR Office area, and four plots were installed in Ciborok. As a complementary, we used secondary data on feed plant productivity in Cikamal. Vegetation analysis classified the areas in the plots into areas of Javan deer feed plants, non-food vegetation areas of Javan deer, and areas without vegetation. Then, the data is compiled and averaged to obtain the percentage of the denseness. The reference of data on Javan deer understorey feed plants showed in Table 1.

Table 1. Javan deer feed plants.

No.	Species	Palatability	Source
1	*Axonopus compressus*	0.62	Purwanto (2013)
2	*Panicum repens*	0.41	Purwanto (2013)
3	*Fimbristylis aestivalis*	0.33	Purwanto (2013)
4	*Cyperus kyllingia*	0.33	Purwanto (2013)
5	*Fimbristylis dichotoma*	0.26	Purwanto (2013)
6	*Cynodon dactylon*	0.21	Purwanto (2013)
7	*Chrysopogon aciculatus*	0.17	Purwanto (2013)
8	*Grona triflora*	0.36	Kangiras (2009)

Vegetation analysis was followed by estimating the productivity of the Javan deer feed vegetation. The productivity of Javan deer feed was calculated based on field experiments in the form of defoliation refers to Azwar et al. (2019) by modification. The experiment was carried out in two phases comprising 20 days for the first phase and then 30 days for the second one. The annual productivity was summed from the dry season and rainy season productivity. The carrying capacity was estimated according to Susetyo (1980):

CC = P×A×X/C, where CC = carrying capacity; P = productivity of feed vegetation (kg/m²/year); A = area (m²); X = correction factor (0.7); and C = 6,725 kg/individual/day (Kangiras 2009).

Analysis of Alternative Strategy

Analysis of alternative strategies is used to choose the best strategy based on priorities (Alizadeh et al. 2021). Analysis of alternative strategies was analysed qualitatively and quantitatively through the SWOT-QSPM method. SWOT is used to determine the potential of internal (Strength and Weakness) and external (Opportunity and Threat) factors in Javan deer conservation management and to design a solution strategy. Meanwhile, the QSPM (Qualitative Strategic Planning Matrix) is applied to determine the priority of the strategy to be selected based on the quantification of the strategy resulting from the SWOT analysis. The steps in the SWOT-QSPM method are as follows (Wang et al. 2020; Budihardjo et al. 2021).

Step 1: Analysing internal and external factors in the management of Javan deer conservation based on ecological data, interviews with PNR staff, and information from files and scientific literature related to Javan deer in PNR;

Step 2: Evaluating internal and external factors using IFE (Internal Factors Evaluation) and EFE (External Factors Evaluation). In IFE-EFE, factors are quantified in the form of weighting and scoring. The weights are given in the range 1-4, with the number 4 given if the SWOT factor significantly influences the management situation (Alamanda et al. 2019). The weight figures are processed by dividing the weight value of each factor by the total weight for each factor classification, namely internal (Strength + Weakness) and external (Opportunity + Threat), to produce a decimal number with a total internal and external weight that is equal to 1 (Alizadeh et al. 2021). Meanwhile, the score is filled with provisions of Strength/Opportunity, given a score range of 3 or 4, while Weakness/Threat is given a score range of 1 or 2. Values on weights and scores are multiplied to obtain a Weighted Score. The Weighted Score of Strength and Weakness are summed to obtain the Total Weighted Score of internal factors, and the Weighted Score of Opportunity and Threat are summed to obtain the Total Weighted Score of external factors. The researcher and four staff of PNR conducted the weighting, yet the score was filled in only by the researcher to establish the conservation strategy specifically related to this study.

Step 3: Total Weighted Score on internal and external factors is interpreted in the IE matrix with cells I-IX to determine the direction of the SWOT strategy (Wibowo et al. 2021).

Step 4: Formulating the SWOT strategy on the SWOT matrix. The Strength factor was crossed with the Opportunity factor to produce an S-O strategy and then crossed with the Threat factor to produce an S-T strategy. Then, the Weakness factor was crossed with the Opportunity factor to produce a W-O strategy and the Threat factor to produce a W-T strategy.

Step 5: Quantifying strategy using QSPM. The SWOT strategy is given an Attractive Score (AS) assessment heading to the SWOT factors. Then, the AS value is multiplied by the weight of each SWOT factor to obtain the Total Attractive Score (TAS). TAS are summed to produce a total value which is the priority value of the strategy.

