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Current status and conservation prospects for the Javan rhinoceros *Rhinoceros sondaicus* Desmarest 1822

By Francesco Nardelli

Introduction

The Sundaland rhinoceros or, more popularly, the Javan rhinoceros (*Rhinoceros sondaicus*)—known locally as Abah Gede ("Great Father")—is a notable victim of change. This solitary megafolivore is an inveterate wanderer that formerly colonized suitable habitat in lowland forest over a vast area of South and Southeast Asia, ranging from Bangladesh to Viet Nam in the north, to Java and Sumatra in the south. Following decades of severe decline, the Javan rhino can now make the sad claim of being one of the rarest large mammals on earth.

Barring a new sensational discovery, the species' last refuge is a single site on the Ujung Kulon peninsula in Java, Indonesia, where the last remaining wild population lives in the 30,000 ha core area of the Ujung Kulon National Park (NP). The International Union for Conservation of Nature (IUCN) lists as extinct the Indochinese and Western subspecies of *R. sondaicus —R. s. annamiticus* (Myanmar, Cambodia and Vietnam) and *R. s. inermis* (Bangladesh and India)—which are thus not further considered in this paper.

The Ujung Kulon peninsula is virtually an island, located on the western tip of Java, and connected to the main island only by a narrow 2 km wide isthmus. Once a hunters' paradise, the area was declared a nature reserve in 1921 by the Dutch Government. The reserve became a game sanctuary in 1937 and controlled forestry exploitation was allowed, partly to raise funds for better protection. The same year saw the first attempts to post guards in the area (Van Strien and Rookmaaker 2010).

In 1977 the Food and Agriculture Organization of the United Nations (FAO) and a team from the Indonesian Department of Forest Protection and Nature Preservation [Perlindungan Hutan dan Pelestarian Alam (PHPA), now called Perlindungan Hutan dan Konservasi Alam (PHKA)], drew up a management plan (Blower and Van der Zon 1977) as part of preparations to designate the area as a full national park in 1980. The boundaries of the park were extended to include the Krakatau archipelago. The whole Ujung Kulon NP, consisting of a total land area of 122,551 ha and a 43,000 ha marine area, was designated a UNESCO World Heritage Site in 1992.

Despite such measures, by 1967, the Indonesian population of the Javan rhinoceros was down to only 25 rhinos, all in Ujung Kulon NP (Schenkel and Schenkel 1969a). Thanks to the efforts of Prof. Rudolf Schenkel, his wife Lotte and Indonesian guards, supported by the World Wildlife Fund (WWF) the main threat to the surviving

animals, poaching, has been slowly defeated. Strong patrol activity has allowed population numbers to recover and by the 1980s there were an estimated 60 rhinos in Ujung Kulon (Amman 1986). The latest evidence that the species is still reproducing is a clear sign of hope. However it is obvious that *R. sondaicus* has reached a high density in Ujung Kulon, the species' cul-de-sac, that is unusual for this normally solitary and highly territorial species. Similar densities were never recorded in any part of the species' vast historical area.

A common response to this condition is emigration (Lidicker 1962), an option not feasible for the Javan rhinoceros without appropriate human intervention. Recent analyses suggest the time has come to start applying widely intensive, even controversial, methods to save one of the world's most imperilled species (Erickson-Davis 2014; Seddon et al. 2014).

This paper is a review of publications from 1980 to 2015. It summarizes data on the species' status, identifies key threats, and reviews recent conservation efforts. It concludes by discussing recommendations for the more effective conservation of the species.

Recent conservation efforts

Given that the Javan Rhino's entire global population is restricted to Ujung Kulon NP, its protection and the conservation of its habitat are crucial management priorities. Without the constant presence of UKNP patrolling guards and Rhino Protection Units (RPUs), in particular along the coasts and rivers that allow easy access to poachers travelling by boat, this small population of rhinos would inevitably perish. Recent conservation activity is a part of a major effort to save the Asian rhinos by leading environmental NGOs.

WWF (2002) developed the Asian Rhino and Elephant Action Strategy, a comprehensive conservation framework targeting priority landscapes in South Asia, Indochina, and Southeast Asia. Within these key habitats, WWF and its partners work to:

Restore and secure wilderness;
Strengthen anti-poaching efforts;
Mitigate conflicts over resources to benefit both humans and elephants;
Facilitate creative land-use planning to solve problems facing wildlife and people;
Translocate rhinos to strengthen existing populations and establish new ones;
Monitor populations to improve management strategies for Asian elephants and rhinos.

IUCN (2013) outlined emergency actions specifically to save the Javan and Sumatran rhinos from extinction. Because the future of the two species depends on actions deployed in Indonesia, IUCN proposed the following measures be taken at a higher level to benefit both species by:

Establishing a high-level task force of national and international experts on rhino population and habitat management, which will report each year to the President of Indonesia on progress achieved in rhino conservation;
Starting a programme for managing rhinos following international best practices by identifying the most suitable areas for establishing free-ranging Sumatran and Javan rhinos;
Allocating sufficient resources to enforce protection of the remaining rhino populations in Ujung Kulon, Bukit Barisan Selatan, Way Kambas and Gunung Leuser NPs, and the Leuser ecosystem;
Developing the Javan Rhino Study and Conservation Area (JRSCA) in Ujung Kulon NP to maximise the breeding potential of the remaining animals, and identify, prepare and actively establish an appropriate site for a second population of wild Javan Rhinoceros within Indonesia;
Ensuring regular, frequent and intensive monitoring of all rhino populations in Indonesia, and ensuring all stakeholders collaborate to detect population trends and inform future conservation and management decisions.

