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Critically Endangered Sumatran Rhinoceros

Inputs for Recovery Strategy and Emergency Actions 2017 – 2027

John Payne and K. Yoganand

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This report was commissioned by WWF. In general WWF endorses the policies and actions recommended, but does not necessarily support every detail

SUMMARY

The Sumatran rhinoceros (*Dicerorhinus sumatrensis*) is the most ancient extant rhinoceros. It emerged in the Miocene about 20 million years ago and is most closely related to the extinct Woolly Rhinoceros. The Sumatran rhinoceros was listed as critically endangered in 1996 due to very severe population declines and very small clusters of animals remaining. It has gone extinct in almost all of its former range outside Sumatra and in most localities within Sumatra, including large protected areas. This critical status continues to date and appears to be worsening. This underlines the urgent need for a revised strategy, based on a critical review of the past strategies, an assessment of the current status, and an analysis of the various factors involved. This report, containing a proposed policy and many recommendations for a species recovery strategy, is the result of an effort to address this need. This report can be seen as an input for the Indonesian National Sumatran Rhino Strategy and Action Plan 2017 -2027 and as a basis for WWF's strategy and possible role to support the Government Strategy and Plan.

Currently, the main biological issue with Dicerorhinus is the extremely small, declining population, whereby individuals are too scattered to sustain adequate breeding to prevent extinction. In hindsight, this could be characterised as a "declining population" problem, where insufficient rhino numbers in any one location, 'Allee Effect' and reproductive pathology of female rhinos pose the biggest demographic hurdles to species survival and population growth. Poaching, in recent decades particularly through snaring, is a constant risk to all remaining rhinos and was the major contributory reason for their decline until about 1980s.

What is a viable Sumatran rhino population size? The question was answered at the Sumatran Rhino Crisis Summit in 2013 and again in 2015 by Caroline Lees (Miller et al 2015). The answer is: at least 20 rhinos with a roughly equal sex ratio, no inbreeding depression and an inter-birth interval of three years. We know from accumulated observations of the species over the past five decades, however, that for any cluster of wild Dicerorhinus, even if there are 20 rhinos, at least some females are reproductively compromised, and overall they are not producing offspring at an inter-birth interval of three years. We can assume that all clusters have some degree of inbreeding.

Currently, a significant population consisting of > 20 rhinos and showing signs of breeding is reported (by Aceh based NGOs) to occur in the western part of Leuser Ecosystem. A smaller population but with some breeding is reported by YABI to occur in Way Kambas National Park. In other parts of Leuser Ecosystem, Bukit Barisan Selatan National Park and the interior forests of East Kalimantan there are definite signs of only a few rhinos each. With the exception of West Leuser, no wild Dicerorhinus cluster appears large enough to be viable. All other wild rhino clusters will drift to extinction, with or without poaching.

The conservation strategies since 1960s until recently were focused on reducing the threat of poaching, including establishing protected areas and rhino protection units, and on conducting population surveys. In the past, rhino conservation strategies did not address the serious

demographic problem of poor reproduction. The establishment of Sumatran Rhino Sanctuary (SRS) in 1997, which has the aim of building a captive population, was a suitable strategy. But the breeding effort and output did not match the need to counter the widespread and serious yet invisible problem of very few scattered rhinos and not enough births.

Intensive Protection Zone (IPZ) and Intensive Management Zone (IMZ) concepts are currently being discussed in Indonesia as new strategies. However, IPZ is a new name for an old approach, directed towards the poaching threat without addressing low birth rate. IMZ involves capturing scattered rhinos and translocating them into large fenced areas in order to promote natural breeding. This approach is partly directed at the low birth rate problem but, due to many issues that we identify in this report, not least that there are not enough fertile rhinos left in the wild to form an IMZ population, it is unsuitable for Dicerorhinus in the current situation. SRS has proven to be very suitable for husbandry and breeding of rhinos. Therefore, all rhinos captured should be maintained in facilities of a similar design, i.e. small individual paddocks with night stalls, one unit per rhino (termed "rhino sanctuary"). There is no need to experiment with IMZs or with translocating captured rhinos back "into the wild" for consolidation of the currently unviable clusters. These experimental approaches will not make best use of precious female and male gametes, and should not be attempted with a species on the verge of extinction.

The days of "conserving" Sumatran rhino are gone. The species is in advanced crisis mode. To facilitate the species recovery program, we outline below a broad policy that we believe is necessary to prevent extinction, and to be adopted in Indonesia and globally.

Proposed policy for the species recovery program

The argumentation leading to the proposed policy is detailed in this report. The proposed policy is placed here, at the beginning of the report, in order to emphasise the urgent need for change, not only within WWF, but nationally and internationally, and without further delay.

Dicerorhinus is on the verge of extinction.

Dicerorhinus is a unique and ancient genus. Its extinction will represent the first terrestrial mammal genus extinction globally since 1936. Responsibility to prevent its extinction now lies ultimately with Government of Indonesia.

Civil society, national and international organisations and other governments can potentially assist, but none can take the key decisions for actions now needed to prevent extinction.

Previous actions recommended, and still being implemented, to prevent extinction of Dicerorhinus have focused on counting wild rhinos, on reducing rhino deaths, on consulting stakeholders, on awareness, on fund-raising and on reducing habitat loss and promoting habitat restoration.

Together, they have failed to halt the decline in numbers because the most crucial action of increasing rhino births has not been prioritised.

The new paradigm to prevent the extinction of Dicerorhinus has the following key features:

- One recovery program.
- Focus on increasing the number of rhino births.
- Ensure that every remaining Dicerorhinus rhino is facilitated to contribute to the survival of the genus, and that every rhino, whether reproductively optimum or not, contributes eggs or sperm or cells.
- Facilitate movement of rhinos and gametes among conservation areas and captive facilities as a population management tool to promote rhino births.
- Bring two forms of wild rhinos into rhino sanctuaries: (a) young fertile rhinos (for natural breeding, to quickly boost captive birth rates) and (b) old and reproductively disabled rhinos (as candidates for application of assisted reproductive technology, ART).
- Focus on preventing extinction and on eventual overall population growth rather than trying to protect every isolated cluster of rhinos.
- Base decisions on science and the advice of Dicerorhinus experts, including rhino veterinarians and reproductive biology experts.
- Make the policy and then seek the necessary financing to implement the actions that support the policy (do not seek funds based on what funds seem to be available at the current time).
- Seek and employ the best people for the agreed actions.

These policies, and the analyses, views and recommendations made in this document represent a radical change from those that have been made in relation to Sumatran rhinoceros elsewhere over the past few decades, including those contained in the 2007-2017 "Strategy and action plan for the conservation of rhinos in Indonesia: Rhino Century Program". The recommended policy change can be summarized as shifting from monitoring and counting rhinos, and from preventing rhino deaths, to making sure that all Sumatran rhinos contribute to making more Sumatran rhinos. A longer term (30 – 50 years) goal of reintroducing Dicerorhinus from captive stock to suitable natural habitats (not necessarily the mountainous protected areas where the remnant rhinos currently linger) for in situ management is implicit in the proposed new paradigm.

This policy can lay a foundation for the new governmental strategy and action plan that will be needed to replace the 2007-2017 plan.

We suggest that WWF-Indonesia takes up six very significant roles to play:

1. To be the institution that introduces the need for a shift away from the prevailing focus on counting and protecting free-ranging rhinos in protected areas to the new paradigm outlined in this report.
2. To sustain that shift by continuing to advise government, and in effect drive the new strategy, even though it is not necessary to take a lead in implementing some of the actions of the strategy (such as captive breeding).
3. To bring in and support the introduction of new players in Sumatran rhino efforts, including philanthropists (for Indonesian sources of funds), lobbyists (to secure greater political support) and land-owners (for potential locations of new sanctuary facilities).
4. To advocate the establishment of a new unit or agency to lead the Dicerorhinus recovery program, under the Ministry of Environment and Forestry (and in coordination with the President's office).

5. To continuously monitor all aspects of Dicerorhinus, including conservation actions being undertaken, and alert government to changes that might be needed in policies and actions.
6. To reach out to the relevant stakeholders and convince them about the merits of the well-studied positions and evidence based decisions taken by WWF on Sumatran rhinoceros.

The single recovery program we propose here is meant to manage all species recovery work, including capture and translocation, and management of all present and future rhino sanctuaries in Indonesia. The main aim of the program is to assist every remaining rhino to allow its gametes (eggs or sperm) to contribute towards making rhino calves, including through advanced reproductive technology, and thereby maximise rhino reproduction.

We deduce that decision-making on rhino captures depends largely on logistical issues, and not on the number of rhinos in one locality, except in the case of West Leuser. Except for West Leuser, the longer rhinos remain *in situ*, the less each one can contribute to the survival of its species. Thus, for fertile females, the intention is that birth rate is maximised. For fertile males, the intention is to make best use of the sperm. For sub-fertile females, oocytes are to be removed and fertilized in vitro, for implantation of embryos into surrogate mothers. We argue that rhino capture should start as soon as possible at all sites: Kutai Barat (work is already underway and permission granted for capture of the few rhinos in "pocket 3"), Aceh (Leuser Ecosystem) , Bukit Barisan Selatan (the remaining rhinos are not viable) and Way Kambas (best hope to secure more fertile females). If the preliminary report on existence of a viable population in West Leuser, Aceh, can be confirmed, then practice *in situ* management and robust population monitoring in an adaptive management framework. However, some fertile females should be removed from Aceh in order to help build a viable and growing captive population.

In terms of leadership on species recovery strategy, our comparative analysis suggests that all the major institutions that could potentially take up the leadership role need to fill major gaps in essential requirements in order to be the leader. A new government-instituted special unit or agency under MoEF, established for the specific purpose of preventing the extinction of Dicerorhinus, appears to have the best chance of providing effective leadership. By definition, the leadership has to be an institution or an individual office-bearer in that institution, and cannot be a collection of institutions (i.e. not the rhino task force or the NGO consortium). The collection of institutions involved in preventing the extinction of Dicerorhinus can play the role of advisors and partners to the lead institution.

<u>The key and immediate needs for the leader to agree on are:</u>
(1) that government needs to put in place a policy along the lines presented in this report for the species recovery, authorize the lead agency to implement the special programme and allocate funds to prevent the extinction of Dicerorhinus;
(2) that there will be one programme managed by a competent team (not several programmes in different places run by different institutions);
(3) that the goal of the programme is to maximise number of births of Dicerorhinus and production of Dicerorhinus embryos;
(4) that capture of wild rhinos will be authorized and commence as soon as possible from Kalimantan, BBS, Way Kambas and Aceh;

(5) that simple low cost facilities probably need to be built in suitable sites to hold several rhinos in the next three years; and
(6) advanced reproductive technology needs to be applied to Sumatran rhinos in fenced, managed facilities, as a means to produce additional embryos.

Finally, we make the following conclusions: Dicerorhinus will very likely go extinct in the absence of quick, decisive actions, because the main problems in recent years have been and still are long delays in decision-making, and implementation of wrong decisions that have been made largely because of cognitive biases. There are now three options open: (a) make the best decisions now for preventing the extinction, as elaborated in this report, and implement them, and / or (b) delegate preventing extinction of Dicerorhinus to land-owners and private individuals (as happened successfully with African rhinos, and American and European bisons), or (c) cease making any further efforts and allow extinction to happen.

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Glossary

Allee effect – *positive correlation between population density and individual reproductive fitness, implying that the smaller a population, the lower the fitness and accordingly low prospects for population survival*.
AREAS – Asian Rhino and Elephant Action Strategy
ART – Assisted Reproductive Technology (also known as "advanced reproductive technology")
BBS – Bukit Barisan Selatan (National Park)
BORA – Borneo Rhino Alliance
BP – years before present
BRS – Borneo Rhino Sanctuary (located in Tabin Wildlife Reserve, Sabah, Malaysian Borneo)
Cluster – *two or more remnant rhinos occurring in an isolated area that together are very unlikely to constitute a viable population over the medium to long term.*
Dicerorhinus – we interchangeably use this genus name with Sumatran rhino to emphasize that not just a species but a mono-specific genus is likely to go extinct.
EoF – Eyes on the Forest
FKL – Forum Konservasi Leuser (Leuser Conservation Forum)
ha - hectares
GMPB – Global Management and Propagation Board
IMZ – Intensive Management Zone
IPB – Institut Pertanian Bogor (Bogor Institute of Agriculture)
IPZ – Intensive Protection Zone
IRF – International Rhino Foundation
IUCN – International Union for Conservation of Nature and Natural Resources
Meta-population – *a group of populations of a species that are separated by space yet interact, as individual members move (or get moved) from one population to another. A key characteristic of a meta-population survival is one or more source populations, where the population grows and can supply individuals to repopulate other occupied or unoccupied areas.*
MoEF – Ministry of Environment and Forestry, Government of Indonesia
NGO – Non Governmental Organization
NP – National Park
PA – Protected Area (used synonymously with conservation areas in Indonesian context)
PHVA – Population and Habitat Viability analysis
PVA - Population Viability Analysis
Rhino Sanctuary – *fenced facilities where rhinos are maintained under close care, with adjacent units of small forest paddocks with night stall, one unit per rhino. This design allows constant monitoring of every rhino, and the potential to apply advanced reproductive technology.*
RPU – Rhino Protection Unit
RSPO – Roundtable for Sustainable Palm Oil
SMART – Spatial Monitoring and Reporting Tool
SRCS – Sumatran Rhino Crisis Summit (also referred as "crisis summit")
SRS – Sumatran Rhino Sanctuary

Sub-population – *group of rhinos occurring in an area that are breeding and likely to constitute a viable population over the long term and not well connected to other such groups.*
TNWK - Taman Nasional Way Kambas (Way Kambas National Park)
WCS – Wildlife Conservation Society
WWF – Worldwide Fund for Nature (also, World Wildlife Fund)
WWF-Indonesia – *Indonesian NGO and country office representing WWF network; interchangeably used with WWF in this report.*
YABI – Yayasan Badak Indonesia (Indonesian Rhino Foundation)

FOREWORD

IS IT WORTH TRYING TO SAVE THE SUMATRAN RHINO?

This question is asked from time to time. The implied reasoning usually is that Sumatran rhino numbers are too low to be viable, that not enough effort is being made to halt the decline, that any efforts made will not succeed anyway, and that money spent on this species might be better used to save other, less endangered and low risk species.

There is a strange irony to this question.

If the answer is no, then all institutions involved should immediately cease work and fund raising for the species.

If yes, then it would seem that a group of passionate and competent people ought to focus on boosting Sumatran rhino numbers, and the fourth implication (better spend money on other species) is undermined. Then, the implication of the question becomes clearer. The actions carried out up to now, and still being discussed, must therefore be insufficient. If the emphasis has been for many years on anti-poaching, habitat protection and awareness, with no evidence of a net increase in number of rhinos, then the approach has been wrong.

Kuhn (1962) challenged the then prevailing view of scientific progress as a process of accumulation and refinement of accepted facts and theories, and argued instead that scientific progress depends on the periodic emergence of fresh ideas that challenge the prevailing “normal” ideas. He introduced the terms “scientific revolution” and “paradigm shift”. This report makes a similar argument in relation to Sumatran rhino.

In the late nineteenth century, both African rhino species (White rhino and Black rhino) were saved from likely extinction by active management (Player, 1972; Skinner & Chimimba, 2006). It is believed that southern white rhino numbers were down to about 100 at that time, and now there are 22,000 southern white rhinos. The same was done for American and European bison (Hornaday, 1887; Pucek et al, 2004), with both saved from extinction by zoos and private land owners. More recently, the Californian condor and black-footed ferret have been saved by captive breeding, despite the strong objections of some detractors (Nielsen, 2006; USFWS, 2008). In contrast, mammals which could have been brought into captivity in the 1980s but were not, and are now extinct, include the Vietnam sub-species of the Javan rhino (Brook et al, 2011) and Christmas Island pipistrelle (Martin et al, 2012).

Thus, there are pre-existing models for the case of Dicerorhinus. All the precedents involve: (a) small groups of passionate people, (b) capture and translocation, (c) private land-owners or zoos, and (d) captive breeding.

While recognising the successes by Cincinnati Zoo and subsequently Sumatran Rhino Sanctuary (SRS), captive breeding for Sumatran rhino has been slow to date, with only five births since year 2000. That rate of reproduction will not be enough to save the Sumatran rhino. There is no evidence to believe that the overall birth rate amongst wild Sumatran rhinos is any better. The implication should be clear.

Scientifically, both knowledge and practice in advanced reproductive technology are progressing quietly but rapidly around the world. Intra-cytoplasmic sperm injection (ICSI; whereby a selected sperm is injected into an egg in the laboratory) allows every sperm and egg to be utilized in order to make embryos in vitro. Indonesia has a world expert in this technique, working in Institut Pertanian Bogor, who has been called to work in Malaysia on Sumatran rhino. Galli et al (2016) report the first production of two, five-cell stage embryos of white rhinoceros using ICSI, as well as a summary of their recent similar work on Sumatran rhinoceros.

Due to widespread but irrational revulsion at mention of the word "cloning", one possible means to boost number of births, somatic cell nuclear transfer (whereby the nucleus of an egg cell is replaced with a nucleus from a diploid cell), has hardly been tried with endangered mammal species. The best polo horses in South America are all clones of the same parent, and these horses were produced in a laboratory in Argentina (Cohen, 2016). Rhinos are taxonomically not far from horses. In 2016, the first healthy mice were born in a laboratory in Japan where the eggs that produced them were made from mouse skin cells (Hikabe et al, 2016). Cell cultures of *Dicerorhinus* from Sabah (Malaysia) are maintained in Germany and USA, with the intention to transform them into induced pluripotent stem cells, the same technique as used in the Japanese mice.