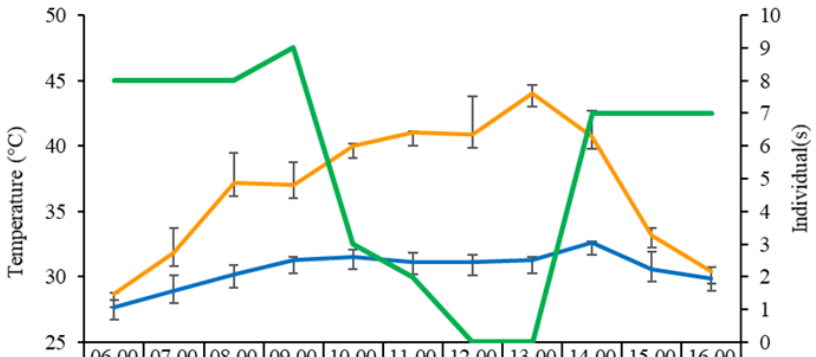
RESULTS AND DISCUSSION

Presence of Javan Deer

Observation showed that the highest number of Javan deer encountered in Cikamal was nine individuals, eight of them grouped, and another one was usually a solitary adult male. Eight individuals of the herd consisted of two adult females, a juvenile female, three juvenile males, and two fawns. The herd was less than 20% of the census which was 43 individuals with a substandard 17:14 ratio of male to female (Firdaus et al. 2022) and indicated that the majority of Javan deer present outside Cikamal were either still in the conservation area (forest area in PNR and PNTP) or roaming out of the conservation area border. The herd was often encountered in the morning (06.00-10.00), subsequently unseen as the Sun rose (10.00-14.00), and they appeared again in the afternoon (14.00-17.00). The presence of Javan deer was inversely proportional to temperature in Cikamal (Figure 2). The temperature in Cikamal was measured as having a higher mean than shaded vicinity, with the highest point reaching more than 40°C at 13.00-14.00. Javan deer and most other ungulates spend time wallowing in muddy waterholes or resting under the tree canopy when the temperature increases to avoid scorching Sun rays and to cool down the temperature of their bodies (Bismark et al. 2011; Arumugam & Buesching 2019; Selvarajah et al. 2022).

The presence of Javan deer in Cikamal was additionally influenced by human activities and feral dogs (*Canis familiaris*) intruding on the site. We found many tourists illegally came across Cikamal on the way to the waterfalls in the Southern PNR, and they intimidated the Javan deer herd. Nature reserve in Indonesia, as stated in the Regulation of the Government of the Republic of Indonesia No. 28 of 2011 concerning Management of Nature Protected Area and Nature Reserve Area, is a conservation area strictly aimed to preserve the pristine ecosystem without any kind of usage besides research and ecological monitoring. Meanwhile, feral dogs came into and trespass the conservation area, damaged the border wall and fence. As stated by PNR rangers in interviews, feral dogs continually preyed on deer and dominantly occupied Cikamal. Hence, the presence of the deer was unpredictable.

The Javan deer herd was together with a feral Balinese cow when they were in Cikamal or out of the site (Figure 3). The feral Balinese cow was the last surviving of its species since the introduction of several individuals in 2000-2010. The cow follows the deer herd wherever they browse, yet occasionally roamed solitary when feral dogs chased the Javan deer herd.



Hour interval	06.00 - 07.00	07.00 - 08.00	08.00 - 09.00	09.00 - 10.00	10.00 - 11.00	11.00 - 12.00	12.00 - 13.00	13.00 - 14.00	14.00 - 15.00	15.00 - 16.00	16.00 - 17.00
Cikamal Grassland (°C)	28.65	31.8	37.15	37	40.05	41.05	40.9	44	40.75	33.2	30.45
Forest area (°C)	27.7	28.95	30.15	31.25	31.55	31.15	31.1	31.25	32.65	30.6	29.9
Deer individual(s) in Cikamal	8	8	8	9	3	2	0	0	7	7	7

Figure 2. The presence of Javan deer and temperature in Cikamal.

Figure 3. Javan deer herd with a Balinese cow in Cikamal.

Daily Behaviour Patterns of Javan Deer

The result illustrated the daily activities of Javan deer in Cikamal without specifying the sex and ages. Data in Figure 4 indicated that Javan deer allocated their time in Cikamal mainly for feeding activities followed by alerting, inactive activities, locomoting, and other activities.