Rhino habitat in the Ujung Kulon NP

The Ujung Kulon NP is Indonesia's oldest national park (Figure 1). The park is located on the south-western tip of Java and also includes the volcanic islands of Krakatau archipelago (60 km to the north across the Sunda Straits), the island of Pulau Panaitan (10 km to the northwest across the Panaitan Strait) and the smaller islands Handeuleum and Peucang (Fig. 1). It is in Banten province, formerly part of West Java. The park covers a total area of 120,551 ha, consisting of 76,214 ha of highland and lowland forest, and a marine zone covering 44,337 ha of adjacent coastal waters.

The Ujung Kulon peninsula is mostly lush low-lying forest, but at the western end rises to a height of 430 m (Gunung Payung) before plunging into the Indian Ocean. The peninsula is connected to the mainland by a narrow, swampy isthmus. In the portion of the national park to the east of the peninsula, Gunung Honje peak rises to 620 m above sea level.

The Ujung Kulon peninsula is the core area for Javan rhinos. Covering a territory of circa 30,000 ha, the peninsula is dominated in the southwest by the three north–south aligned ridges of the Gunung Payung massif and its peaks, Gunung Guhabendang and Gunung Cikuja (Mc Ginley 2009). To the north, the mountains give way to the low rolling hills and plains of Telanca Plateau and ultimately to the low-lying swamps in the region of the isthmus to the east.

In his survey of the Ujung Kulon NP peninsula, Griffiths (1993) identified 18,000 ha (60%) of optimum habitat and the remaining 12,000 ha (40%) as sub-optimum; however his appraisal includes the Gunung Payung area, where rhinos do not venture.

Figure 1. Ujung Kulon National Park (Source: UKNP)

Population studies

Van Strien and Rookmaaker's (2010) meticulous research brought to light the presence of a viable number of the Javan rhinoceros in Ujung Kulon before and after the Krakatoa eruption in 1883. Several demographic analyses were carried out before and after Ujung Kulon NP became a protected area. It is beyond this paper to consider historical accounts, but I feel obliged to mention the eminent works of Sody (1959), Schenkel and Schenkel (1969a) and Hoogerwerf (1970).

Amman (1986) authored an extensive field study on *R. sondaicus*; he collected a range of data and counted some 60 rhinos. Shortly afterwards, Sadjudin (1987), assisted by 47 men, identified 52 rhinos. He also found that rhinos had repopulated the area where rhino deaths had occurred in 1982 (see below for further details), though their distribution was uneven throughout Ujung Kulon NP. Santiapillai and Mc Kinnon (1990) gave a figure of 52–62 rhinos. Amman's estimate was therefore essentially correct, as Sadjudin's and Santiapillai's censuses corroborated this information.

Griffiths (1993) undertook a two-year research project on the ecology of the Javan rhinoceros in Ujung Kulon NP, including an extensive population survey with photo registrations taken by 30 cameras that were positioned to over 60 different locations during the study. This was the first attempt to use cameras to estimate the population of the Javan rhinoceros after more than 20 years of using the footprint/track count

method. Unlike footprint counts that rely on transects to collect data, the video trap survey is grid-based, with cameras located in each cell (plots of land) within the grid.

This technique, with its capacity to distinguish between different individuals, is so far the most reliable censusing system, as confirmed by the very precise data provided by the most recent census (Haryono et al. 2015). According to Hiby and Lovell (1993), the photo ID catalogue assembled during a video trap survey is highly relevant for conservation efforts. The register can provide essential information on survival, fecundity and migration, which are determinants of population changes in response to local conditions and it is a basic tool that can inform decisions on how to respond to events such as an outbreak of disease, poaching, pollution or an increase in human pressure. For example, in Ujung Kulon, Hariyadi et al. (2011a) survey photos showed some rhinos with excessive salivation and in undernourished condition.

Griffith estimated 37 to 58 rhinos with a median of 48, and an even sex ratio of 1:1. This data was used to compile the pivotal IUCN SSC Asian Rhino Specialist Group's 1995 report (Van Strien and Sadjudin 1995), which recommended scientific management of Ujung Kulon NP, including ex situ breeding.

According to Khan et al. (2000), at the end of the century there were about 70 rhinos; however WWF (2002) estimated the average number of rhinos to be 50–60. No specifics on sex ratios etc. were given by these authors.

During an 18 month census carried out between April 2008 and September 2009, Hariyadi et al. (2011a) assessed the population at 29–47 rhinos with a mean of 32 rhinos, providing evidence of the first population decline in 25 years. They further estimated a sex ratio of 3:2 (male:female), while average birth rate was estimated at 1.4 births per year and the average mortality rate as 0.9 deaths per year. Hariyadi et al. (2011a) did not expound on the causes of such low numbers, but pointed out that they found three rhinos that had died from illness.