There is an additional important point that has to be considered. Sumatran rhino is an ancient (about 20 million years) mono-specific mammalian genus: *Dicerorhinus*. It is not merely a sub-species or species. Its extinction will represent the first extinction of a terrestrial mammal genus since the Thylacine (Australian marsupial carnivore) in 1936. In fact, there is a large element of luck associated with the fact that the last wild Dicerorhinus are in Indonesia. The name Sumatran rhino derives from the fact that the first scientific description of this rhino was based on a specimen from Sumatra. The name Dicerorhinus is used throughout this report, to emphasise that this is a genus that needs attention. Indonesia will be in the global spotlight if its extinction is allowed to happen through lack of dedicated and adequate effort. And preventing the extinction of Dicerorhinus needs a group of passionate people to stop looking at past failures and instead look to the future.

John Payne
May 2017

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We would like to acknowledge the contributions made by many associates, Dicerorhinus experts and admirers towards preparation of this report.

WWF Indonesia sought our expertise and contracted us for preparing this report. We are thankful to Anwar Purwoto and Arnold Sitompul of WWF Indonesia for providing us this opportunity.

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Yuyun Kurniawan of WWF Indonesia and Arnaud Lyet of WWF US shared with us various pieces of information, the reports they had prepared on Sumatran rhino surveys and other relevant documents and thereby gave very useful inputs.

Widodo Ramono of YABI, Susie Ellis of IRF, Mike Griffiths and Rudi Putra of FKL shared their views during the skype calls and in person meetings we had with them. Mike Griffiths and Rudi Putra also shared with us their assessment of the rhino situation in Leuser Ecosystem. Their interest in our work and their contribution is very much appreciated.

We are grateful to Nan Schaffer for sharing with us a crucial report on analysis that she and her co-authors have done on reproductive pathology in Sumatran rhino and for allowing us to add it as an appendix to this report. She also shared with us some notes on Sumatran rhino reproduction which is reproduced as an appendix to this report.

There are several other rhino experts who answered our email questions and joined consultations on this report – they are listed in Appendix 1 of this report, and we are grateful to them.

Yuyun Kurniawan and his colleagues in WWF Indonesia and Rudi Putra and his colleagues in FKL organized our brief field visits to Kutai Barat, East Kalimantan, in March 2017 and Leuser Ecosystem, Aceh, in April 2017, respectively.

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K. Yoganand and John Payne
May 2017

1 INTRODUCTION

1.1 Significance of Dicerorhinus

The rhinoceros family Rhinocerotidae has its origins in the middle Eocene epoch (about 40 million years ago) with 41 named genera and 142 species from Europe, Asia, North America, and Africa. The family has only four extant (living) genera: *Ceratotherium* (White rhinoceros), *Diceros* (Black rhinoceros), *Rhinoceros* (Indian and Javan rhinoceros) and *Dicerorhinus* (Sumatran rhinoceros). The two African species, White and Black, belong to the tribe Dicerotini, which originated in the middle Miocene, about 14.2 million years ago. The two living Rhinocerotini species, the Indian and Javan rhinoceros, are more recent, and may have diverged from one another about 3 million years ago. The Sumatran rhinoceros is the only surviving representative of the most primitive group, the Dicerorhinini, which emerged in the Miocene (about 20 million years ago). Sumatran rhinoceros is thus the most ancient extant rhinoceros, most closely related to the extinct Woolly Rhinoceros, *Coelodonta*.

1.2 Why was Sumatran rhinoceros assessed as "critically endangered"?

A critically endangered (CR) species is one which has been categorized by the International Union for Conservation of Nature (IUCN) as facing a very high risk of extinction in the wild. It is the highest risk category assigned under the IUCN Red List. Sumatran rhino exhibits two IUCN CR criteria: (i) a declining population of less than 250 mature individuals, with a decline of 25% in overall numbers over one generation and no subpopulation estimated to contain more than 50 mature individuals, and (ii) at least 50% chance of going extinct in the wild over three generations.

Sumatran rhino was first listed as CR in 1996 and this status continued in the latest Red List assessment of 2008 (van Strien et al 2008). The characteristics that justified this status are: "very severe declines of greater than 80% over three generations (generation length estimated at 20 years); and because its population size is estimated to number fewer than 250 mature individuals and there is an expected continuing decline of at least 25% within one generation; and because its population size is estimated to number fewer than 250 mature individuals, with no subpopulation greater than 50 individuals, and it is experiencing a continuing decline."

1.3 The urgency to develop a recovery strategy and emergency actions

The Sumatran rhinoceros has been the focus of substantial conservation attention across its range in Sumatra, Borneo and peninsular Malaysia since the 1960s. However, its distribution range and population status has declined rapidly over the past decades. It has remained as an endangered species for many decades and is currently spiralling toward extinction. It has already become extinct in peninsular Malaysia, Malaysian part of Borneo and in many localities across Sumatra including large protected areas such as Kerinci-Seblat National Park and large parts of Bukit Barisan Selatan National Park. This raises questions such as, why the downward trajectory of the species could not

be stopped and reversed by the conservation efforts? Were the past conservation strategies inappropriate? Were the actions inadequate? Were the priorities for various actions assigned rightly? Are there other factors upsetting conservation efforts? Such questions underlined the urgent need for a revised strategy, based on a critical review of the past strategies, an assessment of the current status, and an analysis of the various factors involved. This report, containing a proposed policy and many recommendations for a species recovery strategy is the result of an effort to address this need.

1.4 Purpose of this report

This report was commissioned as an input to help guide WWF-Indonesia in implementing effective conservation actions for preventing extinction of the Sumatra rhinoceros. The report is also intended to be used to reach agreement with other local and international NGOs and the government of Indonesia on the most appropriate and effective strategies for preventing this extinction. Therefore, this report proposes (1) ways to rescue the Sumatran rhino from extinction (to be presented by WWF Indonesia to the Government and other NGOs), and (2) identifies the role WWF Indonesia can play in this species recovery strategy. The species recovery strategy and emergency actions recommended in this report and the argumentation leading to these recommendations are expected to shape and lay a foundation for the new 10-year strategy and action plan of the Indonesian Ministry of Environment and Forestry (MoEF).

2 ECOLOGICAL AND CONSERVATION HISTORY OF DICERORHINUS

2.1 Range contraction and population decline over a century

20,000 years ago, sea level was about 120 metres lower than now. The amount of Dicerorhinus habitat would have been enormously greater than the present, and what we now call "Sumatran rhino" was likely widespread through the lowlands of Sundaland (Figure 2.1), and northwards to Bangladesh and southern China.

By 1,000 years ago, when sea level was about the same as now, leaving much less rhino habitat, and persecution of wild rhinos was underway for the horns to be used in traditional Chinese medicine, the rhino population would already have been severely depleted in distribution and numbers.

People concerned with Dicerorhinus have allowed themselves to be subject to "shifting baseline syndrome" (Pauly, 1995) whereby small remnant clusters of rhinos have been treated as a "baseline" population, even though the actual baseline would be more than 1,000 years old and most Dicerorhinus clusters were demographically not viable by mid twentieth century, and in a state of terminal decline towards extinction (Table 2.1).

Examination of the relevant literature shows that Javan rhinoceros (Groves & Leslie, 2010) and Dicerorhinus were already probably the most endangered large mammal species in Indonesia and in South-east Asia by the 1930s (Hubback, 1939; Harper, 1945). Either or both species might have gone extinct at any time, due to a combination of excessive hunting and habitat loss. As it happens, both have survived, for two different reasons. And both might go extinct at any time, also for different reasons.

Javan rhino survived because after 1930s, Ujung Kulon was the only location where the species could realistically survive. This meant that attention has for many decades been focused on the Ujung Kulon population. The risks are that this population is inbred, that the habitat has reached carrying capacity decades ago, and a single severe adverse factor (e.g. volcanic eruption, tsunami, disease) could wipe out the last population entirely.

Dicerorhinus has not yet gone extinct because the overall numbers were still much higher than those of Javan rhino in 1930s, and a few breeding rhinos survived in each of many scattered areas, some being sufficiently remote to slow the impact of chronic hunting.

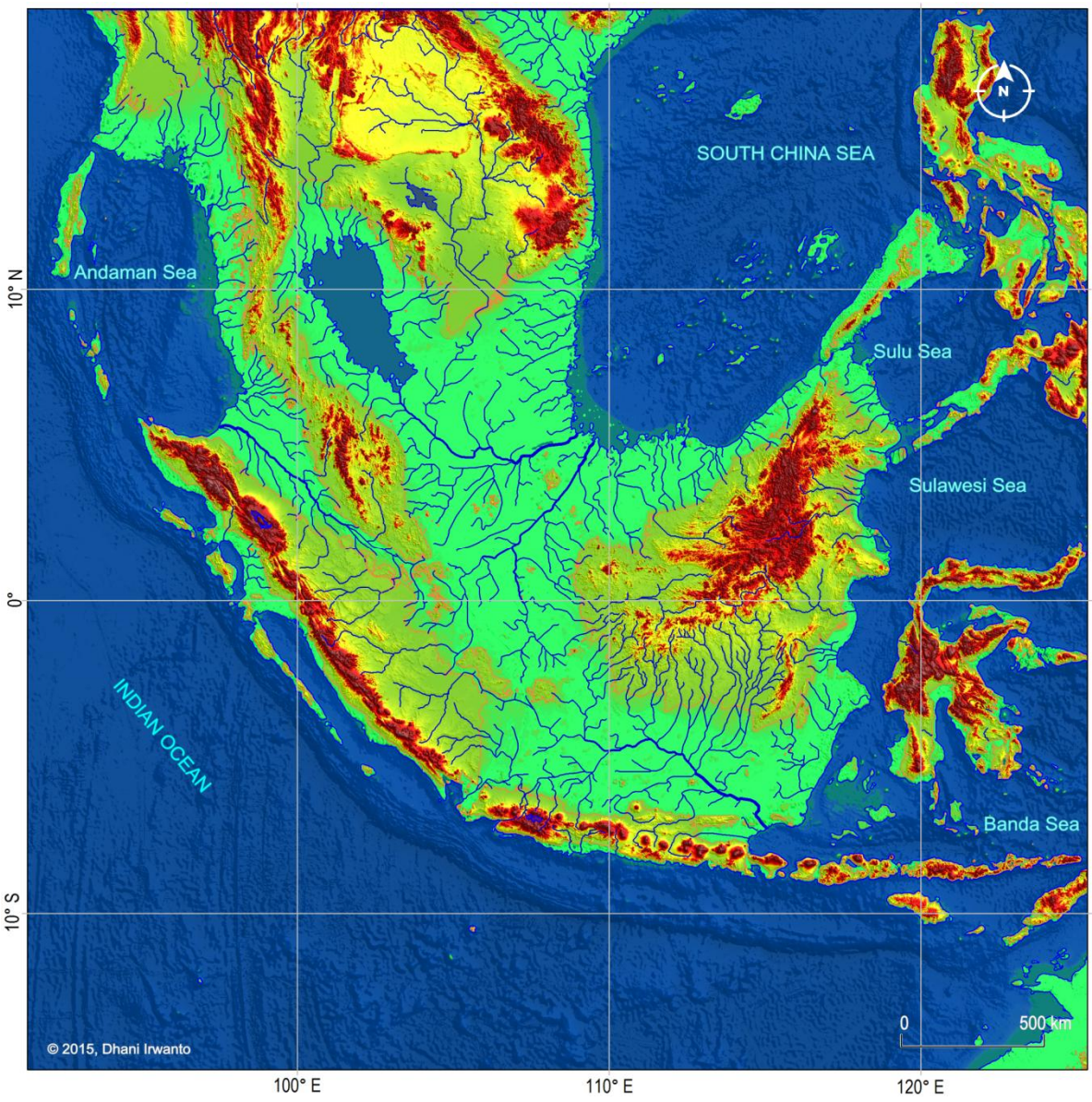

Figure 2.1. Extent of exposed land in Sundaland 20,000 years ago (source: https://atlantisjavasea.com/2015/09/29/sundaland/)

Kretzschmar et al (2016) provide an analysis of the decline of Dicerorhinus in Sabah. A similar picture probably applies to mainland Asia, Sumatra and Kalimantan, with only the years of the death of the last rhino in the wild varying from region to region. That was around 1980 in Thailand (Lekagul & McNeely, 1977), possibly around 2007 in Peninsular Malaysia (Havmoller et al 2015), 2014 in Sabah (Havmoller et al 2015), and can be projected at around 2025 in Kalimantan and around 2035 in Sumatra.

With two exceptions (van Strien 1985; Wells 2003), all estimates of Dicerorhinus population size and density known to the authors are little more than optimistic guesses.

*Table 2.1. Illustration of decline in Dicerorhinus as a result of rising sea level and human hunting**

Years before present	20,000 BP	1,000 BP	80 BP**	Now
Maximum approximate extent of habitat available and used by Dicerorhinus (ha)	800,000,000	300,000,000	100,000,000	500,000[1]
Estimated approximate order of magnitude of total Dicerorhinus numbers	200,000	50,000	2,000	<100
Constraints to unhindered breeding	None	Separation of mainland Asia, Borneo and Sumatra; loss from lowlands inhabited by humans in parts of mainland Asia	Severe; small breeding populations confined to a few large forest areas	Extreme; probably breeding only in a small, remote part of western Leuser Ecosystem and in Way Kambas
Degree of hunting	Very little	Hunting by humans for horns underway	Hunting by humans for horns intense in last remaining concentrations	Low, because of extremely low numbers and presence of protection units
Impact of Allee Effect	None	None	Strong in most areas except parts of Sumatra	Extreme

(* the numbers provided here are the best guesses of the authors, with the intention of demonstrating the orders of magnitude of the changes;
** 80 BP is chosen because late nineteenth century to 1930s was the period when widespread intense hunting appears to have led to the terminal decline that was seen by the late 20th century)

2.2 Natural history of the Sumatran rhino

Borner (1979) published the first major study of wild Sumatran rhino after Hubback (1939). The only truly comprehensive study of wild Dicerorhinus, however, remains that of Nico van Strien. Following a ground-breaking review of the existing literature on the genus (van Strien, 1975) he went on to conduct a vast amount of field work from 1975 to 1980 in the Mamas valley area of Gunung Leuser National Park, Aceh, with the data compiled in his published PhD thesis (van Strien, 1985). The basis of his work was a series of about 400 sets of full plaster casts of rhino footprints, an almost incredible feat for a region so vast and remote. He was able to distinguish individual rhinos by

[1] From area estimated as likely occupied by Pusparini et al (2015). To this, 120,000 ha was added as the total area of the two forest pockets where rhinos are currently known to occur in East Kalimantan.

looking at the plaster casts and even to follow the growth of several rhinos from birth to adulthood. From 371 sets of good casts, van Strien identified 8 adult females, 4 adult males, 9 adults of uncertain sex, and 17 sub-adults, of which 12 were born during the study period. Although the Leuser habitat is different from that of most other Dicerorhinus habitats, his work provided some basic data against which all future Dicerorhinus work should have been formulated.

Some key information inferred were: (1) rhinos live individually, (2) average home range size of adult females was about 2,000 ha, using a smaller area when with calf, (3) average home range size of adult males was about 3,000 ha, (4) home ranges of rhinos overlap, (5) population density of rhinos in Leuser was 13 to 14 per 100 sq km (= 130-140 rhinos in a 100,000 ha forest block), (5) recording any aspects of footprints without taking plaster casts cannot provide an estimate of rhino numbers.

Some key points to take from these findings are: (1) individual rhinos do not "roam" over vast areas, (2) female and male home range sizes are not vastly different, (3) even during van Strien's study period, the Leuser rhino population had been hunted and was being poached, indicating that natural population density of Dicerorhinus may be remarkably higher than we have been accustomed to in all other areas after that period (if Bukit Barisan Selatan National Park (BBS) contained Dicerorhinus at a similar population density now, there would be about 440 rhinos; if the latest estimate of less than 5 rhinos in BBS is correct, then current Dicerorhinus population density is less than 1% of what historically existed in Leuser).

2.3 What does history tell us about optimal habitat for Sumatran rhino?

We now see Dicerorhinus only in a few isolated tracts of closed canopy rainforest. It cannot be assumed that these habitats are optimum and, indeed, we may assume that the locations where Dicerorhinus remains may be sub-optimal and not ideal for breeding. Why? Firstly, in the global context, large-bodied mammals are typically animals of sparsely forested temperate or dry lowlands (the opposite of closed-canopy, hot and humid hills). Secondly, due to the intensity of hunting over a millennium, the locations of the last remnant individuals and clusters are unlikely to be the best sites for Dicerorhinus, but instead a combination of areas that historically received the least hunting pressure and that persist by random chance. Thirdly, there is evidence that in recent historical times, Dicerorhinus distribution was linked to occurrence of concentrated natural mineral sources (references in Davies and Payne 1982). Fourthly, Dicerorhinus specialize in leaves of woody plants, a low-quality form of food, often high in fibre and toxic plant secondary compounds and poor in nutrients. An anecdotal comparison may be relevant. Sumatran rhinos kept in captivity at Tabin Wildlife Reserve (which has clay-rich soils, sloping land, and annual rainfall of around 4,000 mm) select leaves from pioneer tree and liana species as food, and reject leaves from woody plant species characteristics of closed-canopy forest; these rhinos are given daily supplements of horse pellets, to help maintain body weight, which declines dangerously in the absence of this supplementary food. In contrast, Sumatran rhinos kept in captivity at Way Kambas in Sumatra (sandy soils, flat terrain, annual rainfall around 2,200 mm) willingly take a much wider array plant species and do not need supplementary food to maintain body weight. The implication is that there is significant variation in quality of Dicerorhinus food, linked to soil characteristics, and that food quality on some soils might be too poor to sustain breeding (calcium and phosphorus might be limiting minerals for milk production).