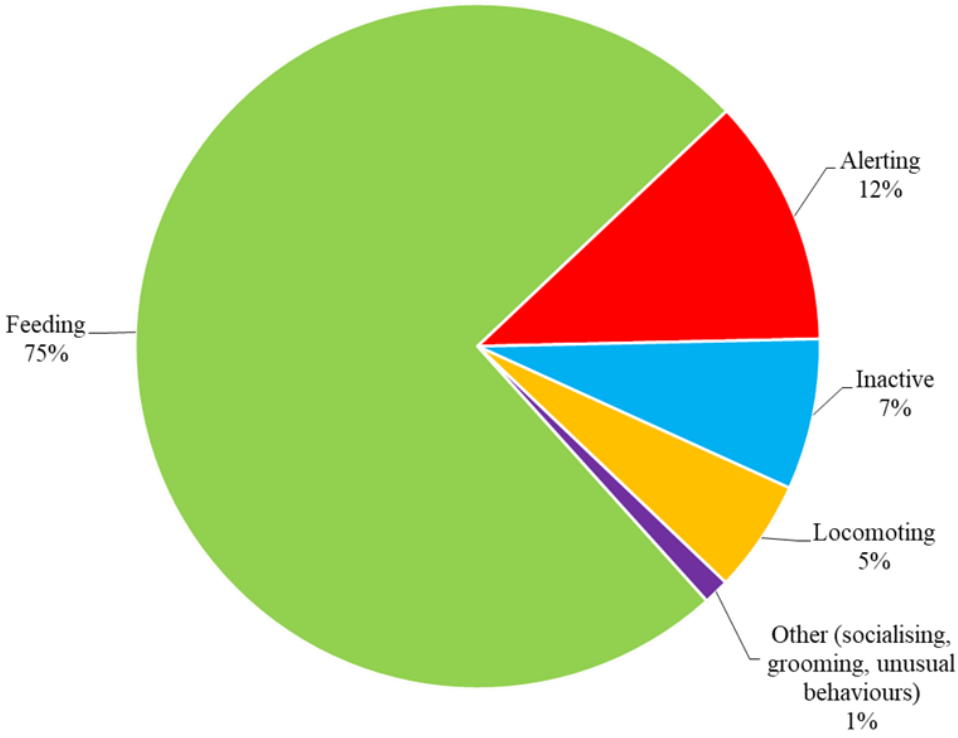


Figure 4. Activity-time budget of Javan deer in Cikamal.

Feeding activity mostly seen was picking up grass, chewing, foraging, and ruminating. It was similar to that in the outside area of Cikamal, particularly PNTP, Javan deer were spotted spending their time mostly for feeding (Withaningsih et al. 2020). In Panaitan Island of Ujung Kulon National Park, Javan deer spent time feeding (Pairah et al. 2014). The Javan deer herd in Cikamal also performed alerting primarily when the observer came to the site for the observation. The herd posed interrogat-

ing with eyes and ears focusing on observer movement and infrequently intimidated by stomping ground and vocalisation (Teichroeb et al. 2013). Instead of attacking the observer, they ran away to the dense forest if they were frightened. In contrast, the Javan deer herd in PNTP were more tolerant of humans and other distracting factors. Javan deer in PNTP tended to locomote slowly and rest after feeding (Withaningsih et al. 2020). Furthermore, Javan deer in Wan Abdul Rachman Forest Park had fed and rested respectively to spend their daytime, not to alert (Sofyan & Setiawan 2018). As confirmed by the PNR rangers and staff, the difference in behaviour between the Javan deer herd in Cikamal and PNTP classified them as inner and outer herds. The inner herd tended to be more intolerant than the outer ones. Therefore, the inner Javan deer herd roamed normally in Cikamal and dense forest in the southern part of PNR. Moreover, the inner herd comprised a smaller number of individuals and visually had slender bodies than the outer herd.

Adult females carried out more protectively aggressive behaviour concerning their fawns. They intimidated the observer dan the feral dogs if they came closer. During the lactating period, mother deer would be more vigilant to protect themselves and show their offspring how to confront predation threats (Grovenburg et al. 2009). Females with fawns dedicated plenty of time to look after them (Hunter & Skinner 1998). Therefore, adult female deer with fawn also needed more feed to provide nutrition for the young (Cook et al. 2004; Ma et al. 2011)

Javan deer and other species of Cervids are matriarchal grouping fauna (Hawkins & Klimstra 1970; van Buskirk et al. 2021). One of the adult females of the herd in Cikamal was seen as the leader, guiding the herd to what they must do and where they must go. The leader female would investigate the situation to ensure that the place was safe for the herd and might be signalling the herd earlier to anticipate a danger. The dominant female might also dominate their home range, as happened to white-tailed deer (*Odocoileus virginianus*) (van Buskirk et al. 2021), mule deer (*Odocoileus hemionus*) (Roerick et al. 2019), and roe deer (*Capreolus capreolus*) (Maublanc et al. 2012).

Inactive behaviour, locomoting, and other activities, including socialising, fighting, rutting, grooming, urinating, and defecating, were not seen as often as feeding and alerting. Javan deer herd in Cikamal showed those minor percentage behaviours roughly once in one-or-more hour interval monitoring. Moreover, the herd was observed doing minor percentage behaviours while feeding. Performing a behaviour while doing other behaviour also occurred in other species, as well as pampas deer (*Ozotoceros bezoarticus*) (Aniano & Ungerfeld 2020), musk deer (*Moschus berezovskii*) (Yang et al. 2020), and red deer (*Cervus elaphus*) (Churski et al. 2021). Javan deer also performed minor seasonal behaviours, for example, rutting. Rutting or mating behaviour would be fighting among adult males (Powell & Evans 2019; de la Peña et al. 2021).

The daily time budget of the inner Javan deer herd is distributed stably in the ethogram (Figure 5). In Figure 2, deer were seen once at 11.00-12.00 during observation, yet it was less than 10 minutes and thereby the behaviour was not qualified to be shown in the ethogram. At that time, the feral dogs run after the deer herd provoking chaos in Cikamal and breaking up the herd. Thus, the behaviour pattern at that time was not recorded. Feeding behaviours constantly dominated the ethogram with the green bar.