Four International Rhino Foundation (IRF) annual reports, from 2010 to 2013 inclusive, estimated there were up to 44 rhinos and that population numbers were stable. However the authors did not provide estimates of the sex ratio

In April 2012, PHKA, World Wildlife Fund (WWF) and IRF added 120 video cameras to better monitor rhino movements and determine the population size. From 2011 to 2013, using these video camera traps, 60 rhinos were clearly identified. With the loss of 2 individuals (in 2012 and 2013), the population size of Javan rhino in 2013 was a minimum of 58 individuals consisting of 50 adults or sub adults and 8 calves. Of the 8 young rhinos 3 were female as reported by Haryono in Jakarta Globe (2014). The adult population was finally confirmed to consist of 35 male and 23 female rhinos by Haryono et al. (2015). Four new calves were also identified in 2013, representing a possible record 13.79% annual population growth; however net population growth decreased to 10.34% following to the loss of two rhinos (3.45%) Haryono et al. (2015).

In summary, Figure 2 shows the Javan rhino population during the 1965–2015 period. Following recovery from the low point in the 1960s, the population had

reached about 60 animals by the end of the 1980s. The population declined relatively slowly between 1990 and 2005, before recovering to previous levels in 2011, since when (2012–2015) it has remained stable.

The absence of abrupt peaks is a sign that poaching, epidemics and other external threats have not significantly affected the Javan rhinoceros population in Ujung Kulon NP in recent decades, but the last, likely due to the higher number of camera traps.

Though recent increases are encouraging, bringing the Javan rhinoceros numbers back to those of the 1980–1995 period, it also confirms as fact that the park has reached its maximum carrying capacity and, correspondingly, the species has reached its maximum population density in Ujung Kulon. Clearly this tiny population remains highly vulnerable to disease and other threats. Moreover low population numbers continue to be a matter of concern *in primis* because they are linked to a lack of genetic diversity.

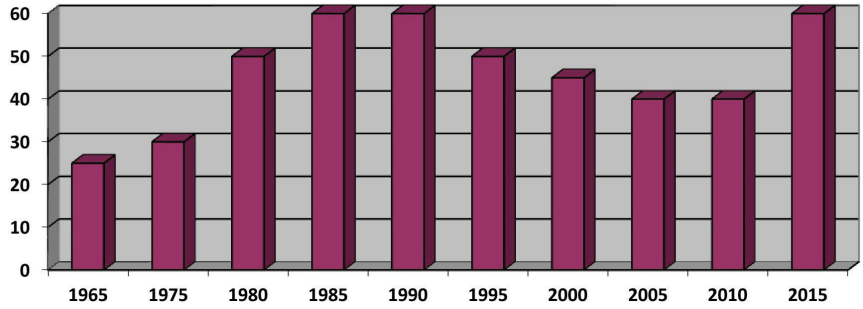

Figure 2. Population of Javan rhino between 1965 and 2015, based on available census data

As indicated by the census results reported above, for unknown reasons, possibly related to the diet of the mothers, the majority of the newborns are male. In addition to reducing the number of breeding females, the skewed sex ratio is potentially a problem because this condition can lead to an increase, among males, in the competition for mates (Haryono et al. 2015).

Although there is historical evidence that rhino species can recover from the edge of extinction, i.e. the recovery in numbers of the Indian rhinoceros (*R. unicornis*) and the southern white rhinoceros (*Ceratotherium simum simum*) in South Africa, it would be erroneous to compare these two relatively social species with the solitary Javan rhino. If no solution is found to expand the limits of Javan rhino distribution beyond Ujung Kulon NP, there is a significant risk of genetic collapse in the population, sooner or later. Therefore, the search for territory large enough for greater number of the Javan rhinoceros to settle in remains a priority. The options for achieving this are discussed in more detail in the final section of this paper.

The problematic status of *R. sondaicus*

Causes of mortality

From 1967 to 1980 rhino numbers increased from 25 to 50 with annual growth at 6.2% (Santiapillai and Mc Kinnon 1990), a rate achieved as a result of efficient protection and better inspection.

Poaching was rampant between 1985 and 1995, the period of maximum population density, and certainly contributed to a decline in the number of rhinos (Van Strien and Sadjudin 1995). Santiapillai and Mc Kinnon (1990) report poachers killed at least two rhinos, Lessee (1994) reports one rhino death and Van Strien and Sadjudin (1995) reports more than one in 1994.

Thanks to intensive surveillance poaching is no longer regarded as a serious threat and no case of poaching has been reported since 2010.

However losses have persisted. Two bodies were discovered between 2002 and 2003, and three in 2010. One of these was the entire carcass with horn; only a few bones remained of the other two (Hariyadi 2011b). Other findings of dead rhinos occurred in 2012 (skeleton), 2013 (skeleton) and 2014 (carcass). In all cases, the suspected cause of death was endemic disease (Nugraha 2014).

These recorded rhino losses add up to a 4% yearly removal of adult rhinos from a population of 50 that has an annual latent growth rate of 1% (Hariyadi et al. 2011b). Thus the status of the species remains precarious. Roth (2011) observed: "For many years, conservationists have kept the Javan rhinoceros safe from poachers while waiting for the population to increase, but instead of increasing these forest residents appear to be decreasing in number".

Three factors are known to threaten the last remaining in situ population of *R. sondaicus*: the presence of wild and domestic cattle carrying pathogens, invasive plant species, and decrease in genetic fitness. The following section analyses these threats in more detail below.