2.4 Conservation History of Dicerorhinus

The first scientific publication on Dicerorhinus was by Hubback (1939), who correctly described the physical attributes, habits, senses and diet of Sumatran rhino, ending his paper with: "The only hope that remains for rhinoceroses in Malaya ... to save them from complete extinction is to constitute inviolable sanctuaries in their own habitat... These sanctuaries must be properly guarded and freed from human activities, and severe penalties should be provided for breaches of any laws as are enacted." Hubback was a maverick who spent four decades battling with the British authorities to conserve Malayan wildlife, his greatest achievement being to persuade the Sultans of three Malay States to allocate 434,300 ha of forest land as King George V National Park, now Taman Negara. His passion was Dicerorhinus and he believed that Taman Negara would be the place that the species would be saved in Malaya.

WWF was established in 1961, with the purpose of preventing the extinction of endangered species, at a time when governments had neither funds nor inclination to do so. The first report of WWF, which at that time was a single organization (Scott, 1965), outlined five projects involving capture of wild mammals and birds for captive propagation, four projects involving translocation and two projects involving reintroduction of captive bred birds, as well as projects numbered 14, 73 and 79, involving status surveys of Sumatran rhino in Sumatra, Kalimantan, Malaysia and Thailand. However, there followed a sharp decline between the 1960s and 70s in interest in preventing extinction of critically endangered mammals through moving individuals into managed, fenced facilities where breeding could be maximized. As the years went by, captive breeding was dropped in favour of surveys, establishment of protected areas and various other safe methods that avoided risks of failure and controversy.

By 1982, there was already a mood in IUCN against capture of Dicerorhinus under any circumstances. The chairman of the IUCN SSC Asian Rhino Specialist Group argued that all Dicerorhinus should remain in the wild (John Payne, personal observations, 1982 and 1984). The fundamental difference between the circumstances of the Sumatran and Javan rhinos was not recognized then. The key issue for Javan rhino being that of how to assure persistence of a small, inbred population, whereas for the Sumatran rhino, the issue being how to deal with a small, declining population, where individuals were too scattered to sustain adequate breeding, and where the remaining rhinos were like small drops of water scattered and evaporating one by one over a vast area. This basic difference in the necessary approach to conserving endangered species was described by the great wildlife population biologist Graeme Caughley (1994), and the implications of his "small population" versus "declining population" paradigms were hardly taken up by conservation biologists. The Allee effect (see section 3.2.3) should also have been recognized by 1980s as having a major impact on Dicerorhinus, and that bringing individual rhinos together through capture and either release into a secure wild area or managed breeding in fenced facilities should have been promoted as the most suitable action.

In 1984, a big window of opportunity did become available through an IUCN-endorsed program, agreed to by the relevant rhino range state governments, to embark on a globally-managed captive propagation project for Dicerorhinus, with rhinos obtained from locations outside protected areas. It

was assumed that rhinos in protected areas would breed and increase in numbers, while only "inferior" rhinos would be taken into captivity for breeding. As it turned out, there were two fatal flaws in this compromise: the wild populations continued to decline in numbers, while many of the captured rhinos were reproductively disabled at time of capture.

In March 2005, an ad hoc body named Sumatran rhino global management and propagation board (GMPB) was established, including range state governments, NGOs and institutions holding Sumatran rhinos. However, GMPB was never able to generate sufficient specific agreements or actions, and its last meeting was held in Ministry of Forestry Indonesia in 2012. At the Sumatran Rhino Crisis Summit held in Singapore in April 2013, an over-riding conclusion was that Indonesia and Malaysia should collaborate on this species, a goal that has yet to materialize. Specific actions to be pursued within Indonesia and included in the draft "emergency plan framework" (prepared by Dr Mark Stanley-Price of IUCN, Anonymous, 2013) were a compromise between many differing opinions.

With these examples, it can be seen that decision-making on Dicerorhinus became slower and slower between 1980s and the present, and the few specific decisions made have in many cases not been implemented.

2.5 Lessons to be learnt from the historical trajectory in Sabah

The island of Borneo is divided politically according to essentially random events in Dutch and British colonial history. Kalimantan is a political unit, not a biological unit, so observations on Dicerorhinus in Sabah are very relevant to Dicerorhinus in Kalimantan. For Dicerorhinus, East Kalimantan is now in a similar position as Sabah in the 1990s.

When a British company took control of what is now Sabah in 1881, rhinos were reported as "not infrequent" and were sometimes found in gardens near Sandakan (Pryer, 1881), a town in some ways similar to Balikpapan. The species was already regarded as very rare and endangered in Sabah by 1961 (Burgess, 1961). Payne (1990) showed that isolated ones or twos of rhinos occurred in many parts of eastern Sabah as recently as the 1970s, but the species quickly became extinct at most sites during the 1980s.

In 1980, it was clear that the Tabin area (about 100,000 ha) in eastern Sabah, some 700 km north of Kutai Barat, contained the largest Dicerorhinus population in Sabah at that time. It was thought that 2 or 3 breeding females remained in the area. IUCN did not sanction a proposal for capture of these rhinos and so instead a proposal was placed by WWF-Malaysia with Government of Sabah in 1982 to establish Tabin Wildlife Reserve (120,000 ha), which was achieved in 1984. At that time, based on intensive ground surveys conducted from 1980-84, it was estimated that 12 – 15 Dicerorhinus remained in Tabin. In 2006, a "SOS Rhino" survey team clearly saw a mature male rhino as it walked through their camp in the middle of Tabin. No male rhino was ever detected again in Tabin after that. In December 2011 a female rhino named Puntung with a severe but healed snare wound was captured in Tabin. Intensive surveys for footprints through 2012 and 2013, and camera traps placed at 52 stations and run over 11,600 trap-days within >30,000 ha in a 2.5 x 2.5 km grid during July

2012–July 2013, overlapping the entire area where footprints had been recorded during 1995–2005, revealed that Puntung was the last rhino in Tabin.

In the case of Tabin, the period between "small wild breeding population" (1980) and total extinction (2011) occurred over a period of about 30 years. Whether or not poaching played a major role in that extinction will never be known. There was indeed significant hunting of rhinos in the Tabin area over the period 1930s by local men (Wenk 1938), through 1960s when the first oil palm plantation was opened in the area, with forest felling done by Ibans from Sarawak (Richard Walsh, personal communication, 1980) until around 1980 (large scale commercial logging started in the area in 1960s and ended in mid 1980s). In July 1981, logging camp workers inadvertently killed an infant rhino in a snare trap set for pigs and deer (John Payne, personal observation). Successful prosecution of the offenders, frequent WWF presence up to 1986, cessation of logging around 1990 (which greatly restricted the former Tabin-wide access to serious rhino hunters), and re-instatement of regular patrols by SOS-Rhino in 2001, along with absence of any reports of deaths of rhinos in the area during the period 1986 to 2011, suggest that rhino poaching may have been minimal between mid-1980s up to 2011. However, what is not clear is the possible impact of snares on the demise of the rhinos. Puntung's left front foot was ripped off by a snare trap probably around mid-1980s.

Although ten rhinos were captured in Sabah from sites other than Tabin between 1987 and 1994, a combination of factors made those efforts of no value other than to gain information on capture, husbandry and reproductive behaviour of Dicerorhinus. The factors included: unwillingness to collaborate with or learn from Peninsular Malaysia, Indonesia or USA; a prominent wildlife biologist (Rabinowitz, 1995) arguing that the rhinos should be kept in the wild; 8 of the rhinos were mature or old males (probably most females, easier to find and kill due to their smaller home range size, had been killed earlier); the only young female captured died young through poor care at Sepilok, while a mature female captured in 1994 died at an old age, with no serious attempts made to harvest gametes before she ceased producing oocytes by around 2009.

Ahmad, Payne, and Zainuddin (2013) show that Indonesia is currently in a position very similar to Malaysia in 1980s. The relevant wildlife institution in Peninsular Malaysia still believed there were many rhinos in the wild up to around year 2000, based only on wishful thinking and unreliable information brought by field staff.

2.6 History of captive breeding efforts

Prior to 1970s, breeding on private lands or in zoos, followed by re-introduction into the wild decades later, was a favoured and successful approach to preventing the extinction of several critically endangered large mammals (e.g. European bison, Pucek et al, 2004; Arabian oryx, Tudge, 1992). The idea has earlier precedents relevant to Sumatran rhino (e.g. white rhinoceros, Player 1972).

The first serious recognition that Dicerorhinus was likely heading for extinction if left in the wild, and that a captive propagation program should be undertaken, came from Thomas Foose in 1982 in his

capacity as conservation coordinator of American Association of Zoological Parks and Aquariums (AAZPA, now AZA; J. Payne, in litt.). Following networking and field visits by Foose and his co-workers, the IUCN Species Survival Commission convened an ad hoc meeting in Singapore, 3-4 October 1984, with the result that agreement was reached to form a captive meta-population. The first principle in the agreement was that “Animals selected for capture in the wild are to be "doomed" individuals or come from "doomed” populations or habitats; that is, those whose future long term viability or contribution to the survival of the species is determined to be unsatisfactory as measured by objective criteria subject to continuing refinement” (Scott, 1984).

Forty-five Dicerorhinus were captured from the wild between 1984-2014, with only five captive births, all after year 2000, and all descendants from a closely-related pair that produced three babies in Cincinnati Zoo.

For a combination of reasons, the collaboratively-managed global population imagined by the 1984 IUCN group was never achieved (Ahmad et al, 2013). The most significant reasons included insufficient knowledge of key elements of Sumatran rhino breeding biology, poor husbandry, unwillingness to share rhinos, more than half the rhinos unable to breed due to age-related problems or reproductive pathology, and no work done to apply advanced reproductive technology.

The failure of the 1984 – 2000 captive breeding efforts can help to inform us of what should now be done, rather than be viewed as a reason not to bring Dicerorhinus into fenced facilities.

2.6.1 Lessons learned in the first attempt to capture rhinos in Kalimantan

On 22 March 2016, the first capture of a rhino in Kutai Barat was announced (http://www.wwf.or.id/?46622/BADAK-SUMATERA-BERHASIL-DITEMUKAN-DI-KUTAI-BARAT-UNTUK-UPAYA-PENYELAMATAN) but this rhino, an old female named Najaq with the snare wound, captured on 12 March 2016, died on 5 April 2016 before being moved to an appropriate facility (http://www.wwf.or.id/?46902/DUKA-ATAS-KEMATIAN-BADAK-SUMATERA-DI-KUTAI-BARAT). An unpublished report (*Paparan hasil nekropsi dan pemeriksaan laboratorium Badak Sumatera Najaq di Kutai Barat Kalimantan Timur, 13 June 2016*) provides a detailed chronicle of events between the camera trap imagery up to post-mortem examinations. Several issues can be discerned from this report, most notably the following: (a) too many people and institutions were involved in the capture and translocation plan, the majority with no relevant skills or knowledge, (b) there was no clear structure of leadership, decision-making and responsibility, and (c) people with Sumatran rhino capture and translocation skills were not involved. This in turn led to a series of unfortunate events, notably (a) Najaq was in the pit trap for too long (at least 54 hours; target is to remove rhino as soon as possible, within 24 hours latest), subjecting her to stress and over-heating, (b) the “boma”, a temporary holding facility into which the rhino is led from the pit trap, had not been made ready for assembly within 24 hours, (c) there was too much noise stress throughout the period between capture and death. It is to be noted that the snare wound was not the primary cause of death: Najaq had been living in the wild with the wound for months, and several of the Sumatran rhinos captured in the 1980s to 90s had similar snare wounds, but survived for years afterwards. The report lists a combination of factors as leading to death: old age, stress, dehydration, malnourishment, decreased immunity, bad environment, massive growth of common bacteria and effects of administered drugs.

It is also unfortunate that preparations had not been made for preservation of the ovaries in liquid nitrogen, which might have permitted salvage of germ cells.

It is appropriate to regard the case of Najaq as a lesson for future capture and translocation work, and not as a reason to question the need for such work.

3 CURRENT CONSERVATION STATUS OF DICERORHINUS

3.1 Current locations and population status

3.1.1 Way Kambas, Lampung

Sumatran rhino population in Taman Nasional Way Kambas (TNWK) has not been systematically estimated since Wells (2003, unpublished report). However, based on rhino tracks and signs seen by RPUs during their patrols, an estimate of c. 35 was made for 2012 (Talukdar et al 2012) and 31 to 36 for 2014 (Miller et al 2015). One of us (J. Payne) examined the YABI quarterly reports from 2010 to 2016 and found them to contain many "rhino" records which are wallows, twisted saplings, scrape marks etc. none of which are definitive proof of rhino. The number of fresh footprints and faeces recorded were always very low, and no evidence has been produced in the quarterly reports to show that there were one or two births every year. These records are not consistent with a population of 30 rhinos in 60,000 hectares of easily-traversed lowland forest.

Rubianto et al (presentation[2] at the 15th International Elephant & Rhino Conservation and Research Symposium[3], Singapore, November 2016) suggested that a total of 17 to 20 rhino calves were observed by RPUs in TNWK between 2006 and 2015, with a minimum of one calf each year. If one calf per year, an inter-calving interval of 3 – 4 years, and a juvenile mortality rate of 15 – 25% are assumed, it would suggest about 5 breeding females and a total population size of about 15 rhinos. However, the potential error in distinguishing calves of any one year from each other by tracks and signs was not quantified, and a rigorous analysis and an independent verification of the RPU data is yet to be done. Such an analysis and verification is essential in light of the large errors in such tracks and signs data discovered in BBS (see section 3.1.2).

Independent of the RPU data, organizations named ALeRT[4] and Yayasan PKHS[5] have been conducting camera-trap surveys over parts of TNWK and have occasionally photo-captured rhino calves (Marcellus Adi Riyanto, personal communication). It appears that such camera-trap survey data gathered in recent years could be used to estimate Sumatran rhino population size and structure in the same way as Wells (2003) did. However, this is yet to be done.

3.1.2 Bukit Barisan Selatan, Lampung

Camera trapping and faecal DNA surveys conducted in Taman Nasional Bukit Barisan Selatan (BBS) between 2012 and 2016 suggested that there are probably fewer than five rhinos remaining in the park currently and with no evidence of breeding (Arnaud Lyet, WWF US, unpublished report). Survey results supporting that conclusion included: (i) only two rhino photo-captures were obtained from camera-trap surveys conducted between 2012 and 2016; (ii) of the 56 dung samples collected

[2] Seen by the authors of this report
[3] https://elephantconservation.org/iefImages/2016/01/15th-Intl_ELE-RHINO_Symp-ScientificProgram_11-16.pdf
[4] Aliansi Lestari Rimba Terpadu - Alliance for Forest Conservation
[5] Perlindungan dan Konservasi Harimau Sumatera

between 2012 and 2013, only 14 of them (25%) were that of Sumatran rhino and the rest were likely to be that of Malayan tapir; (iii) all the rhino dung samples came from a small 7 x 7 km area of the National Park; and most importantly (iv) no rhino was photo-captured in 2015-16 survey period when the survey effort focused on the area where rhino dung was obtained in 2012-13 and a photo-capture was made in 2013-14. Most frustratingly, there has been serious misidentification of tapir tracks and dung as that of rhinos, resulting in a very large overestimate of distribution extent and population size (subjectively estimated as 17 – 24 rhinos from the same tracks and signs data; estimated as 20 – 30 rhinos from occupancy modelling, Miller et al 2015). Such substantial errors also call into question the reliability of the subjective estimates made from similar data in TNWK.

3.1.3 Leuser Ecosystem, Aceh

The population of Sumatran rhinos in Leuser Ecosystem is thought to be further subdivided into six clusters of rhinos, largely isolated from each other and four of which consisting of as few as two rhinos each (Miller et al 2015). Kappi plateau, in the eastern part of Gunung Leuser National Park, is estimated from sign surveys to contain 8 – 10 rhinos. Western part of Leuser Ecosystem which includes the National Park and adjacent Protection Forest is thought to contain about 20 rhinos, including 12 from a single contiguous valley (Miller et al 2015). The population of 12 was estimated from camera-trapping surveys in the valley in 2014. This is the only sub-population in Leuser that had evidences of recent breeding, in the form of camera-trap photos of rhino calves. Furthermore, an average of three rhino calves per year over the past five years was estimated from camera-traps and tracks for this particular valley (Rudi Putra and Michael Griffiths, personal communication). This valley was estimated to have a population on 39 rhinos, including 12 juveniles, in late 1970s (van Strien 1985) and about 18 rhinos in 1991 (Michael Griffiths, personal communication). From surveys over a wider area, and using relative track density, visitation rates at salt licks, and knowledge of past occupancy patterns, FKL estimates a population size of several 10s of rhinos for West Leuser (Rudi Putra and Michael Griffiths, personal communication). This subpopulation is estimated to occur over 320,000 ha of West Leuser, however, a large part of which remains to be surveyed due to the remoteness of some locations. If this estimate is confirmed through further data analysis and peer review, then it will make West Leuser the only substantial sub-population of Sumatran rhinoceros and which can be considered viable in accordance with the population viability analyses (Lees 2013; C. Lees, in Miller et al 2015).