Meanwhile, alerting mode (red bar) towered up at 06.00-07.00, 10.00-11.00, and 14.00-15.00, pressing down the feeding-time budget as it was also often affected by the barking of feral dogs in the surrounding

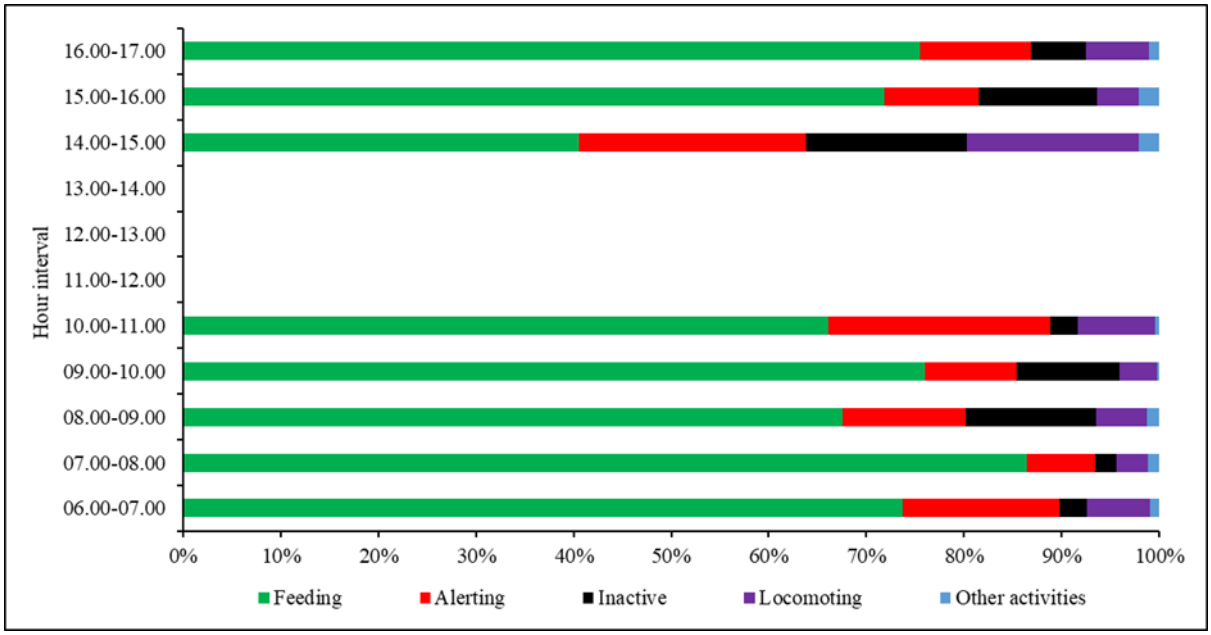


Figure 5. Daily time budget of Javan deer in Cikamal.

area. The increasing alerting behaviour in prey also happened to African Wildebeests when they heard a lion roar (Dannock et al. 2019). Naturally, Javan deer in PNR had no predator, neither dholes nor Javan leopard, yet feral dogs became the one. The intensity of the presence of predators in a territory could influence the prey's home range and diet palatability (Gower et al. 2008; Esparza-Carlos et al. 2016; Mumma et al. 2018; Churski et al. 2021; Gigliotti et al. 2021).

Potency of Javan Deer Habitat

The Javan deer grazing areas at Rengganis, PNR Office, Ciborok, and Cikamal have the same characteristics, especially understorey vegetation that dominates. Table 2 indicates *Cynodon dactylon* dominates the grazing area in PNTP and PNR. Meanwhile, the dominance of other species varies across the four research areas.

C. dactylon and *Imperata cylindrica* dominated Cikamal with a 33% difference, while *Axonopus compressus* was observed to dominate the PNR Office area (percentage difference around 58.5%) and Ciborok (percentage difference around 23.44%). Meanwhile, *Cyperus kyllingia* and *Zyphyranthes* sp mainly were found in the grassy area of Rengganis, although the per-

Table 2. Percentage of understorey plants in grazing areas of PNR.

Species	Category	Cikamal*	Rengganis	PNR Office area	Ciborok
Cynodon dactylon	Feed plant	53.00%	89.17%	78.50%	48.44%
Axonopus compressus	Feed plant	0.13%	-	20.00%	25.00%
Chrysopogon aciculatus	Feed plant	6.40%	-	-	10.94%
Grona triflora	Feed plant	0.60%	2.50%	0.50%	15.63%
Cyperus kyllingia	Feed plant	-	4.17%	0.50%	-
Abildgaardia ovata	Feed plant	8.20%	-	-	-
Zephyranthes sp.	Non-feed plant	-	4.17%	0.50%	-
Imperata cylindrica	Non-feed plant	20.00%	-	-	-
Cyperus rotundus	Non-feed plant	5.67%	-	-	-
Oldenlandia sp	Non-feed plant	3.00%	-	-	-
Chromolaena odorata	Non-feed plant	1.67%	-	-	-
Blumea balsamifera	Non-feed plant	0.20%	-	-	-
Unvegetated area	-	1.13%	-	-	-