Presence of bantengs and domestic cattle

Devoid of a buffer zone (Ellis 2010), the eastern boundary of Ujung Kulon NP is encroached by local villages, and habitat destruction is evident (Gunawan et al. 2012). The new district of Cibaliung will become a growing centre of development that may place pressure on resources in conservation areas. Cibaliung will cover part of the Ujung Kulon National Park (Widodo Ramono, pers. comm., cited in IUCN World Heritage Outlook www.worldheritageoutlook.iucn.org/).

Domestic Water buffalos (*Bubalus bubalis*) and cattle carry deadly diseases and parasites. Pandemics could rapidly spread throughout Ujung Kulon NP via the omnipresent wild cattle or Bantengs (*Bos javanicus*). These animals are also likely competing with rhinos for food (Khan et al. 1997), as they change from grazers to browsers as grazing land becomes impoverished (Muntasib 2000). Cattle, and ruminants in general, are selective when it comes to feeding: they first eat young and

succulent vegetation and then move to mature greenery, that is, from grass to shoots. When two or more species compete for the same resource, this reduces the potential for their population growth.

Cattle-borne pathogens

The most significant loss of rhinos occurred in 1982 when five rhinos (3 males, 1 female, 1 of undetermined sex) were found dead, along with two Bantengs (Van Strien 1982). The five carcasses were localized by their smell or in casual encounters. Since only 20% of Ujung Kulon NP was surveyed following discovery of these deaths, the epidemic may have killed a larger number of rhinos (Van Strien 1982).

A WWF (1982) field survey led by Prof. Schenkel came to interesting conclusions regarding the cause of these deaths. *Septicemia epizootica*, a virus that had previously killed 350 goats and 50 water buffalos in villages around Ujung Kulon NP, was the first suspect, but Schenkel discarded this possibility. He maintained that the cause of death was anthrax. The spores of anthrax can remain dormant in the soil for decades and, indeed, outbreaks had been recorded years back in that area.

No proper investigation followed the 1982 findings. However a subsequent investigation pointed to haemorrhagic septicaemia (*Pasteurella multocida*) and anthrax (*Bacillus anthracis*), diseases prevalent in the region's domestic Water buffalo, as likely causes of the outbreak of disease in Javan rhinos in 1982 (Radcliffe and Felippe 2013). These pathogens are widespread in Indonesia and were originally introduced in the Ujung Kulon NP ecosystem by wild and domesticated bovids (Scopes 2012).

Analysis of Horse flies (*Tabanus malayensis*) and ticks collected from the death sites confirmed the presence of parasites belonging to *Trypanosoma evansi* in five of six samples (Hariyadi et al. 2011b). The authors of this report affirmed: "Water buffalos and cattle are grazing in the eastern side of Ujung Kulon NP. Some testing is still pending, but it seems unlikely that the cause of the animals' demise will be determined. However, we are hoping that our research will at least rule out the likelihood that some of the more lethal infectious diseases were involved". A report by Anderson (2012) is inconclusive because of uncertainty about the reliability of the results. To date, no studies have definitely confirmed the suspected presence of *Bacillus anthracis.*

Less threatening pathogens are also endemic in the rhino population. Palmieri et al. (1980) examined 20 stool samples from 10 rhinos and identified cestodes, trematodes, nematodes, larvae of Trichostrongylinae and Strongylinae, and adults of Strongyloididae and *Amblyomma* sp. Tiuria et al. (2006) identified several endoparasites (helminths and protozoans) found in one to two-day-old faeces collected in 2005 and remarked: "In the present study, we could identify the degree of contamination and classify it as mild infection. On the other hand, if there is no good control measured, this mild condition could affect the health status of the Javan rhino in general".

Decline in rhino food plants

The Javan rhino is a folivore known to eat typically arboreal vegetation, i.e. leaves, shoots, and saplings, by no means grasses (Nardelli 2013). Recent studies provide evidence of major vegetation changes in the area (Sectionov 2013), causing a deficiency of rhino food plants, and intensifying the potential competition for resources between rhinos and other browsers (Khan 1997). Hyperabundant plant species, mostly the palm *Arenga obtusifolia* (”langkap”) and the vine *Merremia peltata* (”areuy carayun”), are shading seedlings and strangling arboreal vegetation, and in particular saplings the main rhino foodstuff, reducing the limited area of viable environment still further (Hariyadi et al 2012). This plant growth is very fast and tends to dominate the national park. Langkap cover an estimated 18,000 hectares of the Ujung Kulon peninsula (GISD 2011). This results in a long-term decline in the availability of rhino food plants, and poses a severe threat to rhino population.

However, these more recent changes have merely accentuated what appear to be long-term trends. WWF (1982) and Schenkel and Schenkel (1982) concluded that rhinos’ favourite food plants were already becoming scarce in 1982. Amman (1986) found evidence of rhinos travelling considerable distances each night in search of suitable food.

Decrease in genetic fitness

Small population size and isolation decrease genetic fitness. The rhinos in Ujung Kulon NP have numbered 25–60 for as long as 3–4 generations. It is inevitable that most of the rhinos currently breeding are related. This situation leads to inbreeding depression, i.e., higher rate of not necessarily visible birth defects, elevated mortality, slower growth and lower fecundity (Seal and Foose 1989). Using dung samples Fernando et al. (2006) determined that the genetic diversity of the Javan rhinoceros was low, and affirmed that population expansion in the immediate future will be critical for the species’ survival. The Allee effect (Stephens and Sutherland 1999) could draw the last individuals into an extinction vortex. A cluster of animals concentrated in a single location is also extremely vulnerable to natural disasters, poaching, and disease epidemics, in addition to general demographic instability and inbreeding depression.