3.1.4 Kutai Barat – Mahakam Ulu, East Kalimantan

PT Hatfield Indonesia (2014) provided an estimate of 7 – 15 rhinos, scattered over a large area (see Appendix 2) of approximately 200,000 ha in a part of East Kalimantan bordering with Central Kalimantan. The actual number of rhinos would be lower as the evidences provided therein for counting multiple rhinos in each survey block and across blocks are highly error prone and unreliable and which included: rubbing signs, trails, footprints, dung, wallows, and feeding signs. In any case, the estimated numbers, their scatter and the lack of evidence of breeding rhinos suggest that this is not likely to be a viable breeding population. Miller et al (2015) reported a population size of 8 – 17 rhinos, the evidence for which seemingly comes from several areas scattered across East, West, North and Central Kalimantan provinces. This includes an estimated population of 6 – 12 rhinos in a contiguous area ("Zone 1") in Kutai Barat and Ulu Mahakam districts of East Kalimantan (the area covered in the PT Hatfield report), although there is camera-trap evidence for only one female rhino so far. Based on more recent surveys (2016 – 2017) done by WWF-ID, only 2 – 3 rhinos can be

confirmed to exist from camera-trap photos in the survey area, while some potential adjacent areas have not yet been surveyed thoroughly (Yuyun Kurniawan, personal communication).

3.2 Main threats and factors affecting population growth

3.2.1 Low birth rate

Inter-birth interval of the three Sumatran rhinos born in Cincinnati Zoo was 2 years and 10 months, under conditions of high quality food, with constant monitoring to identify optimum times for mating. Interval between births of two rhinos at SRS was three years, eleven months. One young is born at one birthing.

3.2.2 Insufficient numbers in one location

Humans look at maps of large forest areas, and see scattered records of rhinos, and may make the assumption that all the rhinos (and "all" may mean perhaps less than five in any one location) are in regular contact. Female rhinos have individual home ranges of probably less than about 2,000 ha. They will be available for mating only if any remaining males, which have larger home ranges, actively seek the females. Females cycle at intervals of about 22-27 days, and are receptive to mating for only one or two days per cycle. Thus, the prospects for successful natural mating are very small when rhino numbers are very low. Important lessons need to be learned from the 1984 – 95 captures of forty Sumatran rhinos (see section 2.6; Appendix 3). For wild Sumatran rhinos, actual overall birth interval is likely to have been much longer in recent decades than achieved in Cincinnati Zoo and Sumatran Rhino Sanctuary, Indonesia, because of the paucity of sites with fertile females and males present, further limiting prospects of population recovery of wild Sumatran rhinos.

The last known area with high numbers and high population density of Sumatran rhino was that documented by van Strien (1985) for the Mamas area of Leuser up to 1980. All other documented sites with Sumatran rhinos both before and after that study had very much lower rhino numbers and population density. Note that the Allee effect (see section 3.2.3) implies that not only absolute numbers but also population density are implicated in depressed individual (and population) fitness when numbers become abnormally low. The implication is that over the past five decades at least, apart from parts of Leuser in the 1970s, all Dicerorhinus clusters have comprised numbers in one location that are too small and sparse to sustain a breeding population.

3.2.3 Allee Effect

Decision-makers concerned with Dicerorhinus should by the 1980s have acknowledged the relevance of the Allee effect (Allee, 1931), which refers to a phenomenon whereby a positive correlation exists between individual fitness (survival probability, fertility, reproductive rate) and population density of the species (Courchamp et al, 2008). As numbers of individuals decline, the various factors associated with very low numbers (e.g. narrow genetic base, locally skewed sex ratio, difficulty in finding a fertile mate, reproductive pathology associated with long non-reproductive periods) combine to drive numbers even lower, to the extent that death rate eventually exceeds birth rate, even with adequate habitat and zero poaching.

There is an enormous literature, from the 1930s to present, pointing to the role of population density in the potential survivability of wild species (e.g. Krausman & Cain, 2013). The possible relevance of this literature to Dicerorhinus was until recently missed, perhaps because most of the literature refers to much smaller animals, mainly invertebrates and fish, which typically live in large numbers at high densities. For Dicerorhinus, both the absolute numbers of rhinos (very low by 1930s and declining thereafter) and their population density (extremely low at all sites since around 1960s) should have indicated that the genus is on a trajectory to extinction.

Possibly the most relevant case for mammals published in recent times is that of the endemic Vancouver Island Marmot (Brashares et al, 2010; Jackson et al, 2015), which declined in numbers in the wild from around 300 in the mid-1980s to around 30 in 2003. The cause of the decline is not stated in the literature and is not obvious but, interestingly, this issue seems to have been regarded as of little relevance in deciding how to address avoidance of extinction. A captive breeding programme was initiated in 1997, under which a total of 55 marmots were captured between 1997 and 2004, and by 2012 overall marmot numbers had grown back up to around 300. Monitoring of the wild population revealed interesting data. Over the period 1975 to 2005, individual marmot home range size increased by at least ten times, and interactions between individuals declined by 90%. Although Dicerorhinus are much more difficult to manage and breed than marmots, the lessons are clear. One is that managed captive breeding is necessary to boost numbers quickly. Another is that when wild population density becomes very low, opportunities for breeding may be very much less than under normal population densities.

3.2.4 Inbreeding

There are no data yet to prove that Dicerorhinus clusters are suffering from inbreeding or adverse impacts of inbreeding. However, a reasonable assumption can be made that such risks are high in all remaining wild Dicerorhinus clusters, because numbers and population density have been low for several generations, and so mate choice has likely been restricted to related individuals. Unpublished data show that the Sumatran rhino pair that produced three offspring in Cincinnati Zoo were closely related (Nan Schaffer, personal communication).

3.2.5 Reproductive pathology

At least half the female rhinos caught between 1984 and 1995 had reproductive tract pathology (Schaffer et al, 2001). The exact number or percentage is not known, in part because earlier examinations of live females lacked ultrasound devices, not all dead rhinos were examined, and there is no sharp cut-off point between scattered cysts and pathological growths. This is a phenomenon associated with lack of either breeding or carrying of foetuses to successful birth that occurs in many mammalian families, but appears to particularly afflict rhinos (Hermes et. al, 2006). The fact that at least some wild female Sumatran rhinos have exhibited this pathology at time of capture (the last two captured in Sabah) or death in the wild (year 2001 in Sabah) indicates that not all wild female rhinos are breeding, presumably due to insufficient fertile males to meet and mate.

An unpublished report prepared in March 2017 by Dr. Nan Schaffer and co-authors (Appendix 4) examined reproductive pathology in female Sumatran rhinos with more up-to-date data on rhinos captured in Malaysia and Indonesia post 1984. 21 out of 25 (84%) female rhinos captured in Malaysia and Indonesia after 1984 and for which pathology records exist showed evidences of

significant reproductive pathology or problems with conception (Table 3.1; detailed records are given in Appendix 4).

Table 3.1. Reproductive pathology in captive bred and wild Sumatran rhinos captured in Malaysia and Indonesia after 1984 (source: Nan Schaffer and co-authors; Appendix 4).

Country	No. of female rhinos captured	Rhinos with examination records	Rhinos having reproductive pathology
Malaysia	15	14	12 (86%)
Indonesia	15	11	9 (82%)
Total	**30**	**25**	**21 (84%)**

3.2.6 Disease

Excessive growth of commensal bacteria (mainly Escherichia and Klebsiella) has been the major cause of morbidity and mortality in captive Dicerorhinus, but this is due entirely to human management failures, and no similar situation would occur in the wild.

Captive Sumatran rhinos are susceptible to eye disorders (Kretzschmar et al, 2009; Dedi Chandra, personal communications) whereby the etiology is uncertain, but believed to be linked to frequent over-exposure to bright light and therefore much less likely under forest cover.

Dicerorhinus are susceptible to iron storage disease, in which natural physiological mechanisms to excrete excess iron are faulty, and iron builds over the years in the internal soft organs, eventually leading to premature death. The only female Dicerorhinus born in Cincinnati Zoo succumbed to this disease in 2014, aged only 9 years and not yet bred. An analysis by Dedi Chandra et al (2012) showed that the phenomenon is closely linked to diet. Risk of iron ferritin disease is high in zoo diets poor in browse, but appears to be very low when Dicerorhinus are fed essentially natural diets in SRS and in Sabah.

Other than female reproductive tract pathology (that is not caused by infectious organisms), there has been no evidence that wild Dicerorhinus clusters have been adversely affected by diseases. This is not surprising given that population density is sparse (low risk of spread between rhinos) and food consists largely of fresh leaves.

3.2.7 Poaching

The high price paid for Sumatran rhino horns to feed the traditional Chinese medicine market means that poaching is a constant risk to all remaining rhinos. However, this has been the case throughout Southeast Asia for more than one thousand years, and represents the major contributory reason for their critically endangered situation now. Unfortunately, misunderstanding of the significance of poaching of Dicerorhinus after the 1970s has contributed to the current predicament of the genus. The reality is that with the possible exception of a montane cluster of Sumatran rhinos in the Leuser ecosystem, no wild Dicerorhinus cluster is now viable, as a result of insufficient breeding. All wild clusters will now drift to extinction, with or without poaching.

3.3 Past conservation approaches

In the late nineteenth century and throughout the twentieth century, there were two major approaches to preventing the extinction of rare large animals: establishment of protected areas that were intended to support free-ranging wild breeding populations of the target species, and efforts to boost breeding by bringing remnant individuals into managed, fenced facilities. For example, in Malaysia not only Hubback (section 2.4) thought that Sumatran rhino would be saved by establishment of a large protected area, but the same assumption was used as a basis to establish two other significant protected forest areas in Malaysia: Tabin Wildlife Reserve (1984) and Endau Rompin State Park (1985). Now, the former remnant populations of Dicerorhinus in these three protected areas have gone.

The protected area concept is both noble and necessary, but was always going to be inadequate to prevent the extinction of all species – a fact that remains as a concern in wildlife conservation circles. The species-area curve (Arrhenius, 1921, Cain, 1938) and the research that this concept has subsequently generated have remained largely in the realms of academia (e.g. He & Hubbell, 2011; Economo et al, 2016) while the concept's relevance to the inevitable extinction of species in tropical forest regions has been largely ignored. Certain sorts of life forms are clearly at greatest risk of extinction as natural forest habitat area declines, notably localized endemics, highly specialized and co-evolved taxa, and large vertebrate species. Localised endemics and specialist taxa can most readily be preserved from extinction by ensuring that examples of the key habitats are retained as "protected areas". Large vertebrates are especially at risk when previously extensive areas of habitat are lost, because large vertebrates tend to occupy and achieve high population densities in the lowlands and valley bottoms that are settled and farmed by humans. This tendency is likely linked to soil fertility and primary plant production. Even very extensive forests in hills, mountains and swamp may be insufficient to sustain viable breeding populations of large vertebrates either because in these regions primary productivity is too low, or food quality may be too poor, or essential minerals are insufficient (e.g. McDowell, 1985; Seagle & McNaughton 1992, Leshchinskiy, 2014, 2017). In summary, large protected forest areas were and still are assumed to be the key means to prevent extinction of Sumatran rhino, but reality shows that this assumption is not necessarily true.

As noted in the Foreword (above), Africa rhinos and both extant bison species were saved from extinction primarily due to the latter method (maximising breeding in captive facilities). And as noted in section 2.4, there was a sharp decline between the 1960s and 70s in interest in preventing extinction of critically endangered mammals through moving individuals into managed, fenced facilities where breeding could be maximized. This is a tragedy, because the evidence shows that bringing large animals into fenced, managed situations can mean the difference between either boosting numbers up from critical levels or extinction.

The past captive breeding efforts for Dicerorhinus are described in section 2.6 (and Appendix 3).

3.4 A review of current conservation strategies

3.4.1 Rhino Protection Units

Rhino Patrol Units or Rhino Protection Units (RPU) are special teams of rangers formed as part of the protected area approach to rhino conservation (section 3.3). RPUs are deployed in protected areas

and other rhino habitats, often funded by NGOs, to boost protection against the threat of poaching. In Sumatra, the Yayasan Badak Indonesia (YABI) has deployed RPUs in Way Kambas since 1998 and in BBS for conducting regular patrols to deter poachers. The strategy in general is considered to be effective in reducing the poaching threat and in detecting and documenting poaching incidents.

The RPUs also conduct rhino population monitoring, by documenting detections of rhino signs (footprints, dung, other perceived signs) along with GPS coordinates, but often without statistically sound survey designs that would permit use of such data for reliable population estimation.

Indonesia has apparently fared better in terms of fielding experienced personnel to seek rhino signs. However, concerns similar to those found in Sabah still exist. Wallows are not signs of rhino (as it is impossible to distinguish wild pig and rhino wallows in the absence of rhino footprints), yet wallows are commonly recorded as "rhino signs" in RPU reports right up to year 2017. In Sumatra, tapir footprints and faeces may be recorded as rhino, even though field workers allocated to survey for rhinos can and must readily distinguish signs of these two species. Tapir and rhino footprints differ, and the two species usually can be distinguished, without the need for DNA, by measuring lengths of the longest fibres in faeces (Zainuddin et al, 2000; see Appendix 5). Yet, tapir has been counted as rhino in BBS as recently as 2016.

There is recent realisation of records based on footprints and faeces as being unreliable (e.g., mud on tree trunks as animal scratching, bite marks on low plants as "feeding signs", and urine spray as rhino, even when no rhino footprints have been found), which has led to a preference for use of camera traps to estimate rhino numbers.

3.4.2 Distribution and Population Surveys

Spatial occupancy surveys:

Occupancy estimates are not linearly and often not monotonically related to population size and so are not sensitive indicators of changes in populations sizes. Therefore, occupancy models reveal no information of value in urgently deciding what to do to about the remaining wild Dicerorhinus (see section 3.5.5). Their main use appear to be in identifying localities where further population estimation using camera-trapping or faecal DNA surveys should be done. Occupancy estimates made using models containing environmental covariates identify the factors that might influence rhino distribution, and map the probability of rhino use across the study area. However, such identification of factors and habitat suitability are subject to the larger issue of "shifting baselines" described elsewhere in this report (section 2.1). Further, such identification of factors and modelled distribution is subject to the errors in identification of rhino signs, including dung and footprints, which has now become a huge concern (see section 3.1.2). A good example of why such occupancy modelling is not useful is the case of Bukit Barisan Selatan where 820 km^2 extent was estimated as occupied by rhinos in 2010 (Pusparini et al, 2015), while only very few rhinos existed, likely confined to a 7x7 km part of the park when surveyed in 2012-13 (see section 3.1.2). Such modelling results are thus misleading and in fact can severely hinder urgent conservation actions.

Use of camera-traps for population estimation:

The only quantitative estimate of Dicerorhinus numbers in a defined area known to us is an unpublished report by Wells (2003), who utilized camera trap images of Dicerorhinus in Way Kambas National Park, obtained during a study of tigers. The fact that rhinos do not have unique natural markings unlike tigers makes it difficult to use camera-trapping in a mark-recapture statistical framework for estimating population size. Wells (2003) appears to have devised a novel although somewhat subjective way of dealing with this problem. A recent publication on Javan rhinoceros has also used such individual identification of rhinos from camera-trap photos to estimate population size (Setiawan et al, 2017).

Simultaneous surveys of large areas by multiple teams:

In an unpublished report prepared in October 1984 for the IUCN SSC Ad Hoc Meeting on Sumatran Rhino, John Payne suggested that in October 1983 there were about 20 Dicerorhinus in the Dent Peninsula of Sabah, about half of which land area had recently been established as Tabin Wildlife Reserve (1,200 sq km), with at least 3 of the rhinos killed during that 12 month period. This estimate was based on locations of fresh rhino footprints found by teams of known, experienced forest rangers, 3 or 4 persons per team, over the period 1980 to 1983, and assuming that there were a few more rhinos not detected in more remote areas. Criticism was expressed by Rabinowitz (personal communication to J. Payne), that the period between surveys was too long, and that rhinos might have moved from one site to another, and therefore one rhino might have been counted as two or more. Rabinowitz (1992) instituted the idea of conducting simultaneous surveys by several teams to seek rhino signs during a short time period (10 days actual field work). This method has been used until recently in Sabah for periodic surveys to seek rhinos in Danum Valley, typically with about seven teams of about seven persons each. Although good in theory, the method is problematic in practice because many team members have not done similar work previously, or are less fit, not accustomed to life in forest camp, and too much time is spent on logistics and on recording on species other than rhino. One of us (J. Payne) is aware of at least three specific and separate cases in Sabah between 2005 and 2015, where footprints of young elephants were recorded as Dicerorhinus. It is clear that at least some of the “rhino records” obtained during these surveys are erroneous, leading to over-estimates of numbers of living rhinos, at least in Sabah.

3.4.3 Intensive Protection Zone (IPZ)

Intensive Protection Zone (IPZ) is a term introduced at the Sumatran Rhino Crisis Summit of April 2013 based on two assumptions: (a) intensive protection work was not being done; and (b) Dicerorhinus numbers can increase by increasing the amount of protection work done in areas where there are the most rhinos. These assumptions are not entirely valid. Dedicated RPUs have been fielded in Way Kambas and BBS to focus on rhino protection in areas of the most frequently reported rhino presence, and thus Way Kambas and BBS are in effect already IPZs, although the term IPZ was never specifically used previously to describe the situation. We do not see how an IPZ will be substantially different in practice than what is being currently practiced. As repeatedly highlighted in this report, two major threats to Dicerorhinus survival, reproductive pathology and Allee Effect, cannot be resolved by increased protection. We therefore suggest that the term IPZ is redundant in the Sumatran rhino context and therefore should be abandoned.