*Source: Firdaus et al. (2022).

centage of coverage was significant, around 85%. In several other conservation areas in Indonesia, *C. dactylon*, *A. compressus*, and *I. cylindrica* also grow invasively. *C. dactylon* also dominates open areas in the Wan Abdul Rachman Forest Park, Lampung (Nurseba et al. 2020). *C. dactylon*, *A. compressus*, and *I. cylindrica* also dominate grassland areas in Wasur National Park (Hariadi & Sraun 2014), Ujung Kulon National Park (Sudibyo 2015), and Way Kambas National Park (Yanti et al. 2017).

The dominance of *C. dactylon* is caused by several factors, including resistance to disturbances, such as stamping and cutting, because it has rhizomes that can regenerate, providing more significant opportunities for *C. dactylon* to grow back spread to the surrounding area (Zwerts et al. 2015). Grasses and other creeping undergrowth, including *A. compressus*, *I. cylindrica*, *Abildgaardia ovata*, *Chrysopogon aciculatus*, *Cyperus kyllingia* and *Cyperus rotundus*, thrive because they have rhizome and light seed structure that can easily be carried by the wind and stick to the body surface. animals and humans (Simpson 2010; Setyawati et al. 2015; Schweingruber & Berger 2019). Other vegetation, namely *Grona triflora* and *Oldenlandia* sp, spread rapidly with vegetative propagation in the form of stolons (Setyawati et al. 2015; Silalahi & Mustaqim 2021). Meanwhile, *Blumea balsamifera* and *Chromolaena odorata* have light flower structures that are easily carried away by water currents and wind gusts, and both are tolerant of land damage (Setyawati et al. 2015; Guan et al. 2022).

Field experiments conducted in Cikamal, Rengganis, PNR Office area, and Ciborok Area resulted in total productivity data of 93,826 kg/year with a grazing area of 5.61 ha and an estimated habitat carrying capacity of 23 heads/year. The carrying capacity of the grazing area habitat in PNR/PNTP has not been able to support life of the population of Javan deer. The population of Javan deer that exceeds the carrying capacity of its habitat is caused by the activities of the Javan deer, which most of the population roam outside the PNR/PNTP area and obtain sufficient feed from various types of feed and places. Details of the plant productivity and the carrying capacity of their habitat are in Table 3.

Table 3. Feed plant productivity in grazing areas of PNR.

Location	Area (ha)	Productivity ± StD (kg/year)	Carrying capacity (head(s)/year)
Rengganis	0.15	5,976.25 ± 900.53	2
PNR Office	0.36	7,582.79 ± 497.90	2
Ciborok	0.67	16,859.19 ± 2,199.69	1
Cikamal Grassland*	4.43	63,407.93 ± 12,696.99	18

*Source: Firdaus et al. (2022).

The carrying capacity of the Javan deer habitat in PNR/PNTP was threatened to decrease along with land cover changes in the area. In 1970s, 18 ha in Cikamal, 8 ha in Nanggorak, and 15 ha in Badeto were all grazing areas (Sumardja & Kartawinata 1977), then in 2011 were 3 ha, 0 ha, and 0 ha, respectively (Rosleine & Suzuki 2012). In 2021, 4.4 ha in Cikamal was still grassland (Firdaus et al. 2022). The grazing areas in PNTP were threatened by the shade of the tree canopy around the grassy area and the distribution of forest vegetation seedlings (Kangiras 2009). Meanwhile, the carrying capacity of Cikamal was threatened by invasive vegetation growth, especially teak (*Tectona grandis*) planted in 1932 and 1936 (Nakazono 2012). Broad teak leaves prevent sunlight from reaching the forest floor, limiting shade-intolerant plants' growth and the grassland's dominant population (Behera et al. 2015). Changes in pasture land

cover by succession have also occurred in various conservation areas in Indonesia, including the Bekol Savana in Baluran National Park which was threatened by the invasion of *Acacia nilotica* (Istomo & Farida 2017; Muis et al. 2018) and the succession of the Cigenter Grassland in Ujung Kulon National Park *Arenga obtusifolia* (Febriana et al. 2019). Natural succession in forest ecology is a positive dynamic. Conversely, it is a threat when analysed from the perspective of grassland ecology where the climax phase is land fires, and the existence of grasslands and their reforestation will always occur as part of the dynamics of nature even though these dynamics differ in time and place (Oliveras & Malhi 2016).