The way forward

In situ activity—the Javan Rhino Study and Conservation Area

Several Javan rhinoceros action plans or conservation proposals have been presented. Nardelli (1986, 1987, 1988a), Khan (1989), Seal and Foose (1989), Foose (1990), Santiapillai and Mc Kinnon (1990) and Bogor Agricultural University (1991) all produced sound plans for Javan rhino management in Ujung Kulon NP, but insufficent action followed.

In 2011, a programme was finally approved for the establishment of a Javan Rhino Sanctuary (JRS), known today as the Javan Rhino Study and Conservation Area (JRSCA), as part of a major conservation strategy (Van Strien and Sadjudin 1995). This programme has adopted some key recommendations made in previous conservation proposals, in particular for the creation of a managed area within the park (IRF 2014; Yayasan Badak Indonesia 2015; Ujung Kulon NP 2014; Asian Rhino Project 2014; Save the Rhino International 2014).

Following the decision in principle to set up a managed area, surveys were undertaken to search for relocation areas within the species' historic distribution, within Java, using remotely sensed imagery and socio-economic surveys. Researchers assessed potential rhino habitat around Gunung Honje, Gunung Halimun, Masigit Kareumbi and Leuweung Sancang (Ramono et al. 2009). After many delays, the Indonesian government finally approved the programme in 2011 and, with the support of major NGOs, began activities to implement a managed area, approximately 4,000 ha in size, in the eastern mainland portion of Ujung Kulon NP (Figure 3). The intention is to establish a second population of Javan rhinos in the managed area.

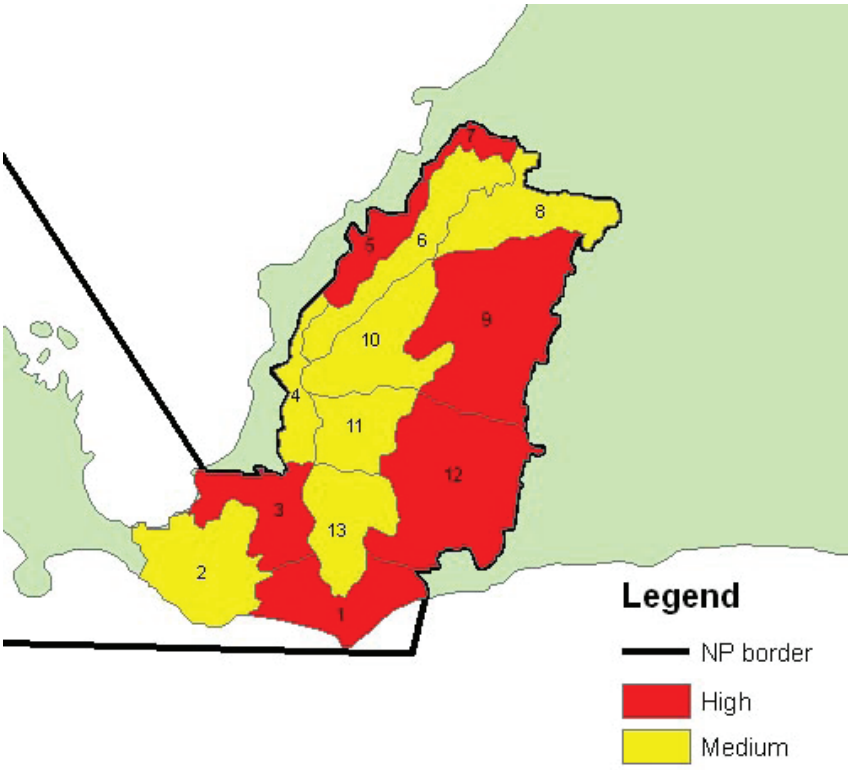

Figure 3. Level of disturbance from human activities in the Honje mountains area (Credit: Van Merm)

Ellis (2011) reported that those responsible for setting up the JRSCA are working on helping to create additional habitat of approximately 4,000 ha in the Gunung Honje area for the Javan rhinoceros by:

Constructing small bridges, an electric fence and a patrol road;
Eradicating invasive species that have taken over a good portion of the habitat;
Planting rhino food plants and providing a water supply and saltlick;
Constructing additional guard posts.

The JRSCA eventually will serve as a 'staging ground' from which translocations to a second site elsewhere in Indonesia can occur.

Harini (2012), in the Ministry of Forestry's JRSCA document, lists three targets, and defines the steps required to reach them:

The Javan rhino sub-population in JRSCA is producing individuals who can be translocated to new locations or that can be added to the natural population in UKNP.
The Javan rhino population is raised in a manner that ensures a viable and healthy population growth.
Partnerships are established among community-based ecotourism enterprises, Ujung Kulon NP and the business world.

While the JRSCA is undoubtedly an important initiative, as a conservation strategy it has a number of limitations. In particular it is likely that the JRSCA will prove too small to allow the species to increase significantly in situ; thus the area risks becoming little better than a large unmanaged zoo. It might be preferable for the area to be developed as an ex situ breeding centre, like the Sumatran Rhino Sanctuary which is starting to show positive results.