3.4.4 Intensive Management Zone (IMZ)

Intensive Management Zone (IMZ) is a term introduced at the Sumatran Rhino Crisis Summit (2013) but lacking in clear definition. Apparently, the concept does not refer to the "rhino sanctuary" concept of adjacent units of small forest paddocks with night stall, one unit per rhino. Instead, it seems to mean very large fenced areas inside forests into which rhinos captured from elsewhere in the wild be introduced. Informally, fenced areas of 5,000 to 19,000 ha have been mentioned to us as an "IMZ" to which rhinos captured in East Kalimantan would be translocated. More recently, the BBS National Park authorities have issued a decree to setup a 100,000 ha IPZ within the National Park area. Further to that, the conservation groups appear to have proposed a 10,000 ha IMZ within the IPZ area (Yuyun Kurniawan, personal communication).

However, for several reasons elaborated below, the IMZ concept is inappropriate and impractical for the Sumatran rhino and should be abandoned:

(i) building a fence that is capable of keeping rhinos inside and which covers thousands of hectares cannot possibly be maintained at all times under the prevailing conditions of slopes, high rainfall, tree falls and branch falls, erosion and weed growth of areas where Sumatran rhinos now occur or occurred until recently. The fence will be breached often before repairs can be done;

(ii) the African proponents of this idea simply did not factor in the tropical rainforest visibility conditions. Once a rhino is released into such a large area, it might never be seen again;

(iii) a large proportion of female Sumatran rhinos in the wild are expected to have reproductive pathology (20 out 23 females captured from wild post 1984 and kept in captive conditions had reproductive pathology; Nan Schaffer, personal communications; see Appendix 4). So, bringing them together in IMZs is unlikely to result in increased breeding rates, rather these females would need treatment and subjected to assisted reproductive technologies to make them suitable for reproduction;

(iv) once a rhino has been captured, it is imperative to maximize its potential to contribute gametes to production of offspring, and this can be done only under a regime of close observations equivalent to that at the Sumatran Rhino Sanctuary. It is essential to be able to continuously monitor every rhino captured in terms of health and reproductive condition, which translates to a need for a small individual paddock for each rhino, with night stall and crush, whereby monitoring can be done as frequently as needed (including daily for parasites and wounds, and at least weekly for blood sampling);

(v) Sumatran rhino PVA assessments have shown that a contiguous population of about 20 rhinos is needed for a viable population if managed passively (i.e. natural breeding with an inter-birth interval of 3 years). It is baseless to expect that any such number of fertile rhinos will ever be captured again, anywhere in Indonesia;

(vi) Supplementing (= "restocking") extant rhino clusters, e.g., Way Kambas, with females captured from elsewhere to build a viable population (after making an unlikely assumption that the females will be reproductively fit), has a lower chance of success as compared to reintroduction to vacant habitats (Linklater et al 2012). Such restocking if done in an IMZ type of fenced design, can become a disaster, for reasons described in the other points in this section;

(vii) for a rhino, a few thousands of hectares is not so large, and rhinos will be able to seek one another by smell (urine and faeces). Resident males are likely to find and may kill any additional rhinos that are released and cannot escape; this is a major concern in African black rhino reintroductions (Linklater and Swaisgood, 2008);

(viii) unlike the African white rhinos which are grazers and for which food and nutrition can be well managed through grassland management, the Sumatran rhinos are browsers with more widely dispersed food patches and therefore will be difficult to manage them within IMZs. Restricting their ranging within a smaller area in fact would accentuate resource restrictions and hence adversely affect their reproductive performance; and

(ix) if despite all these advices, a decision is made to proceed with a large fenced enclosure, the cost will be in the order of many hundreds of thousands of dollars, funds which could be better spent on SRS type facilities and on work to boost reproductive potential of the rhinos.

3.4.5 Sumatran Rhino Sanctuary

"Sumatran Rhino Sanctuary" (SRS) has come to be the name applied to the 100 ha fenced area where rhinos are maintained under close care within Way Kambas National Park. The facility was developed in 1997, and a key feature is the provision of 10 ha paddocks, with only one rhino, and a night stall, in each paddock. With the birth of two rhinos in SRS, the potential suitability of this design for natural breeding is now proven. In addition, this design allows constant monitoring of every rhino, and the potential to apply advanced reproductive technology.

3.4.6 Reduction of encroachment into BBS

The complex issues associated with encroachment into BBS have been summarized by Levang et al (2012). Concerted efforts to halt this encroachment have been and remain a very significant nature conservation need for Indonesia, but the relevance to Sumatran rhino is very small in comparison to (a) the massive Bukit Barisan ecosystem, biodiversity and water supply issues, and (b) to Dicerorhinus, where Allee effect, sparseness of rhinos and insufficient breeding are the key issues of concern.

3.4.7 Awareness

Public awareness was identified at the IUCN Species Survival Commission meeting on Sumatran rhinoceros in Singapore, October 1984, as one of three components of a species conservation plan. There is no evidence that awareness has had any bearing on the subsequent trajectory. However, this is largely because the public has been informed repeatedly that habitat loss and poaching are the cause of the species decline. Perhaps a more realistic story, if told by the experts, might have galvanized appropriate action by the relevant decision-makers.

3.4.8 PVA and PHVA for Dicerorhinus

Indonesian Rhino Conservation Workshop (1991)

This was convened in Bogor in October 1991, with inputs from previous workshops on both Dicerorhinus and Javan rhino. It was estimated that 420 – 785 Dicerorhinus remained alive. A report is available at http://www.rhinoresourcecenter.com/pdf_files/127/1279927421.pdf?view.

Sumatran Rhino in Indonesia Population and Habitat Viability Report (1993)

This report was prepared by the IUCN SSC Captive Breeding Specialist Group, based on a meeting convened in November 1993 by Ministry of Forestry Indonesia with various international institutions. There were 64 participants, fewer than ten of whom had direct experience of Dicerorhinus issues. The main conclusion was that between 185 and 259 Dicerorhinus existed and that "at the current rate of decline of wild populations, Sumatran rhinos will disappear by the end of

the century" and that protection of wild rhinos must be enhanced. A report is available at: http://www.rhinoresourcecenter.com/pdf_files/128/1280876561.pdf? view

Population Viability Analysis (PVA) for the Sumatran Rhino in Indonesia, February 2015
Miller et al (2015) provide a summary of the Sumatran rhino situation in Indonesia as of February 2015, based on a PVA workshop held at Taman Safari, Cisuara, 16 – 18 February 2015. Fifty-nine people attended the workshop which was convened by Ministry of Environment and Forestry Indonesia in collaboration with YABI, International Rhino Foundation, WWF-US and the IUCN-SSC Asian Rhino Specialist Group. The workshop included around 14 with specific Dicerorhinus expertise, of which four participants (Arief Rubianto, Haerudin Sadjudin, Jansen Manasang, Marcellus Adi) also participated in the 1993 Sumatran rhino PHVA workshop.

The 2015 report states that "Experts now estimate that about 100 individuals survive only in Indonesia in Gunung Leuser, Way Kambas, and Bukit Barisan Selatan National Parks on the island of Sumatra. Within Sumatra, rhinos in these three sites are further divided into 10 subpopulations thought to range in size from 4-36 individuals each. Multi-disciplinary surveys of these populations combining patch occupancy, camera trapping and fecal DNA methods are planned for 2016 to verify population estimates. A tiny population also occurs in East Kalimantan."

An analysis of the February 2015 PVA report (Miller et al 2015)
(a) Despite stating that there are about 100 rhinos divided into 10 sub-populations, the report calls for a "multi-disciplinary surveys … combining patch occupancy, camera trapping and fecal DNA methods … planned for 2016 to verify population estimates." When the numbers and dispersion of a species reaches such levels, there is no merit in conducting such time-consuming studies. It is obvious that all wild clusters are non-viable ("doomed") and the sole need should be to bring as many as possible together to boost birth rate and enhance genetic diversity.

The statement that there are "4-36" individuals in each sub-population in Aceh is misleading. A summary of the current situation based on latest information available to the authors is provided in section 3.1.3. The Leuser data in this PVA report states the following text: "Population ID: Leuser Barat (west). The PVA report has "Current population size: Comprises three sub-populations we think are connected, at least 24 individuals estimated in total; Babah Rot (4), Menggamat Meukek (5), Mamas (at least 12 identified by camera-trapping in 2014). Around 300 camera trap nights in Menggamat Meukek – no photos of rhino but signs present." In other words, the authors only "think" that three sub-populations are connected. Humans tend to look at maps, often of forest land designated by government and coloured in green, and assume that rhinos also understand that there is another rhino many kilometres away. There is no justification to automatically assume that rhinos are in contact with one another because they are located within the boundaries of a human-generated concept. The only hard data presented is that 12 individuals were recorded on camera trap images in the Mamas area in 2014. Leaving aside the fact that no photos are provided in order to allow independent evaluation of that number, the best that we can say is that the largest definite contiguous concentration of rhinos in the Leuser ecosystem is twelve rhinos. That is different from claiming that there are 36 individuals in one sub-population.

The "current population size" estimates given for Bukit Barisan Selatan and Way Kambas are not justified by any data presented. More recent camera-trapping and faecal DNA surveys and data analysis conducted in 2015 – 2016 for BBS identified huge errors in terms of misidentification of tapir signs as that of rhino that then caused a large over-estimation of the population size. These same RPU data formed the basis for the figures given in Miller et al (2015). Similar misidentification issues are likely to be present in the Way Kambas data too.

(b) The approach to the analysis seems to have been use of Miradi, a project management software, which is not appropriate as a means to tackle the fact that Dicerorhinus is on the edge of extinction. The document shows 65 boxes with issues to be noted. In fact, only six of the topics included in the boxes are relevant to Dicerorhinus: isolation of individual animals, low population density, Allee effect, inbreeding depression, reproduction and poaching. The first five are strongly correlated.

(c) Some fundamental points are not addressed at all:

- No existing cluster of Dicerorhinus is viable if left in situ (except possibly West Leuser)
- Overall birth rate has been lower than death rate over many decades
- The approach to Dicerorhinus has not changed over the past decade, with issues that are irrelevant or of low significance (e.g. habitat loss, invasive species, logging, pollution etc) added into the discussion, thereby pulling the focus away from the key issues
- There is no champion or leadership for Dicerorhinus, and this is the single main reason for lack of progress after the SRCS in April 2013
- The need for a single programme with a single guiding goal

3.4.9 Sumatran Rhino Crisis Summit (2013) resolutions and follow-ups

"Sumatran Rhino Crisis Summit" (SRCS), had its origins in a proposal by the Sabah-based NGO, Borneo Rhino Alliance (BORA) in 2012. The initial thinking was the convening of a wide array of people with different backgrounds and experience, not only in Indonesia but globally, and bound by a common interest in deciding jointly the most urgently-needed measures to prevent the extinction of *Dicerorhinus sumatrensis*. Singapore was suggested as a neutral venue, close to the locations of the remaining rhinos but independent of Indonesia and Malaysia. Wildlife Reserves Singapore hosted the event, 31 March – 4 April 2013.

An assessment of progress made 18 months after the summit was done by one of us (J. Payne) and a summary version of the report has been added as an appendix to this report (Appendix 10).

Some conclusions from the assessment (from Appendix 10)

- SRCS was probably doomed to result in a wide array of rather generic recommendations, due to the sheer number and wide variety of backgrounds of participants. To expect very specific, mutually-agreed actions was probably overly optimistic.
- The view of some participants in the pre-SRCS planning phase that SRCS had to be convened by IUCN because that was the only way to obtain governmental "buy-in" remains unproven.
- Malaysia has a detailed plan underway for Sumatran rhino, lacking only rhinos in order to effectively implement it.
- Up to October 2014, there is no bilateral agreement for collaboration between Indonesia and Malaysia.
- There is no international level plan for preventing the extinction of Sumatran rhino.

3.4.10 Sumatran rhino 10-year strategic plan log-frame (2016)

(Revised 18 May 2016, by the Sumatran Rhino Consortium (Forum Konservasi Leuser (FKL), International Rhino Foundation (IRF), Leuser International Foundation (LIF), Wildlife Conservation Society – Indonesia (WCS), Worldwide Fund for Nature - Indonesia (WWF), Yayasan Badak Indonesia (YABI))

The goals set for this strategic plan are:

Goal 1: "By 2025, Sumatran rhinos will have experienced no net loss to the meta-population and the population is increasing at the three IPZs (Way Kambas National Park or WK, Gunung Leuser National Park or GLNP, and Bukit Barisan Selatan National Park or BBS) and the Sumatran Rhino Sanctuary (SRS), relative to initial baseline data from the 2015 PVA (Miller et al., 2015) and confirmed by surveys to take place in 2016-2017."

Goal 2: "Over the entire project period (2016-2025), no additional forest cover is lost in rhino habitat, including park lands (including Intensive Protection Zones or IPZs), and in rhino habitat outside of national parks in Aceh."

Our comments on these goals are:

Given the critical situation the Sumatran rhino is in and the main threat to it, as elaborated elsewhere in this report, the Goal 1 should have been set more like: "By 2020, 10 new wild Dicerorhinus brought into fenced facilities, and managed as a single meta-population together with the existing 10 rhinos in SRS and BRS, with the intent to maximise annual Dicerorhinus embryo production and births." Goal 2 is entirely irrelevant to the current needs of Sumatran rhino conservation.

The outcomes expected from this 10-year plan are:

1 From 2016-2025, zero-level of poaching of Sumatran rhinos is maintained.
2 From 2016-2025, uncontrolled deforestation rates in BBS and Leuser are reduced to less than 1% per annum.
3 All illegal human activities, including Non-Timber Forest Product collection reduced by 40% within IPZs in BBS, WK, and GLNP by 2018 from 2016 baseline.
4 Illegal logging within IPZs in BBS and WK, eliminated by 2018 (no illegal logging currently in IPZ in GLNP).
5 By 2025, all rhinos will be in a situation that optimizes breeding and minimizes population constraints.
6 By 2025, be prepared to quickly identify and ameliorate disease outbreaks

Our comments on these expected outcomes:

The outcomes 2 to 4 and 6 are largely irrelevant to the current Sumatran rhino situation and conservation needs, the outcome #5 is not specific and measurable, and the outcome # 1, although still relevant, does not reflect the fact that the key problems of low birth rate, insufficient numbers in one location, Allee effect, and reproductive pathology will not be resolved by achieving this outcome alone.

The rest of the material in this strategic plan (indicators, outputs, etc) follow from the flawed goals set and outcomes expected. Therefore, they are largely unsuitable for detailed analysis and do not allow us to provide constructive feedback.

3.5 Factors hindering effective conservation actions

3.5.1 Irrelevant and ineffective strategies

Protected areas have been shown empirically to be ineffective in sustaining wild populations of Sumatran rhinos (see sections 2.4, 3.3). In recent years, the amount and complexity of stakeholder consultation has increased. In fact, necessary actions for Dicerorhinus have been known for several years amongst a small array of specialists. At best, stakeholder consultation simply slows down implementation of necessary actions and at worst, as is now apparent, leads to wrong decisions because of incorporation of the views of people who do not know the full situation (a good example of this trend can be seen in the development of the 10-year strategic plan; section 3.4.10).

3.5.2 Undue focus on irrelevant issues

The view and basic recommendation of this report is that only one priority needs to be implemented if Dicerorhinus is to be saved from extinction: produce more rhino calves. Thus, all efforts need to be directed to that goal. Efforts which do not support that goal are to be abandoned and actions which provide the greatest support are to be prioritized. Viewed in this way, many issues currently being pursued are irrelevant. Major examples are: counting rhinos, studying wild rhinos, awareness building, reducing forest degradation, habitat restoration, establishment of new institutional structures, and more stakeholder consultations.

3.5.3 Absence of conservation leadership

Stakeholder consultation has a necessary role at the beginning stages of developing a plan to prevent the extinction of a critically endangered species. But fine-tuning and implementation can be achieved only with clear leadership by one institution or person. The single biggest reason why Sumatran rhino is now so critically endangered is that there has been no leadership. A new institution proposed in this report (section 5.4) could best provide that role.

3.5.4 Weak collaboration between interested parties

There has been a tendency for one non-governmental institution to take a prominent role in each location where Sumatran rhinos are present. The establishment in 2014 of a joint secretariat on Indonesian rhinos, consisting of prominent interested parties together with government, has gone some way to promoting collaboration, but the need to view the species under a single programme has emerged only recently. There remains a tendency to view Sumatra rhinos in terms of province, protected area and lead institution for each.. As a result, there has been no clear idea on how to approach government with one voice.

3.5.5 Unsupported research conclusions misguiding conservation actions

Pusparini et al (2015) assessed a fraction of the total landscape occupied by Sumatran rhinos over a 30,345 km^2 survey area (Leuser, Bukit Barisan Selatan and Way Kambas) using an occupancy model

with spatial dependency. A fundamental concern is that occupancy modelling is not appropriate for Dicerorhinus, a species where population density and numbers are grossly lower than under natural circumstances, and for which factors limiting natural distribution are unknown. Occupancy estimates are only weakly related to population sizes and so are not sensitive indicators of changes in population size. Therefore, occupancy models reveal no information of value in urgently deciding what to do to about the remaining wild Dicerorhinus (see also section 3.4.2). Furthermore, this study draws doubtful conclusions regarding actions to be taken, as they are not supported by data.