Alternative Strategy to Improve Javan Deer Conservation

Internal Factor Analysis

In this section, besides showing the ecological aspects, we also showed the management implication of Javan deer and the habitat conservation performed by the PNR staff. Internal factor analysis is presented as an IFE table, as shown in Table 4. In this research, ten internal factors are based on the ecological aspects and management of Javan deer conservation in PNR. The strength factor consists of two factors, both of which are ecological aspects, while the weakness factor consists of eight factors consisting of three factors from the ecological aspect (W1, W2, W3) and five factors from the conservation management aspect (W4, W5, W6, W7, W8). The highest point for internal factors is S1, with a value of 0.44. The S1 factor was supported by the statement that Javan deer conservation in PNR has been ongoing since 1921 by the Dutch Colonial Government (Sumardja & Kartawinata 1977; Rosleine & Suzuki 2012), indicating that PNR conditions are suitable as a habitat for Javan deer. Meanwhile, the total IFE value for Javan deer conservation in PNR is 2.10.

External Factor Analysis

External factors were analysed using the EFE table as shown in Table 5. This study analysed ten external factors, three of which are opportunity factors and the other seven are threat factors. The opportunity factors collected are factors in the management aspect, while the threat factors consist of three factors in the ecological aspect (T1, T2, T3) and four in

Table 4. Internal Factor Evaluation.

Code	Factor	Weight	Score	Weighted Score
Strength				
S1	Geographical and climatic conditions in PNR/PNTP are suitable as a habitat for Javan deer	0.11	4	0.44
S2	There is no territorial competition between Javan deer and other herbivores	0.07	3	0.22
Weakness				
W1	The substandard ratio of male to female Javan deer	0.09	1	0.09
W2	The inadequate ecological carrying capacity of Javan deer habitat	0.11	2	0.22
W3	The changes in Javan deer behaviour patterns inside and outside PNR	0.11	1	0.11
W4	High cost for the conservation management	0.12	2	0.24
W5	Unskilled staff theoretically and practically	0.09	2	0.18
W6	Destruction of conservation-supporting facilities and infrastructures	0.11	2	0.22
W7	There was no agreement on the status of the Javan deer in conservation management between PNR and PNTP	0.11	2	0.22
W8	Undeveloped conservation management of Javan deer	0.08	2	0.16
	Total	1		2.10

the conservation management aspect (T4, T5, T6, T7). The external factor with the highest value is O1 with a total of 0.44 because the majority of the ecological data that forms the basis for Javan deer conservation in PNR is data obtained from academic research. Meanwhile, the total value of the analysed EFE is 2.31, which is greater than the total value on the internal aspect.

Analysis of SWOT Strategy

The IFE and EFE values are combined to obtain a point on the internal-external matrix as the direction of strategy formulation that must be planned. With an IFE value of 2.10 and EFE of 2.31, the position of the Javan deer conservation in PNR is in cell V (Figure 6). Therefore, the direction of the conservation strategy was to hold and maintain that could be in the form of integrative renewal or improvisation (intensification) of the existing management system (David 2011).

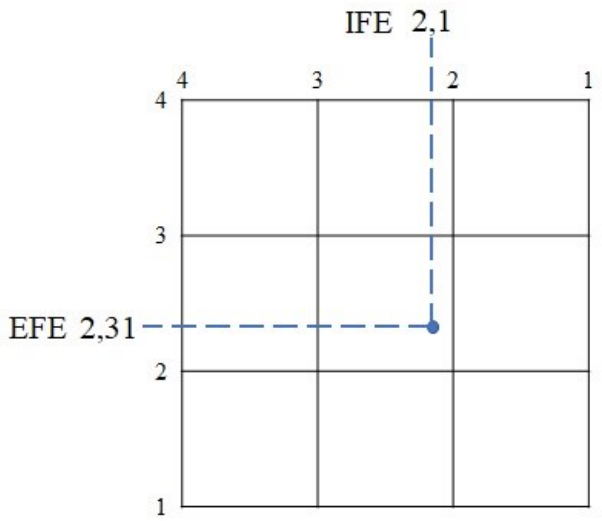


Figure 6. Internal-External matrix.

Table 5. External Factor Evaluation.

Code	Factor	Weight	Score	Weighted Score
Opportunity				
O1	The role of academics and researchers in the research and development of Javan deer and their habitat	0.11	4	0.44
O2	Local community participation in Javan deer conservation outside the PNR	0.10	3	0.30
O3	Availability of data and literature from Javan deer research in PNR as a guide for conservation management	0.10	4	0.40
Threat				
T1	Disturbance of wild dogs that prey on Javan deer	0.10	2	0.20
T2	Destruction of habitat, facilities, and conservation-supporting infrastructures by local communities and tourists	0.09	2	0.18
T3	Distribution of non-feed invasive vegetation species that can restrict the growth of the feed plant	0.13	1	0.13
T4	Delays in the process of applying for funding for Javan deer conservation	0.10	2	0.20
T5	Natural destruction of conservation-supporting infrastructures	0.10	1	0.10
T6	Priority conflict between conservation management of Javan deer and other species	0.07	2	0.14
T7	There is no contribution from external non-governmental stakeholders or institutions (NGO) to Javan deer conservation	0.11	2	0.22
	Total	1		2.31

The strategy formulated based on internal and external factors is displayed in the SWOT matrix. The number of alternative strategies obtained was six strategies. Each strategy has the possibility of a solution to several internal and external factors. The correlation between solutions and SWOT factors was shown by writing the factor code at the end of each strategy in Table 6.