The potential for the Javan rhino population to naturally expand further from the new conservation area is low. The topography at Gunung Honje massif is quite different from the part of peninsular Ujung Kulon inhabited by rhinos, which consists mainly of very low undulating hills with a maximum altitude of 50 m. Gunung Honje has a deeply dissected relief with steep slopes and altitudes of up to 620 m (Van Merm 2008) that are devoid of *R. sondaicus*, a lowland forest dweller (Schenkel and Schenkel 1969a; Sadjudin 1987; Hommel 1987; Nardelli 1988b; Santiapillai and Mc Kinnon 1990). This peculiarity of *R. sondaicus* has probably also been overlooked in calculating areas available for the rhino to spread in various action plans.

Moreover, east of the peninsula, natural habitats are subject to high levels of human disturbance, including within the national park (Figure 4). Except where it is connected to the peninsula, the JRSCA is bordered on all sides by villages and farming lands populated by people and their livestock (Sadjudin 1991; Konstant 2014). Risks of human-wildlife conflict clearly exist. Though specialists and supporting NGOs agree on the actions to be taken, declarations from local authorities sometimes contradict the original plans (Anonymous 2014a).

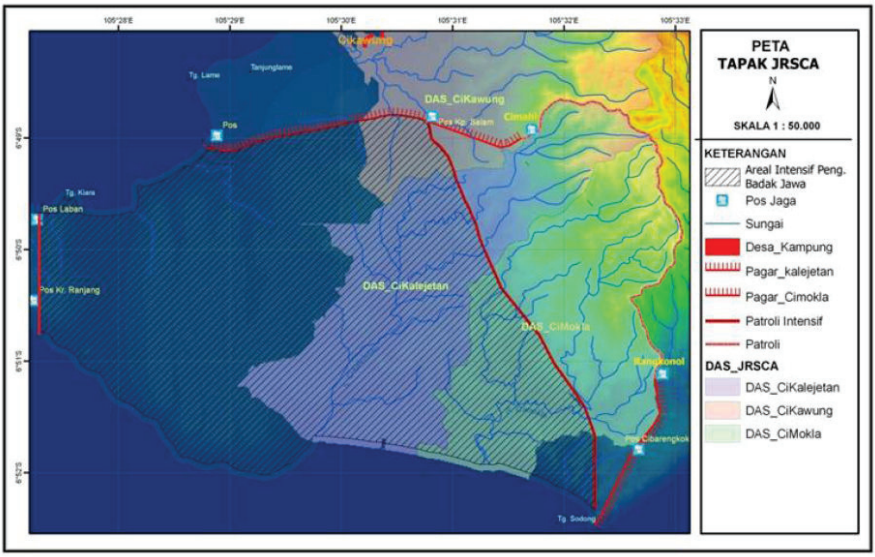

Figure 4. Javan Rhino Study and Conservation Area (JRSCA) site map, showing the overlap with the villages of Cikalejetan, Cikawung and Cimokla. Scale: 1:50,000. KETERANGAN: description; Areal Intensif Peng. Badak Jawa: intensive (Peng.) Javan rhino area; Sungai: river; Desa_Kampung: rural village; Pagar_kalejetan: fence; Patroli Intensif: intensive patrol; Patroli: patrol. DAS (Daerah Aliran Sungai): watershed. (Credit: Ujung Kulon NP)

Outlook

Thanks to efforts by all the parties involved, protection of the last Javan rhinos in situ has improved but numbers remain the same. But for how long can this state of affairs be prolonged, despite the fact that evidently there is goodwill? Regrettably this rhino is a prime example of a 'conservation-reliant' species (Scott et al. 2009). This notion has become increasingly prominent: it refers to a species that needs direct and ongoing human management throughout its lifespan and for its environment in order to persist in the wild.

The concept should assist in developing recovery priorities and allocating funds, if we wish to avoid the Javan rhino becoming 'a relict species confined to an island' (Scott et al. 2009).

Ongoing initiatives to return the Ujung Kulon NP to good shape and consolidate the JRSCA should be fast tracked and new ones set in motion soon, in order to sustain the Javan rhino's present 'stable' population and then enable it to grow. In the author opinion such initiatives could include:

- Pinpoint and monitor the rhino females and allocate two RPU guards to each individual around the clock, along with still and video camera traps, tracking equipment, etc. No non-intrusive option should be discarded in order to supervise these invaluable rhinos and collect as much data on them as possible.