This peer-reviewed paper is already influencing future conservation actions. For example, funding under the Sumatera Tropical Forest Conservation Action facility for work to initiate capture of Sumatran rhino work in Aceh is reported to be linked to first conducting occupancy surveys (Rudi Putra, personal communication). Capture is a policy decision, and once the policy decision has been made, trapping details will depend on a range of factors but none require occupancy surveys.

4 DICERORHINUS RECOVERY STRATEGY AND EMERGENCY ACTIONS

4.1 One species recovery program

The urgent need is to make more Dicerorhinus rhinos: the more and the sooner, the better. Every remaining rhino has to be assisted to allow its gametes (eggs or sperm) to contribute towards making rhino calves. It does not matter whether the rhino is in Aceh, Lampung, Bengkulu, East Kalimantan or Sabah. There is no sense in having anything other than one species recovery program (a model Terms of Reference for such a program is given below), with the single goal to increase rhino reproduction. Indonesia has the most Dicerorhinus. Therefore, Indonesia has to take the lead, also bringing in rhino gametes and specialist expertise from other countries to supplement its effort.

Main points of the Terms of Reference for the Dicerorhinus recovery program

Scope of work

Dicerorhinus sumatrensis, the Sumatran rhinoceros, is about to go extinct. The current total of fewer than 100, scattered amongst more than 10 locations is frightening. The number of actually breeding rhinos is now very small.

Natural breeding is to be prioritized for healthy rhinos with good gamete production. Application of advanced reproductive technology is to be prioritized for old rhinos, rhinos with low gamete production and those with reproductive tract pathology. Advanced reproductive technology has to be applied and practiced in appropriate facilities with state-of-the-art equipment operated by experts, either in Indonesia or elsewhere.

Very few wild rhinos can now contribute to rhino reproduction if they are left in the wild – probably just a few in Way Kambas and some more in West Leuser. Except in West Leuser and Way Kambas, as many as possible of the remaining wild rhinos should be brought into fenced facilities managed by competent veterinarians and keepers. A few fertile females and young rhinos should be captured from Way Kambas and West Leuser for rhino sanctuaries.

Key elements for location of rhino sanctuaries are the availability of natural Dicerorhinus foods and willingness of staff to live on site. Apart from that, location of the rhino sanctuaries does not matter because rhinos and their gametes can be moved between facilities when needed. SRS in TNWK is a proven successful model for maintenance and breeding. Simple, cheaper interim facilities can be built in cases where total number of catchable rhinos is uncertain. Other models (e.g. rhinos released into very large fenced areas, termed IMZ) will not support maximization of births and can become a useless, impractical, or a disastrous experiment and therefore should not be tried.

Timeline

TIME	ACTIVITY & OUTPUTS
Mid 2017	- The Indonesian Rhino Joint Secretariat to bring the "one Dicerorhinus recovery program" to Government of Indonesia for consideration and endorsement - - The Joint Secretariat to ask the government to appoint a lead unit/agency with responsibility and adequate powers to implement the recovery program - WWF-ID to finalise location of holding facilities, start building interim facility and initiate capture of rhinos in East Kalimantan - The Joint Secretariat (or the lead agency) to prepare for capture of rhinos in BBS to be moved to SRS in TNWK. However, if by mid-2018 there is still no evidence of the existence of Sumatran rhino within BBS, it is pragmatic to assume that the species is either extinct in BBS or any remaining rhinos are reproductively not viable. Therefore, preparations should commence immediately for capture of rhinos from TNWK and Aceh - An appropriate organisation to be delegated to lead identification of location of holding facilities and initiate plans for capture of rhinos in eastern Aceh
Late 2017	- Joint Secretariat to initiate and facilitate the process to replace the "Strategy and Action Plan for the Conservation of Rhinos In Indonesia 2007-2017" with a new ten year strategy and action plan, using WWF's "Critically Endangered Sumatran Rhinoceros: Recovery Strategy and Emergency Actions 2017 – 2027" document as a source - the new lead agency/unit for the recovery program established - "one Dicerorhinus recovery program" approved by Government of Indonesia - WWF-ID to complete building interim facility in East Kalimantan - Rhino captures commence in Kutai Barat - Commence work to capture of rhinos in BBS and / or TNWK - Delegated Aceh organisation to initiate construction of holding facilities and commence preparatory work for capture of rhinos in eastern Aceh - program and plans developed for application of advanced reproductive technology for rhinos held in SRS, focusing on semen banking and means to achieve pregnancy in Bina and Rosa
Early 2018	- plan initiated for capture of young fertile rhinos (males and females) in TNWK

	- program of gamete harvesting from Bina, Rosa, Andalas and Harapan at TNWK commences, with initial in vitro fertilization attempts and artificial insemination of Rosa - first rhino captured in East Kalimantan and moved to interim facility
Mid 2018	- SRS extension in TNWK completed and preparations for capture begun - second rhino captured in East Kalimantan and moved to interim facility - likely number of remaining wild rhinos in East Kalimantan clarified, and decision made on whether to build major long-term facility - trapping for young rhinos in TNWK initiated - location for holding facilities agreed upon by stakeholders in Aceh and planning started - new ten year strategy and action plan (using WWF's "Critically Endangered Sumatran Rhinoceros: Recovery Strategy and Emergency Actions 2017 – 2027") completed and approved by Government for implementation
Late 2018	- first wild rhino captured in TNWK and moved into SRS - review of advanced reproductive technology work at SRS and plans made and initiated for future work - evaluation of progress in East Kalimantan conducted - first rhino captured in Aceh and moved to local holding facilities
Early 2019	- lead agency leads a review of progress to date - priority work initiated, based on the review

<u>WWF-ID Role</u>

WWF-ID can take a lead advocacy role in the recovery program and implement emergency actions towards the goal to prevent the extinction of Dicerorhinus. The endorsement of WWF network needs to be secured as soon as possible.

<u>External expertise</u>

WWF should not implement all tasks, especially those for which it has no in-house expertise. WWF needs to seek and effectively collaborate with various external experts including in capture operations, captive breeding, ART, and veterinary care.

4.2 Captive breeding for maximising rhino reproduction

With the exception of West Leuser, the goal of Dicerorhinus recovery strategy - maximizing rhino reproduction - is best achieved by captive breeding in well managed rhino sanctuaries. Natural breeding is to be prioritized for healthy rhinos with good gamete production. Application of advanced reproductive technology is to be prioritized for old rhinos, rhinos with low gamete production and those with reproductive tract pathology.

More females which are reproductively fit are needed for the rhino sanctuaries to enhance prospects for natural breeding. There appears to be a view among some rhino conservationists to leave all wild breeding females in situ, or translocate them to an IMZ, and to target capture only of non-reproductive rhinos for captive breeding in rhino sanctuaries. This is a flawed idea, as it does not help to maximize rhino reproduction overall and therefore will undermine the species recovery strategy.

It is important to be clear that two forms of wild rhinos are needed in SRS type facilities:

Young fertile rhinos:

This refers to rhinos which are around four to eight years old. They have the best prospects for natural breeding when brought into SRS type facilities, and for maximizing number of births in the future. Camera trap images can help to guide identification only to some extent (Kalimantan rhinos are smaller when adult than are Sumatran rhinos in Sumatra). The young rhinos to be captured will likely have to be secured from Way Kambas and Aceh, as no other sources are now available. Capture of young females is preferred over males, because two fertile bulls are already in captivity in SRS as sperm sources, and it is maximization of birth rate of females that now represents the single greatest need in order to prevent extinction.

Old and reproductively disabled rhinos:

It has to be anticipated that the majority of rhinos captured other than targeted young rhinos in Way Kambas and Aceh, are likely to be old and reproductively disabled. However, no old or reproductively disabled rhino, or rhino that does not have access to a rhino of the other sex, should be left in the wild. If left in the wild, none will help prevent the extinction of the genus. All such rhinos are candidates for advanced reproductive technology. The main value of these rhinos will likely prove to be as sources of eggs and sperm additional to those in the young, fully fertile rhinos. Even the oldest, post-reproductive individuals could provide cells for culture which, at a later stage in the programme, can serve to revive otherwise doomed, unrelated genomes. In view of the critical state of Dicerorhinus, this may have to be achieved either through insertion of cultured cell nuclei into egg cells, or through the newer and currently developing techniques of producing gametes from skin cells.

4.3 In situ management and monitoring of Dicerorhinus

It appears from preliminary information that there is a substantial sub-population of Dicerorhinus (in the range of a few tens) in West Leuser (see section 3.1.3). The preliminary information also indicated regular breeding, however, information is limited on the other factors that determine viability, such as inter-birth interval, proportion of females breeding, age structure, sex ratio, and poaching rate. However, it appears that this population is rebounding from poaching that caused

depletion in the 1980s (M. Griffiths, personal communication). Accurate information on population parameters and poaching rates are needed for robust in situ population management and for optimal harvest of young fertile rhinos for rhino sanctuaries. Subject to review of existing information, this subpopulation can be considered for in situ management, in an adaptive management framework. However, such a management option will be effective only if done in a highly professional way and with allocation of adequate resources.

It is paradoxical that the most monitored cluster of rhinos in Way Kambas has the least convincing of information on population size and growth rate, hampering conclusions on population viability. A quantitative analysis of data from RPU and other camera-trapping surveys of recent years is urgently needed. Subject to such a future analysis, the preliminary conclusion we can currently make based on available data on rhino calf observations by RPUs is that this population is not large enough or productive enough to be considered viable (see section 3.1.1). Therefore our recommendation is to take an 'mixed approach' for TNWK of capturing a few young fertile females from the wild for the rhino sanctuary as a precaution, and manage the remaining rhinos in situ and closely monitor the crucial population parameters for adaptive management. If the population is inherently viable, it should rebound like it happened in the 1980s and 1990s after the near extinction of 1970s, and the current perceived growth after the post El Nino decline of 1997-98 (Wells, 2003).

4.4 Capture and translocation

Very few wild rhinos can now contribute to reproduction if they are left in the wild, outside of West Leuser and Way Kambas. The longer that wild rhinos remain isolated, the more likely they are to be non-productive once captured. Capture and translocation of remaining Sumatran rhinos from the wild to rhino sanctuaries, therefore, is the most fundamental part of the recovery strategy. The required approach then is to capture as many as possible of all remaining wild rhinos as an emergency action and translocate them to excellent fenced facilities ("rhino sanctuaries") managed by experienced veterinarians and animal keepers. The logistical difficulties of this enterprise should not be under-estimated. But this is the outcome of decades of cognitive bias which saw small clusters of rhinos as viable.

It is essential for all rhinos, particularly for females to be captured and examined in order to determine if they are fertile or have reproductive pathology, and accordingly decide how to maximize their reproductive rate. Initial ultrasonographic examination can usually be done within a few days of capture, when the rhino is still at the capture location. Assessment of fertility will require more detailed ultrasound imagery. Age and relatedness are also required factors to successfully manage critically endangered species that are in crisis (Nan Schaffer, Appendix 8). It is abundantly clear that these required information cannot be acquired with the methods currently in use for assessment of the remaining wild populations in time to save the species.

4.5 Rhino sanctuaries

Sumatran Rhino Sanctuary (SRS) in TNWK has proven to be very suitable for natural breeding of fertile rhinos, and in terms of close monitoring of individual rhinos. Sub-fertile rhinos (those with reproductive tract pathology or low sperm production) also will need to be retained in such

closely-managed fenced facilities in order to maximise their potential to contribute to production of embryos through techniques such as artificial insemination or other advanced reproductive technology.

All rhinos captured should therefore be maintained in facilities of a similar design, i.e. small individual paddocks with night stalls, one unit per rhino. This basic design is called a "Rhino Sanctuary". A similar model is also used in Malaysia, and called "Borneo Rhino Sanctuary". There is no reason to change the SRS model. Also, it is best to continue to use the term "rhino sanctuary" consistently for the kind of design developed at Way Kambas.

Such rhino sanctuaries can be built at each rhino holding province if essential, although it will not be cost efficient or ideal. In any case, free exchange of rhinos and gametes between sanctuaries should be ensured and all such sanctuaries should be managed under one rhino recovery program. Key elements for location of rhino sanctuaries are the availability of natural Dicerorhinus foods and willingness of staff to live on site (see Appendix 6, for details on how many rhino sanctuaries are needed in the near future, their locations, etc.). Apart from that, location of the rhinos in managed facilities does not matter because rhinos and their gametes can be moved between facilities when needed.

Simple, cheaper interim facilities can be built in cases where total number of catchable rhinos is uncertain or to retain captured rhinos prior to translocation to more permanent rhino sanctuaries. Why? Firstly, the cheaper and simpler the facility the quicker it can be built, thereby not constraining capture work. Secondly, based on experience with this species since the 1970s, it is likely that there will turn out to be fewer rhinos still alive and catchable in every wild cluster, and large, expensive structures may end up housing fewer rhinos than anticipated. Any models of rhino holding facilities other than the Rhino Sanctuary type (e.g. rhinos released into very large fenced areas, popularly termed IMZs) will not support maximization of births, and should not be tried.

4.6 Advanced Reproductive Technology

Many rhinos remaining in the wild are expected to have reproductive pathology or face conception problems (see section 3.2.5 and Appendix 4). This condition means that most rhinos to be captured will require treatment and their reproduction can be maximized by application of assisted reproductive technology (ART). Hence, a key focus of the recovery strategy for Dicerorhinus is the application of ART to make more Dicerorhinus embryos. ART is to be prioritized for old rhinos, rhinos with low gamete production and those with reproductive tract pathology and it involves the use of harvested gametes (eggs and sperm) for artificial insemination and in vitro fertilization.

4.7 Collaboration with Malaysia

The Strategy and Action Plan for the Conservation of Rhinos in Indonesia: Rhino Century Program, 2007-2017, action 8.4 does call for "a detailed conservation plan for the conservation of Eastern Sumatran Rhino is formulated and agreed jointly by Indonesia and Malaysia" by year 2009. Efforts for this did indeed commence at the 2009 Sumatran Rhino Global Propagation and Management Board meeting. Given that the action is included in a Government of Indonesia document, there is no reason not to continue along this path. In the meantime, links have already been initiated

between the two nations in terms of *in vitro* fertilization attempts for Sumatran rhino, as well as informal dialogue between individuals and NGOs.

4.8 Existing policy in Indonesia on Sumatran rhinoceros

Law No. 5/1990 on "conservation of living resources and their ecosystems": Article 13 of the law prescribes preservation of animals inside and outside natural sanctuary areas, with the aim of avoiding species extinctions. It further states that the preservation outside natural areas (i.e. in captive facilities) shall be conducted by promoting breeding efforts to prevent extinction.

Further, in a recent directive under this law and another law, no. 5 of 1994 on UN-CBD, a list of 25 priority species has been prepared which includes the Sumatran rhinoceros, on whose population status the government needs to report to the parliament. The directive has set a goal of increasing the population size of each species by 10% over a 5-year period of 2015-2019. Even though the goal may be unrealistic and in practice un-measurable, the directive provides an opportunity to advance Sumatran rhino conservation. For instance, these laws and this directive can provide the policy foundation for focusing on increasing rhino reproduction rate.

The 2007 Ministry of Forestry STRATEGY AND ACTION PLAN FOR THE CONSERVATION OF RHINOS in Indonesia for the period 2007-2017 contains several policy actions with an underlying aim to support a 3% annual increase in Sumatran rhino numbers. The long-term (no year stated) target for Sumatran rhino conservation in Indonesia (section 6.1 of the action plan) is to have:

• 1,200 Western Sumatran rhinos (Dicerorhinus sumatrensis sumatrensis) in two populations of 400-500 and two to three populations of at least 100; and

• 600 Eastern Sumatran rhinos (D. s. harrissoni) in one population of 400–500 animals and two populations of at least 100 animals.

The short term goal (2007–2012; section 6.2) states that the following objectives will be pursued to contribute to the long-term goal:

1. Expand the wild population in Leuser, Bukit Barisan Selatan and Way Kambas National Parks by at least 30%;

2. Secure adequate habitat for viable wild populations in Kerinci Seblat National Park (500,000 ha), Bukit Barisan Selatan National Park (100,000 ha), Gunung Leuser National Park (700,000 ha) and in Kalimantan (500,000 ha); and

3. Successfully breed Sumatran rhinos in sanctuaries for reintroduction purposes.

Section 7 in the CONSERVATION ACTION PLAN FOR SUMATRAN RHINOCEROS (2005 – 2015):
The plan has a strong site-based emphasis, projecting that Gunung Leuser, Bukit Barisan Selatan and Way Kambas National Parks will represent the basic units of conservation work, that rhino protection units will prevent poaching and that securing additional habitat will also assist in boosting rhino numbers. There is no mention of means to boost birth rate. In fact, the terms birth and reproduction are not mentioned at all in relation to Sumatran rhino.

Section 7.3.2, Ex-situ Sumatran rhino population management, states that "Captive breeding of Sumatran rhinos will be continued in the Sumatran Rhino Sanctuary (SRS) in Way Kambas National Park. Recently, two female Sumatran rhinos have been brought into the SRS from Bukit Barisan Selatan and Way Kambas National Parks, and a male born at the Cincinnati Zoo (USA) was moved to the SRS in February 2007 to enhance chances of reproduction."