The SWOT strategy matrix produced six alternative strategies for Javan deer conservation in PNR. Some of the strategies in Table 6 combined several internal and external factors, intending that alternative strategies can integrate all potentials to be more effective and efficient. Furthermore, the six strategies obtained were quantified in the QSPM matrix (Table 7) by analysing the correlation and influence of each strategy on internal and external factors. The correlation value of each strategy was displayed in the Attractive Score column and multiplied by the weight of each SWOT factor as contained in the IFE-EFE. The six alternative strategies were given a strategy code as follows:

A. improving the conservation management of Javan deer and its habitat;
B. improving facilities and the management system of those facilities and conservation-supporting infrastructures;
C. improving the capability of PNR staff theoretically dan practically;
D. collaboration with researchers to perform some research and innovations for the Javan deer conservation;

Table 6. SWOT analysis matrix for Javan deer conservation strategies.

Internal / External	Strength (S)	Weakness (W)
	S1, S2	W1, W2, W3, W4, W5, W6, W7, W8
Opportunity (O)	S-O Strategies	W-O Strategies
O1, O2, O3	• Educating and empowering the local people in terms of Javan deer conservation (S1, O1, O2) • Collaboration with researchers to perform some research and innovations for Javan deer conservation (S1, S2, O1, O2, O3)	• Improving the capability of PNR staff theoretically dan practically (W1, W2, W3, W4, W5, W8, O1, O2, O3) • Collaboration with researchers to perform some research and innovations for Javan deer conservation (W1, W2, W3, W4, W5, W7, W8, O1, O2, O3) • Improving the conservation management of Javan deer and its habitat (W1, W2, W3, W8, O1, O2, O3) • Improving facilities and the management system of those facilities and conservation-supporting infrastructures (W4, W5, W6, O1, O3) • Considering the management status of Javan deer in the conservation management of PNR and PNTP (W1, W2, W3, W4, W5, W6, W7, W8, O1, 03)
Threat (T)	S-T Strategies	W-T Strategies
T1, T2, T3, T4, T5, T6, T7	• Educating and empowering the local people in terms of Javan deer conservation (S1, T1, T2) • Improving the conservation management of Javan deer and its habitat (S1, S2, T1, T3, T4, T6, T7) • Improving facilities and the management system of those facilities and conservation-supporting infrastructures (S1, T1, T2, T3, T4, T5, T7)	• Improving the capability of PNR staff theoretically dan practically (W1, W2, W3, W4, W5, W7, W8, T1, T2, T3, T4, T5, T6, T7) • Improving the conservation management of Javan deer and its habitat (W1, W2, W3, W8, T1, T3, T4, T6, T7) • Improving facilities and the management system of those facilities and conservation-supporting infrastructures (W4, W5, W6, W7, T1, T2, T3, T4, T5, T7) • Considering the management status of Javan deer in the conservation management of PNR and PNTP (W1, W2, W3, W4, W5, W6, W7, W8, T2, T3, T4, T6, T7)

E. educating and empowering the local people in terms of the Javan deer conservation;
F. considering the management status of the Javan deer in the conservation management of PNR and PNTP.

The QSPM matrix sorted strategies based on the priority as quantified in TAS values.

1. Considering the management status of the Javan deer in the conservation management of PNR and PNTP.

Pangandaran Nature Conservation Agency (hereafter "PNCA") manages PNR, while Perum Perhutani manages PNTP. The difference between the managers indirectly abstracts the status of Javan deer conservation management. So far, the Javan deer is fully managed by the PNCA, even though the Javan deer often wander in the PNTP and become one of the tourist attractions in that place. Therefore, the Javan deer conservation management system must ensure whether the Javan deer is only a protected animal in the PNR or at the same time as part of a tourist attraction in PNTP. This strategy is essential to also determine the duties of internal stakeholders (PNCA and *Perum Perhutani*) in preserving the Javan deer and their habitat management.

1. Improving the conservation management of Javan deer and its habitat;

PNCA had activities to conserve Javan deer in PNR, mainly managing Javan deer which were outside the Javan deer area. However, improvement in the conservation management system is needed so that the problem of the Javan deer can be ecologically resolved. Two implementation steps in improvising Javan deer conservation management: 1) Javan deer population census periodically to ensure population growth and encounters of Javan deer; 2) intensification and extensification of the Javan deer habitat, mainly in Cikamal (Firdaus & Sakenia 2021).

Table 7. Quantitative Strategic Planning Matrix (QSPM).