- Carry out extensive and accurate soil and faecal analyses to identify the presence, location and type of pathogenic agents and to devise strategies to halt their spread and eventually to eradicate them.
- Fence the entire Ujung Kulon NP's eastern lowland boundary and create buffer zones.
- Step up containment of the invasive palm *Arenga obtusifolia* and the vine *Merremia peltata,* the most invasive plant species in Ujung Kulon NP. Three procedures can be used to contain the problem: manual cutting, injection of pesticides, and introduction of natural biological agents. The first two options are already in use, and in areas where palms have been removed and saplings planted the habitat is changing in favour of the rhinos (Sectionov 2013). Konstant (2014) reports: "This work has been underway for almost two years now during which approximately 70 ha of langkap are rapidly being replaced by regenerating forest. The project is based in a 4,000 ha section of Ujung Kulon designated as the JRSCA." According to Paynter et al. (2006), "biological control could offer some advantages over current control methods for the management of invasive plant species".
- Intensify the search for optimum habitat for the Javan rhino outside the Ujung Kulon NP peninsula, maybe using the Habitat Suitability Index (HSI). The HSI is a simple mathematical expression for calculating one or more environmental variables not related to demography and survival of parents and their offspring. Calculated HSI values are typically mapped and used to analyse potential distribution of a species, with high values indicating more suitable habitat (USFWS 1980). HSI models are usually developed for animal species. The index is rarely calculated for plants, but it could be, for example to assess the potential distribution of rhino food plants.
- Reduce the number of bovids in Ujung Kulon NP. The Bantengs capture and transportation should not represent a particularly difficult problem. Animals can be driven towards large funnel-shaped fences that will force them enter capture yards, from where they can be translocated to distant areas. This capture method has been successful in Africa for wild cattle but proved deadly in capturing Sumatran rhinoceros, resulting in the loss of 1 animal. Thus, it should not be used to trap Javan rhinos (Tony Parkinson pers. comm.). Removal of domestic Water buffalo and cattle represents a more complex problem because of these animals' close association with local people.
- A translocation initiative should be moving three carefully selected males to Pulau Panaitan or Bukit Barisan Selatan NP followed by careful translocation of two females, identified with certainty as 'satellite individuals', after the males have proved to have settled down.
- Expanding the population into one or more new areas, would reduce pressure on the females by increasing their territory, and providing more nutrition, thereby reducing stress. The opportunity could be taken during the translocation process to perform health checks and genetic inspections of captured animals.

Such studies are urgently required to enhance knowledge of the condition and ecological needs of Javan rhinoceros, this still poorly known species.

- Construct an ex situ breeding facility in the JRSCA based on the model of the Sumatran Rhino Sanctuary (SRS) in the Way Kambas NP. An extension of SRS would be an alternative possibility, to allow for a population of Javan rhinos also to be held there. But for the unknown consequences of interfering with existing Sumatran rhino populations (in situ and ex situ), which may pose an unnecessary risk for both species.

Figutre 5. Javan rhinos – mother & calf – in Ujong Kulon N.P, 1992. Note scars on calf 's shoulder and mother's ears, possibly inflicted by adult male tusks.

Options for ex situ management

The ideal environment for rhinos is a vast area of natural habitat in which they can breed safely and naturally, undisturbed by man and largely unmanaged. Ex situ breeding has traditionally been used only as a last resort strategy to save species on the verge of extinction, although in the case of endangered species it has long been recognized as fundamental to secure the survival of breeding colonies as 'insurance' for the species (Maguire et al. 1987). For the Javan rhino, in the current situation, with less than a hundred individuals remaining in a tiny enclave from which there is no possibility of natural expansion, the case for pro-active ex situ management has become overwhelming. The Javan rhino population is being sustained at its maximum density in Ujung Kulon NP for the time being. However there is a real threat of a sudden, catastrophic decline, that could prove fatal for the species. To leave ex situ action too late was and remains naïve and selfish: a clear sign of failure and fear of liability.

Examples of species saved from extinction and reintroduced into the wild are now so numerous that ex situ breeding should today be considered a priority, not a last resort.

The JRSCA programme apparently contemplates the transfer of a small number of Javan rhinoceros to controlled facilities, but the proposed arrangement is not clear. Sumatran rhinoceros at the Sumatran Rhino Sanctuary in Indonesia, at the Cincinnati Zoo in the USA and at Borneo Rhino Sanctuary in Sabah have contributed greatly to the body of knowledge of this rhino species. One example: the births of three Sumatran rhino calves at the Cincinnati Zoo and Botanical Gardens and one at Way Kambas SRS, have provided unique opportunities to study early development and cow–calf behaviour in this elusive, critically endangered species (Plair et al. 2011).

Despite the Indonesian Ministry of Forestry (MoF 2007) and IUCN (2013) who have set a target of 3% for the annual growth of Javan rhinoceros population, currently the estimated latent growth rate is 1% (Hariyadi et al. 2011b). To better appreciate the risk of extinction of this rhino species, it should be remembered that in 2002, WWF aimed to reach Ujung Kulon NP's maximum carrying capacity of 80 individuals (increasing from 50) before initiating translocation of a few rhinos to a former range area in Indonesia to found a second population (Wielandt 2002).

An ex situ programme could be based on two male and two female rhinos to start breeding. A few extra males, could be used as subjects of various analyses and as pioneers for introduction, under the proper protocol for the species, into new, safer areas (e.g. Pulau Panaitan and/or Bukit Barisan Selatan NP). All the candidate rhinos should be identified with certainty as 'satellite individuals' and moved with the utmost care. All aspects of ex situ program should be closely coordinated with research and in situ conservation activities.

As early as 1970, Hoogerverf suggested starting 'captive breeding' with two pairs of Javan rhinos, but not until 1986 were comprehensive plans presented, with two locations, Way Kambas in Lampung province, Sumatra and Pulau Panaitan, suggested

for possible ex situ breeding of four to five pairs (Santiapillai and Suprahman 1986; Nardelli 1986, 1987).

At the time, the two locations proposed were assessed as unsafe: Way Kambas (with 60,000 ha of forest remaining) because of rampant poaching (the last Javan rhino there was killed in 1961 (Santiapillai and Suprahman 1986) and Pulau Panaitan (15,000 ha) because there was no previous record of rhinos having occurred there, probably because of lack of water (Santiapillai and Mac Kinnon 1990). The current situation at Way Kambas is that the area, though situated in one of Sumatra's most densely populated provinces, is kept secure from poaching by dedicated RPUs. Overall, the area is better protected and suitable rhino habitat seems to be expanding. Way Kambas contains two populations of Sumatran rhino (*Dicerorhinus sumatrensis*), another critically endangered species: there are an estimated 25 animals living in the wild and five (two males, three females) including one pregnant female are kept in the SRS for ex situ breeding.