The hopes of the Action Plan have not been realised. Sumatran rhino numbers have declined. Captive breeding efforts have resulted in only two births, both from the same parents, and two females have not bred at all, despite close care and management over the entire Action Plan period.

The process of decentralization that started in 1999 has not impinged on conservation of endangered species. Central government maintains legal authority over Sumatran rhino. In practice, experience with Javan rhinos and more recently with Sumatran rhino in East Kalimantan has indicated a tendency towards significant local sentiment against allowing rhinos out of the province or even the district in which they are found or captured. To date, central government has not exerted its authority to insist on placing the needs of rhino species conservation over political and emotional sentiments. For Sumatran rhino, it will be necessary for Ministry of Environment and Forestry either to over-rule provincial and district level sentiments, if necessary through a specific new legal mechanism, or give way to local sentiment and ensure that all rhinos are managed under one program, even if individual rhinos are maintained in widely separate facilities. The second option is feasible: rhinos might be loaned between facilities, or their gametes (eggs and sperm) harvested and used in the context of advanced reproductive technology, such as artificial insemination or in vitro fertilization.

The First Asian Rhino Range States Meeting, held in Bandar Lampung, 2-3 October 2013, resulted in the Bandar Lampung Declaration, in which the Governments of Bhutan, India, Indonesia, Malaysia and Nepal, agreed to a number of actions. For Asian rhinos in general, those included: "Sub-fertile rhinos (those with reproductive tract pathology or low sperm production) may need to be retained in closely-managed fenced facilities in order to maximise their potential to contribute to production of embryos through techniques such as artificial insemination or other advanced reproductive technology."

For Sumatran rhino, the Bandar Lampung Declaration contained an overly-complex set of recommendations which were drawn from the Sumatran Rhino Crisis Summit, held in Singapore 31 March to 4 April 2013. The Crisis Summit, an ad hoc meeting proposed by NGOs but ultimately convened top down by IUCN, involved 100 participants, most of whom had little or no expertise in Sumatran rhino. Thus, rather than focus on a very few essential needs, the Summit recommendations tried to incorporate an enormous diversity of conflicting opinions. A part of the Bandar Lampung Declaration recommendations on Sumatra rhino includes the following:

"Sumatran Rhinos that are isolated from others, and therefore cannot breed, need to be detected. … a policy should be developed urgently for the management of isolated animals so that they can contribute to the survival of the species. … An integrated strategy needs to be developed for the management of Sumatran Rhinos in contained or confined conditions, in order to increase the rate of breeding in all sites. … assisted reproduction facilities and expertise will need to be established. …

There will need to be infrastructure development for the management of Sumatran Rhinos in contained or confined conditions." Despite the need for urgency, four years later these elements of the recommendations still remain at early stages.

As shown in this report, the key actions needed to prevent the extinction of the Sumatran rhino are now known. Lacking - but probably necessary - is a clear policy statement from the Minister of Environment and Forestry (or Cabinet) on those needs. With a clear statement, the relevant elements of the governmental apparatus, assisted by non-governmental organisations, Sumatran rhino experts and donors, can then proceed immediately.

Lack of funding has often, seemingly, acted a constraint on deciding policy and actions for Sumatran rhino. However, this should not and need not be a constraint. Dicerorhinus is the world's most endangered terrestrial mammal genus. Once policy is set, government should allocate funding to follow through the policy commitments and can press Indonesian and external philanthropists, corporations and other institutions to support the policy, including through financial assistance.

4.9 Proposed policy for the recovery program and emergency actions

This report proposes the following policy to facilitate the recovery program and emergency actions. The argumentation leading to this proposed policy is outlined in detail in this report. There is an urgent need for change, nationally and internationally, and without further delay.

Dicerorhinus is on the verge of extinction.

Dicerorhinus is a unique and ancient genus. Its extinction will represent the first terrestrial mammal genus extinction globally since 1936. Responsibility to prevent its extinction now lies ultimately with Government of Indonesia.

Civil society, national and international organisations and other governments can potentially assist, but none can take the key decisions for actions now needed to prevent extinction.

Previous actions recommended, and still being implemented, to prevent extinction of Dicerorhinus have focused on counting wild rhinos, on reducing rhino deaths, on consulting stakeholders, on awareness, on fund-raising and on reducing habitat loss and promoting habitat restoration.

Together, they have failed to halt the decline in numbers because the most crucial action of increasing rhino births has not been prioritised.

<u>The new paradigm to prevent the extinction of Dicerorhinus has the following key features:</u>

- One program
- Focus on increasing the number of rhino births
- Ensure that every remaining Dicerorhinus rhino is facilitated to contribute to the survival of the genus, and that every rhino, whether reproductively optimum or not, contributes eggs or sperm or cells

- Facilitate movement of rhinos and gametes among conservation areas and captive facilities as a population management tool to promote rhino births.
- Bring two forms of wild rhinos into rhino sanctuaries: (a) young fertile rhinos (for natural breeding, to quickly boost captive birth rates) and (b) old and reproductively disabled rhinos (as candidates for application of assisted reproductive technology).
- Focus on preventing extinction and on eventual overall population growth rather than trying to protect every isolated cluster of rhinos
- Base decisions on science and the advice of Dicerorhinus experts, including rhino veterinarians and reproductive biology experts
- Make the policy and then seek the necessary financing to implement the actions that support the policy (do not seek funds based on what funds seem to be available at the current time)
- Seek and employ the best people for the agreed actions

These policies, and the analyses, views and recommendations made in this document represent a radical change from those that have been made in relation to Sumatran rhinoceros elsewhere over the past few decades, including those contained in the 2007-2017 Strategy and action plan for the conservation of rhinos in Indonesia: Rhino Century Program. The recommended policy change can be summarized as shifting from monitoring and counting rhinos, and from preventing rhino deaths, to making sure that all Sumatran rhinos contribute to making more Sumatran rhinos. A longer term (30 – 50 years) goal of reintroducing Dicerorhinus from captive stock to suitable natural habitats (not necessarily the mountainous protected areas where the remnant rhinos currently linger) for in situ management is implicit in the proposed new paradigm.

If these new viewpoints and recommendations are to be taken up, they will need to secure endorsement at the highest levels. We suggest the sequence of that might be: (1) WWF-Indonesia and WWF globally, (2) the major non-governmental organizations working on rhinoceros, (3) Ministry of Environment and Forestry, and (possibly) (4) Cabinet.

The policy presented here can lay the foundation for a new governmental strategy and action plan that will be needed to replace the 2007-2017 plan.

4.10 Decision making for Sumatran rhinos

The purpose of the decision guide (Table 4.1) is to decide how to maximise the potential for every remaining Sumatran rhino to contribute towards preventing the extinction of the species, primarily by increasing rhino birth rates. With the possible exception of West Leuser, all remaining clusters of Dicerorhinus are not viable if left in situ. Thus, decision-making depends largely on logistical issues, and not on the number of rhinos in one locality, except in the case of West Leuser. It does not matter how many rhinos exist in any locality, whether the rhino is female or male, young or old, fertile or sub-fertile. The sooner and the more rhinos are captured, the better. The longer rhinos remain in situ, the less each one can contribute to the survival of its species. Thus, for fertile females, the intention is that birth rate is maximised. For fertile males, the intention is to make best use of the sperm: semen is to be secured and cryo-preserved. For sub-fertile females, oocytes are to be removed and fertilized in vitro, for implantation of embryos into surrogate mothers.

Dicerorhinus is near extinction. Urgency is the need of the hour. Capture work should start as soon as possible at all sites: Kutai Barat (work is already underway and permission granted for capture of the few rhinos in zone-3), suitable sites in Aceh, Bukit Barisan Selatan (the remaining rhinos are not viable) and Way Kambas (best hope to secure more fertile females for the rhino sanctuary). If the preliminary report on existence of a viable population in West Leuser, Aceh, can be confirmed, then practice in situ management and robust population monitoring in an adaptive management framework. However, some young fertile females should be removed from Aceh in order to help build a viable and growing captive population.

Sumatran Rhino Sanctuary (SRS) has proven to be very suitable for husbandry and breeding of rhinos. All rhinos captured should be maintained in facilities of a similar design, i.e. small individual paddocks with night stalls, one unit per rhino. This basic design is called a "Rhino Sanctuary". There is no need to experiment with large enclosures ("IMZs") or with releasing any captured rhinos "into the wild" for 'consolidation' of the currently unviable clusters. These experimental approaches will NOT make best use of precious female and male gametes, and should not be attempted with a species on the verge of extinction.

<u>The decisions to be made, therefore, are:</u>
(A) whether or not is it feasible logistically for rhinos in the targeted locality to be moved from the capture site to a managed "Rhino Sanctuary" elsewhere;
(B) location of the "Rhino Sanctuary" for maintaining captured rhinos;
(C) precise design of the "Sanctuary"; and
(D) details of trapping.
These four issues are listed below in a rational sequence for decision-making, but all the issues need to be approached in parallel.

Table 4.1. The four major decisions to be made for Sumatran rhinos and the criteria based on which decisions could be made.

A. Logistical feasibility of moving rhinos from current wild location to a Sanctuary	
1.	Translocation by land is usually the preferred option, as the translocation team has control over all procedures including timing. The following potential constraints need to be assessed. Is there one or more of the following constraints: (a) legal or policy constraints (legal or policy barrier to allowing heavy machinery to operate between capture site and exit site, for example, in Taman Nasional)? (b) topographical constraints (slopes too steep to move a rhino in a crate)? (c) distance constraints (linked to topography; the total period between start and end of land transportation may be judged too long and stressful)? (d) rivers or other barriers which cannot be crossed or which are subject to frequent floods ? (e) non-availability of small tracked excavator and old four-wheel drive vehicle large enough to bear rhino in crate? (f) non-availability of competent team to conduct land transportation of rhino in crate. If there are no such constraints, the rhino is to be translocated by land. If there are one or more such constraints, go to 2.
2.	Is translocation from capture site by helicopter feasible? Are all the following available: (a) a helicopter capable to lift at least 1,000 kg available for hire? (b) assurance that the helicopter will be available whenever needed (i.e. within about 1 week from whenever a rhino is captured)? (c) a crew with experience of lifting heavy crates from remote forest

	sites? (d) funds to cover costs? If all four points are judged satisfactory, the rhino is to be translocated by helicopter. (Note that Air Force helicopters are not necessarily a good option, as points (b) and (c) cannot be guaranteed). If one or more points are judged unsatisfactory, go to 3.
3	If translocation by land or helicopter are both judged to be limited by one or more constraints, all efforts are to be made to address and solve the constraints. Examples of addressing constraints might include: (a) use of two larger tracked excavators to operate on steep and broken terrain, (b) building a temporary bridge across the river, (c) hiring helicopter from overseas. If there is a constraint to translocation which cannot be solved, consideration is to be given to whether or not capture without subsequent translocation of the rhino might contribute in some way to preventing the genus extinction. Examples might include: (a) gamete harvesting, (b) biopsies for cell culture, (c) an adequate holding facility built and maintained near the capture site, (d) satellite GPS tracking of the released rhino.
4.	If 1, 2 and 3 are judged to be impossible the rhino will not be captured.
	B. Location of the Sanctuary for maintaining the captured rhinos
1.	In parallel with decision-making on translocation, decisions will be made on the location where captured rhinos will be maintained after capture and translocation. The three basic criteria for deciding on this location are: (a) adequate supply of rhino food (50 kg of fresh, diverse leaves and twigs per rhino daily), (b) clean reliable water supply, and (c) competent veterinarian and keeper team are willing to live at the location. All other criteria are of lesser importance, but it is to be noted that the flatter the topography, the easier it is to design, build and maintain the facilities. Please see Appendix 6.
2.	At present, the only two Sanctuaries already available and ready to receive rhinos are Sumatran Rhino Sanctuary (SRS) and the Borneo Rhino Sanctuary in Sabah, Malaysia. In order to not delay capture work, both can be considered as potential interim or long-term holding sites for captured rhinos. SRS is ideal from the viewpoint of being already well-established and successful, and readily accessible. No additional rhino paddocks should be built in Way Kambas National Park other than those already planned and approved. Maximum number of rhinos to be held within Sanctuary facilities in Way Kambas will be ten rhinos.
3.	For any new Sanctuary, there should be an expectation of a minimum of three rhinos (one male, 2 females) occupying the Sanctuary on a long-term basis. If only one or two rhinos are anticipated to be captured from one location, it is better that the target be to translocate them to SRS, or a new Sanctuary designed to hold at least three rhinos.
4.	Rhinos stay in same Province or not? There may be local sentiment against moving Sumatran rhinos out of the District or Province of capture. This point has to be taken into account (see section 4.10.1). If local government wants a sanctuary to be built locally, then the sanctuary can be built locally. Capture of rhinos must not be delayed based on lack of agreement between Ministry of Environment and Forestry, and local government.
5.	The decision must be ultimately based on point 1, above.

	C. Precise design of the Sanctuary
1.	The basic Sanctuary design is an individual fenced paddock and night stall for each rhino. The SRS design does not have to be followed precisely. The precise design will depend on a combination of local topography, likely amount of funds available for construction, alignment of existing roads and streams, estimated number of rhinos to be captured (probably no more than 3 for one location over a three year period) and other site-specific factors.
2.	Over 75% of Sumatran rhinos captured between 1984 and 2014 had significant reproductive pathology, and the same can be expected for future captured rhinos. Some captured rhinos will never need to be moved to a breeding area with another rhino. Paddocks can be built as separate entities if topography does not permit a SRS model.
3	Size of paddocks should be at least 1 ha each.
4.	In most cases, it is unknown how many rhinos will be captured from one location and moved to a new Sanctuary. It is best at each Sanctuary location to initially build simple paddock/night stall for between one to three rhinos. The design and alignment should allow for additional paddocks to be added later if needed.
	D. Details of trapping
1.	If it seems that only one rhino exists in a particular location, this will be the immediate target animal (even if it later becomes apparent that there are more rhinos)
2.	If there is more than one rhino in a location, decisions are needed on: (a) exactly which rhino will be captured first, and (b) exactly where traps are to be made.
3.	Decision-making on trap sites will be based on three factors, which must be assessed, integrated and decided at the earliest stages: (a) where the rhino is most likely to pass over the trap (ridge tops may be best, and the site should not be where there is no clear rhino pathway, for example near streams and rivers), (b) a site convenient for translocation (e.g. near an old logging road for land translocation; on a ridge top with no large trees for helicopter translocation), and (c) a site accessible for twice-daily visual checking by the trap monitoring team, at least one kilometre away and in a different sub-catchment.
4.	Female rhinos are more important, as sources of eggs (e.g., sperm can be obtained from Andalas, Harapan and Tam), so females are to be prioritised.

4.10.1 Should the captured rhinos be kept in the native kabupaten or province?

By law, all policy decisions on Dicerorhinus are made by Ministry of Environment and Forestry Indonesia. There are no local (provincial or kabupaten level) laws or regulations governing capture, translocation or husbandry of Dicerorhinus. In practice, however, local government views are taken into consideration when making policy on endangered wildlife, particularly in relation to moving rhinos out of one kabupaten or province to another, different kabupaten or province. Local resistance to moving rhinos out of the kabupaten in which they were captured is an issue that

cannot be ignored. As noted earlier, the only significant criteria for deciding where a captured rhino should be maintained are:

(i) that the rhinos can have maximum opportunity to contribute to breeding;
(ii) that there is a guaranteed source of rhino foods nearby; and
(iii) that the team of veterinarian and keepers looking after the rhino(s) are willing to live at the chosen site.

Given the urgency of capture of the remaining rhinos, simple facilities need to be built in or near Kutai Barat to sustain the captured rhinos in the short (3 years) and, if necessary, medium term (beyond three years). By three years from now, it will be possible to see if there were only three rhinos, or if there are (say) 15 rhinos with breeding ongoing.

The SRS expansion can take all rhinos captured from the wild in TNWK and all those captured in BBS. A third Sanctuary needs to be built in Aceh, to cater for any rhinos captured in that province.

WWF's role should be to support the principle of capture and management in Rhino Sanctuary facilities, and to assist in fund raising for the capture and translocation, the building of Sanctuaries, and the long-term management of the rhinos in the Sanctuaries thereafter.

If some form of compromise becomes necessary, there are two possible options for discussion: (a) the rhino remains in the same province but not necessarily the same kabupaten, or (b) the rhino is loaned to be held in a sanctuary facility in a different province, either until a local facility and care team are established, or for an agreed period, such as 3 years.

4.11 Emergency actions for the different Dicerorhinus clusters

Table 4.2. Emergency actions needed for the different rhino clusters to prevent extinction and implement the recovery strategy for Dicerorhinus.

Emergency actions	Bukit Barisan Selatan	Way Kambas	West Leuser	Other parts of Aceh	East Kalimantan
Capture rhinos	• Yes, all remaining rhinos	• Capture a few young rhinos	• Continue monitoring wild rhinos	• Yes, all remaining rhinos	• Yes, all remaining rhinos

Emergency actions	Bukit Barisan Selatan	Way Kambas	West Leuser	Other parts of Aceh	East Kalimantan
In situ management	• No • Increase protection in rhino locations until capture	• Yes, using a mixed approach (section 4.3) • Continue protection • Monitor population parameters and breeding rates	• Yes • Continue protection • Closely monitor population parameters and breeding rates	• No • Increase protection in rhino locations until capture	• No • Increase protection in rhino locations until capture
IPZ (section 3.4.3)	• Not relevant for rhinos	• Already exists	• Already exists	• Not relevant for rhinos	• Not relevant for rhinos
IMZ (section 3.4.4)	• NO	• NO	• NO	• NO	• NO
Rhino sanctuary	• Not needed	• Expand existing SRS facility	• Yes, identify a suitable site	• Yes, identify a suitable site	• Only holding facilities for now; identify a suitable site
Population surveys (to estimate population size or occupancy)	• Completed	• Analyse existing data first	• Review existing information	• Not needed	• Not needed; however, simple field surveys to locate remaining rhinos (by their footprints) are needed for subsequent capture

4.12 The main challenges to a consensus on the SR recovery strategy and how to overcome these?

The following notes are presented on some of the major challenges that exist and need to be overcome. They represent the objective views of the authors of this report.