Factor code & Weight		(A)		(B)		(C)		(D)		(E)		(F)	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
S1	0.11	4	0.44	4	0.44	1	0.11	4	0.44	1	0.11	4	0.440
S2	0.07	2	0.144	1	0.072	1	0.072	3	0.216	1	0.072	4	0.288
W1	0.09	4	0.36	1	0.09	2	0.18	4	0.36	1	0.09	3	0.270
W2	0.11	4	0.44	1	0.11	4	0.44	4	0.44	1	0.11	4	0.440
W3	0.11	4	0.44	4	0.44	4	0.44	4	0.44	4	0.44	4	0.440
W4	0.12	4	0.48	4	0.48	2	0.24	1	0.12	1	0.12	4	0.480
W5	0.09	4	0.36	4	0.36	4	0.36	4	0.36	2	0.18	4	0.360
W6	0.11	2	0.22	4	0.44	4	0.44	1	0.11	4	0.44	3	0.330
W7	0.11	4	0.44	4	0.44	2	0.22	3	0.33	4	0.44	4	0.440
W8	0.08	4	0.32	4	0.32	4	0.32	4	0.32	1	0.08	4	0.320
O1	0.11	4	0.43	3	0.323	3	0.323	4	0.43	4	0.43	4	0.430
O2	0.10	2	0.195	1	0.098	4	0.39	4	0.39	4	0.39	2	0.195
O3	0.10	4	0.387	3	0.29	4	0.387	4	0.387	3	0.29	4	0.387
T1	0.10	4	0.392	4	0.392	4	0.392	2	0.196	4	0.392	4	0.392
T2	0.09	4	0.366	4	0.366	4	0.366	1	0.092	4	0.366	2	0.183
T3	0.13	4	0.506	1	0.127	4	0.506	4	0.506	1	0.127	3	0.380
T4	0.10	4	0.403	4	0.403	3	0.302	3	0.302	1	0.101	4	0.403
T5	0.10	1	0.098	4	0.393	1	0.098	1	0.098	3	0.295	1	0.098
T6	0.07	4	0.265	4	0.265	4	0.265	4	0.265	1	0.066	4	0.265
T7	0.11	2	0.228	4	0.456	2	0.228	4	0.456	1	0.114	4	0.456
Total			6.915		6.305		6.08		6.259		4.654		6.998

3. Improving facilities and the management system of those facilities and conservation-supporting infrastructures

PNR's infrastructure and facilities significantly influence Javan deer conservation activities. It is not only the form of procurement of utilization and essential infrastructure and facilities but also their management. The proposed implementation based on this research is an investigation/ inventory of the condition of facilities and infrastructure, followed by the procurement of facilities and development and infrastructure planning.

4. Collaboration with researchers to perform some research and innovations for the Javan deer conservation

PNR has become a research location for various fields, especially conservation. Field research data from researchers and agencies from different years can be used as the basis for conservation development for PNR conservation as a whole and specifically for Javan deer. The popularity of PNR as a research area has excellent potential to collaborate with researchers to improve the quality of Javan deer conservation. The research process by academics and researchers also provides opportunities for PNR staff to participate. It possibly can increase their capabilities in collecting and processing field data.

5. Improving the capability of PNR staff theoretically dan practically

The availability of facilities, infrastructure, and research data cannot fully support Javan deer conservation activities in PNR. PNR staff's ability to use the latest technology tools, process field data, and interpret conservation management results is needed to optimize other strategies in Javan deer conservation management. Training and certification are needed to improve the ability of PNR staff to operate high-tech equipment, to be able to conduct field observations and process ecological data, conservation management, as well as data interpretation and reporting on conservation management.

6. Educating and empowering the local people in terms of the Javan deer conservation

The people who are the main targets of this strategy are residents around PNR and PNTP tourists. The surrounding community is PNR's closest partner in dealing with Javan deer that roam outside the PNR area. Technically, population empowerment will be minimized along with improving the Javan deer habitat and infrastructure in PNR that focus on the activities of the Javan deer in the conservation area. Meanwhile, the implementation of the tourist empowerment strategy in PNTP must still be carried out considering that PNTP is one of the sources of income for area conservation management in PNR/PNTP; alternative tourism for tourists; and a source of income for the surrounding population (Dhalyana & Adiwibowo 2013). Based on field data, the proposed implementation form for this strategy is the establishment of regulations that are more binding on tourists in relation to nature and Javan deer conservation and discussion accompanied by coordination with residents regarding the Javan deer that roam in tourist beach areas and residential areas.

CONCLUSION

Six alternative strategies were obtained based on the analysis of internal and external factors on the ecological aspects and conservation management, as well as quantification using the QSPM method. Strategies can be used as consideration for PNR in preparation of strategic conservation plans in PNR, identification of internal and external factors that affect conservation management, and determination of long-term vision and mission. Data updates must always be carried out based on the planning,

organizing, actuating, and evaluating points of each management period to develop the conservation management strategy in the future.

AUTHORS CONTRIBUTION

F.I.F. designed the research, collected and analysed data, and wrote the manuscript. R.R.I. and E.S. supervised the research and corrected the manuscript.

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CONFLICT OF INTEREST

The authors confirm no conflict of interest in this research.

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