While Way Kambas is familiar to most conservationists, Pulau Panaitan is perhaps less well known. In 1921 Pulau Panaitan was included in the Ujung Kulon nature reserve area, which later became the Ujung Kulon NP. The island is included in the Asian Wetlands List (Silvius et al. 1989) and contains numerous rivers that make it potentially suitable as habitat for the Javan rhino.

With an area of some 15,000 ha, equal to about half of the Ujung Kulon NP core area, the island is potentially suitable for a population of at least 15 Javan rhinos. This estimate is based on studies carried out on the Ujung Kulon peninsula indicating that male rhinos have territories of 1,200–2,000 ha which only marginally overlap with those of other males; home ranges for female rhinos are much smaller (300–1400 ha) and overlap considerably (Schenkel and Schenkel 1969a; Amman 1986; Van Strien 2005).

I am of the opinion that a thorough survey of the island should be carried out in the near future to evaluate habitat conditions as well as catalogue past and present flora and fauna. What is known about the island is summarized in the following paragraphs.

The topography of Pulau Panaitan is mostly lowland; Gunung Raksa is the highest peak at 320 m, and forms part of a hilly area to the southeast of the island.

Much of the eastern coast is mangrove swamp, interspersed with beaches and coral reefs. Together these form the Kasuaris area; here the terrain is slightly hilly, rising to 100 m. On the eastern side of Kasuaris there are two major rivers: the Cidarhayu and the Cirarashas (Nardelli 1988b). To the southwest, there is a large bay semi-enclosed by two projecting 'arms' of land.

The island contains a variety of habitats, including beach forest, mangroves, fresh-water swamp forest and rainforest. Most of the vegetation is secondary, except for the higher parts where the mature primary forest can still be seen. The abundance of secondary vegetation could be an advantage for the Javan rhinoceros, which eats mostly leaves, young shoots and twigs growing abundantly in forest glades—vegetation types without tall trees or with gaps created by fallen trees. Such places

have better quality of food (Schenkel and Schenkel 1969b; Van Strien 2005).

In 1978 PHPA released some Rusa deer (*Rusa timorensis*) on Pulau Panaitan, that had been translocated from Peucang Island. Other animals observed on the island include monitor lizards, turtles and bats. The management plan for Ujung Kulon NP proposes that Pulau Panaitan should remain a wilderness area.

Before any reintroduction is attempted, several prerequisites must be met, taking account of biological and health considerations, the suitability of the habitat at the release site and its 'free of infectious agents' status, the genetic makeup of the founder population, pre-release necessities of the animals in question, and skills of the personnel involved (Anonymous 2014b).

It should even be borne in mind that recent studies on animal personality indicate that even individual characters can influence the dispersal processes. Evidence is emerging that personality traits can affect departure, distance covered, migration and settlement success, as well as density-dependent processes related to both natal and new habitats (Canestrelli et al. 2016).

I consider the plan to use the island to expand the in situ range of Javan rhinos to be attractive for several reasons. Overall, the site is probably free of pathogens or parasites and devoid of ecological niche competitors; moreover rhinos would not be threatened by poachers or villagers hostile to the presence of rhino. The proximity of the island to the current population on the peninsula minimizes transportation time and therefore disturbance to the rhinos. The volcanic island Anak Krakatau remains active and there is some concern among conservationists about the idea of moving rhinos closer to that place.

However the volcano is a very remote hazard when compared with other current, verified threats to the Javan rhino.

Conclusions

Unfortunately, these matters can be solved only by human interventions using technology, expertise and funds, otherwise the last Javan rhinoceroses will be lost. The low population numbers alone should be sufficient to motivate drastic and prompt interventions, before all the necessary information is in place (Ellis 2012). Long-term logistic commitment and financial investment from the Indonesian government and NGOs are vital, given the long timeframes required for the species' recovery (Brook et al. 2014).

Today, in the midst of what has been termed the Sixth Great Extinction by many in the scientific community, humans are contributing to vertiginous rates of species loss and ecosystem changes. Recent analyses suggest the time has come to start applying widely intensive, even controversial, methods so far used only as last resort strategies to save the word's most imperiled species (Erickson-Davis 2014; Seddon et al. 2014).

These solutions are still a matter for discussion among specialists and government officials. All those involved in negotiations could benefit from becoming more receptive to alternative ideas. On 20 November 2014, *The Singapore Straits Times* reported: ”In the case of Indonesia, many heads of conservation areas are either not capable of carrying out their tasks or are entering their retirement phase, which gives them an excuse for not doing anything. Probably what is needed is for massive motivation efforts to be started among conservation officials in the field to raise their enthusiasm and make them proud of their jobs” (Gawi 2014).

After 35 years, in situ conservation of the Javan and Sumatran rhinos ‘as is’ has proven insufficient (Nardelli 2014, Havmøller et al. 2015) and time is running out. Custodial management, without complementary manipulative management, is failing almost everywhere. Moreover, as Foose and Van Strien (1998) affirmed more than 25 years ago: ‘in situ protection and ex situ breeding are linked’.

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