Strong leadership by Government and immediate action

As soon as this recovery strategy is agreed, then the approach can be made to argue to Government for immediate implementation. "Government" refers to both the executive and elected arms. For Sumatran rhino, the executive is the Director of Biodiversity Conservation Division and /or the relevant Director General. However, the Biodiversity Conservation Division in Ministry of Environment and Forestry remains under-resourced for the challenges that it faces in the twenty-first century. For example, many of the issues associated with Sumatran rhino are linked to expertise in veterinary medicine, large animal capture and translocation, and application of advanced reproductive technology, rather than to forestry or ecology. This is an issue that conservation NGOs may wish to raise.

Weak and outdated information and analysis

The Ministry of Forestry of the Republic of Indonesia Strategy and Action Plan for the Conservation of Rhinos in Indonesia: Rhino Century Program, 2007 -2017 has data that was provided largely by several NGOs. This document states that Bukit Barisan Selatan (BBS) National Park has 60–80 Sumatran rhinos, while Way Kambas National Park has 15–25 rhinos. No original or supporting data was provided in this document, or to our knowledge elsewhere in 2007, to back those claims. The Population Viability Analysis for the Sumatran Rhino in Indonesia, February 2015 (Miller et al 2015), gives 16 – 40 rhinos in BBS. But based on inputs received while preparing this report, we also see a scenario where there might only be one or two rhinos left in BBS At time of writing (2017), the number of wild Sumatran rhinos in Way Kambas National Park remains uncertain, with estimates ranging from 9 to 35, but apparently the lower number is more accurate.

All NGOs involved should provide data or analyses to Government that are superior to these examples In fact, the correct argumentation to Government is simple. Given that the 2013 Sumatra Rhino Crisis Summit and subsequent 2015 Population Viability Analyses indicate that at least 20 fertile rhinos need to be managed as a single population in order to prevent extinction, then all current wild clusters of Sumatran rhino except possibly that in western Leuser Ecosystem are already not viable. Rationally, therefore, all concerned NGOs should argue that all remaining wild Sumatran rhinos, except possibly those in western Leuser, should be brought into managed captive facilities, with fertile rhinos prioritised so as to maximise breeding potential.

Lack of willingness in local authorities and other parties to discuss options of letting "their" rhinos go out of the local government boundary

All that WWF can do is present objective arguments. If local government does not agree, and indicates that there will be no agreement to allow rhinos out of the district or province, this then becomes a "given". It is better to recognize such obstacles as soon as possible, and agree to a small Rhino Sanctuary facility in the relevant district. Capture and breeding of a genus on the brink of extinction cannot wait for or try to change local sentiment.

5 PRIORITY ACTIONS FOR WWF AND OTHER STAKEHOLDERS

5.1 WWF-Indonesia role

We suggest that WWF-ID takes up six very significant roles to play:

1. To be the institution that introduces the need for a shift away from the prevailing focus on counting and protecting free-ranging rhinos in protected areas to the new paradigm outlined above (in section 4.9) titled "Proposed policy for the recovery program and emergency actions".

2. To sustain that shift by continuing to advise government, and in effect drive the new strategy, even though it is not necessary to take a lead in implementing some of the actions of the strategy (such as captive breeding).

3. To advocate the establishment of the new agency/unit to lead the Dicerorhinus recovery program (section 5.4).

4. To bring in and support the introduction of new players in Sumatran rhino efforts, including philanthropists (for Indonesian sources of funds; see section 5.5), lobbyists (to secure greater political support) and land-owners (for potential locations of new sanctuary facilities).

5. To continuously monitor all aspects of Dicerorhinus, including conservation actions being undertaken, and alert government to changes that might be needed in policies and actions.

6. To reach out to the relevant stakeholders and convince them about the merits of the well-studied positions and evidence based decisions taken by WWF on Sumatran rhinoceros.

5.2 Issues on which firm positions to be taken by WWF

WWF, being a science-based conservation organization, should develop its own policy positions on issues surrounding Sumatran rhino conservation based on science and evidence, independent of opinions of other stakeholders or consensus views made in large stakeholder consultations. Furthermore, WWF should promote the well-studied positions to become widely agreeable positions among stakeholders, rather than conform to the views of other stakeholders who are much less likely to have made such evidence based policy positions. WWF should thus take a lead role in mobilising stakeholders in favour of its carefully deliberated positions using its communications and outreach strengths. Some of the issues needing such clear positions are listed below. Many logical arguments have been presented and recommendations made at several places in this report which would help WWF analyse and form its policy positions on such issues.

1. Why should the two subspecies of *Dicerorhinus sumatrensis* (found in Sumatra and Kalimantan) be cross bred?
2. Will consolidating the relict, scattered rhinos into one or more conservation areas or IMZs work?
3. Why is captive breeding urgent and why are reproductively fit females needed for captivity?

4. How likely are population surveys to provide precise estimates reliable enough for making urgent capture decisions?
5. Why is the concept of IMZ unsuitable and impractical for Sumatran rhinos?
6. Why the remote, mountainous locations where Dicerorhinus remain now are not necessarily optimal habitats for them? (particularly, for re-introductions in the very long-term)

5.3 Priority actions for donors

Tropical Forest Conservation Action (TFCA) program (http://tfcasumatera.org/) involves funds provided by government of USA for conservation of endangered species, including Sumatran rhino. Disbursement of funds for Sumatran rhino work has suffered from delays. This has come about through several issues, including a decision to disburse funds according to applications for up to USD 500,000 maximum, submitted by single or consortia of Indonesian NGOs. No policy on Sumatran rhino has been issued either by government or by the institution coordinating disbursement (Yayasan Kehati Indonesia). As a result, there is no over-riding policy on the sort of projects that can receive funding, and there has been a tendency for funding applications to be submitted as a means to seek new funds for existing projects and staffing. WWF-ID could play a role in advocating for the recommendations in this report to be used as a policy document against which TFCA would select projects for funding.

5.4 Indonesian Rhino Joint Secretariat

By definition, leadership has to be from one institution/agency or an individual office-bearer in that institution, and cannot be a collection of institutions. However, the reality is that an Indonesian Rhino Joint Secretariat exists, and so WWF has to operate within that framework

The suggested key and immediate needs for the Joint Secretariat to agree on are:

(1) that government approve the policy presented in this report for the species recovery, authorize one lead agency to implement the programme and allocate or source funds to prevent the extinction of Dicerorhinus;
(2) that there will be one programme managed by a competent team (not several programmes in different places run by different institutions);
(3) that the goal of the programme is to maximise number of births of Dicerorhinus and production of Dicerorhinus embryos;
(4) that capture of wild rhinos will be authorized and commence as soon as possible from Kalimantan, BBS and Aceh;
(5) that simple low cost facilities probably need to be built in suitable sites to hold several rhinos in the next three years; and
(6) assisted reproductive technology needs to be applied to Sumatran rhinos in fenced, managed facilities, as a means to produce additional embryos.

5.4.1 Who can be the lead organization to implement the recovery strategy?

The lead organization for the Dicerorhinus recovery strategy and implementation of emergency actions has to have a few basic characteristics, including: being Sumatran rhino-focused; having the

people who are experienced and competent in many aspects of Sumatran rhino biology, husbandry and reproduction; recognized by Government of Indonesia; national in scope; and able to source funds. We attempt to compare three organisations that appear to have some of the basic attributes: (a) WWF-Indonesia, (b) YABI, (c) WCS, and (d) a possible new organization established specially to take the lead. A summary of these and a further array of characteristics, with comments on how each of these three organisations compare is given in Appendix 11).

There are very significant capacity gaps in WWF-Indonesia, WCS and YABI that would need to be filled if any of these organisations is to become the lead agency (Appendix 11).

The assessments in Appendix 11 suggest that a new organization established specifically to prevent the extinction of Sumatran rhino, might represent a better option to take the lead role. This might be approached through either: (a) an agency instituted by central government by an act of parliament or presidential decree, similar to the Peatland Restoration Agency, and to be led by an independent expert, or (b) an organization established by a small group of specialists and philanthropists, not necessarily linked to government in the initial stages of formation. The former would need to be argued by NGOs to very high levels of government, including probably the President, and it might be argued in reply by government officials that such an agency is not needed for Sumatran rhino, or perhaps that the body should cover all rare species, thereby taking the emphasis and urgency away from the Sumatran rhino.

We do not express a particular preference for either option (government-instituted agency or new organization introduced by concerned citizens). However, we acknowledge that WWF does tend to prefer a consortium approach to addressing the imminent extinction of the Sumatran rhino. In that case, the implication is for a consortium of the major NGOs (WWF-Indonesia, WCS and YABI) to jointly advocate to government for the government-instituted agency. That would need a new impetus from all those three NGOs, to discuss and decide jointly the details of the proposed government-instituted agency. The three NGOs could propose that they would be an advisory board to the government agency.

5.5 OTHER RECOMMENDATIONS

<u>One Strategy and Action Plan for each rhino species</u>

As outlined in sections 2.1 and 2.4, the only thing that Sumatran and Javan rhinos have in common is that they are both rhino species. In terms of reasons for their endangerment and necessary actions, they are very different. It is recommended that separate Strategy and Action Plans are now developed for each rhino species to replace the current 2007-2017 “Strategy and Action Plan: Rhino Century Program” and to commence in 2018.

<u>Abandon the IPZ and IMZ names and concepts</u>

We suggest that the term IPZ is redundant and should now be abandoned (see section 3.4.3). The IMZ concept of large, fenced enclosures into which more than one rhino is released, should be abandoned, as it is an African concept meant for white rhino, a grazer which can be provided with supplementary feed and is unsuitable for the Sumatran rhino in rain forests (more details in section

3.4.4). The SRS model has proven to be suitable for natural breeding of fertile rhinos, and in terms of close monitoring of individual rhinos. A similar model is used in Sabah, Malaysia, and called "Borneo Rhino Sanctuary". There is no reason to change the SRS model. It is best to continue to use the term "rhino sanctuary" for the design developed at Way Kambas, and abandon use of the term IMZ.

Rhino capture, translocation and husbandry team

Learning from experience in Kutai Barat in 2016, we suggest that WWF-ID insist that a small, skilled team be appointed for all future rhino captures, translocations and husbandry. The team should have the following characteristics:

1. Simple structure, with a single appointed team leader (non-government) and one appointed governmental official to take overall responsibility.
2. Overall team as small as reasonably possible, and all staff appointed by or with the approval of the team leader.
3. A full-time veterinarian with experience in handling Dicerorhinus, who might or might not be the team leader.
4. Once general policy is set, as much freedom as possible is granted to the team leader and his team to make decisions on all aspects of capture, translocation and husbandry.

Involvement of private sector and philanthropy

One of the contributory reasons for lack of progress on Sumatran rhino conservation over the past decade (the 2007-2017 "rhino century program") is that the diagnosis of the problems to be solved was already out of date by 2007. Another contributory reason was that responsibility for each action was delegated to a small range of institutions, some of which lacked resources to proceed, or were external (e.g. IUCN Asian Rhino Specialist Group), and in many cases several institutions were delegated to be responsible for one topic, so actual responsibility was unclear. However, all institutions delegated to act were either governmental or mainstream NGOs that lack skills in certain activities such as capture and translocation. Totally lacking in the 2007-2017 action plan was mention of philanthropists (for Indonesian sources of funds), lobbyists (to secure greater political support), land-owners (for potential locations of new sanctuary facilities) or zoos (e.g. Taman Safari Indonesia is not mentioned, even though this institution has been active in YABI and in financing some rhino related actions). The story of prevention of extinction of the African rhinos and both American and European bison species in the late nineteenth and early twentieth century by the efforts of individual land-owners, ad hoc individuals and zoos is highly relevant to Dicerorhinus (see Foreword). It may well be that such agencies now represent an essential missing component in preventing the extinction of Sumatran rhino. WWF-ID should play a role in advocating to government for the potential benefits of the private sector and Indonesian philanthropy being brought into actions on Dicerorhinus.

Sequencing of key actions

There has been a tendency up to date to plan rhino work as a sequence of multiple, complex tasks, with one set of tasks having to be completed before the next task is initiated. This approach is counter-productive. All elements of the necessary rhino work should be started as soon as possible and all elements should continue in parallel; for example, the capture operations should not be put on hold until the population surveys are completed. Ultimately, all that is needed is to recall that

there is one program and that rhinos need to be brought into managed facilities as soon as possible to start boosting births. The capture, translocation and husbandry team can then proceed with minimum delays from other institutions. Capture work should not be delayed just because custom-designed facilities are yet to be completed. Rhinos can be managed in cheap, locally built interim facilities, or brought to SRS (temporarily or for long-term) or even brought for a temporary period to existing facilities in Sabah. Any actions that cannot be implemented by the capture team (e.g. specific policy decisions; fund-raising; coordination with other institutions) will be handled by one or more of the other agencies that are linked to the program.

5.6 CONCLUSIONS

During the 1980s to 1990s, discussions and decisions on Dicerorhinus became mired in cognitive biases (e.g. Allan, 2015). Even though rhino numbers were abnormally and extremely low (much lower than, for example, orang-utans, tigers, African rhinos), rhino population density was extremely low, very few wild rhinos were contributing to breeding, and there was clearly an extreme Allee effect, decision-makers kept on pretending that habitat loss and poaching were the main causes of the continuing decline in numbers and births. Knowing more about rhino numbers and locations would not help in decision-making, yet the conservation organizations continued and still continue to call for surveys to estimate numbers. Even knowing that precisely estimating very small numbers of solitary animals in rainforest is a near impossible task, there are still calls to improve methodology. Even though rhinos need to be captured and examined in order to determine if they are fertile, experts still assume falsely that seeing an image from a camera trap, or examining faeces, will give such information.

Dicerorhinus will very likely go extinct, in the absence of quick, decisive actions, because the main problems in recent years have been and still are long delays in decision-making, and implementation of wrong decisions that have been made largely because of cognitive biases.

There are now three options open: (a) make the best decisions now for preventing the extinction, as elaborated in this report, and implement them, and / or (b) delegate preventing extinction of Dicerorhinus to land-owners and private individuals (as happened successfully with African rhinos, and American and European bisons), or (c) cease making any further efforts and allow extinction to happen.

If (a) or (b) or a combination of both are chosen, there is another basic issue to resolve. Leadership is needed to take ownership of the problem, and to make and implement decisions. This is the most immediate requirement now.

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7 APPENDICES

APPENDIX 1. Conservation experts consulted for this work

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APPENDIX 2. Re-discovery of Sumatran rhino in Kalimantan

The trajectory towards extinction of Dicerorhinus in Kalimantan has followed a similar pattern to that elsewhere. The sparse available literature suggests a long period of decline, with a possible tipping point in the 1930s.

Twenty locations where Dicerorhinus might still exist in Kalimantan the 1990s were reported by Meijaard (1996). An anonymous Australian photographed a rhino footprint at an additional location somewhere in West Kalimantan around 1997 (Figure 1). Sözer (unpublished information, Appendix 8) recorded locations of recent rhino signs from several areas in Kalimantan in 1995-96, but did not publish them due to concerns over security of the rhinos.

In January 2013, Kishokumar Jeyaraj, a Roundtable for Sustainable Palm Oil (RSPO) assessment team member reported confidentially to one of us (J. Payne) a report of the presence of a rhino in the PT Bulungan Citra Agro Persada oil palm concession area, Kabupaten Bulungan, Kalimantan Timur. Contact was made with the Malaysian owner of the concession (TSH Resources Berhad) but no invitation was received.

Figure 1. Photo of a rhino footprint in riverside sand, taken at an unknown location in Kalimantan Barat in 1997.

WWF Indonesia staff conducting field surveys in Kutai Barat District near the border with Central Kalimantan in October 2012 received convincing reports of the presence of rhinoceros in the area, including a claim by a local resident of a sighting of a rhino in December 2011 (Yuyun Kurniawan, personal communication). Then in January 2013, WWF-Indonesia staff conducting surveys for orang-utans in the PT. Ratah Timber concession area photographed footprints of an animal that is clearly a rhino (Figure 2).

Figure 2. Rhino footprint photographed in East Kalimantan by WWF-Indonesia staff in January 2013.

Initial public announcement of the probable re-discovery of Sumatran rhino in Kalimantan was made on 28 March 2013 (http://www.wwf.or.id/?27742/Ditemukan-Bukti-Keberadaan-Badak-Sumatera-di-Kalimantan) with commentary by WWF-Indonesia as well as by the Head of Biodiversity Conservation of the Ministry of Forestry and the Bupati of Kutai Barat District. A joint monitoring team involving WWF-Indonesia and the West Kutai government administration obtained video-trap imagery of rhinos on 23 and 30 June and again on 30 August 2013, and these videos seemed to represent more than one individual. Subsequently, on 2 October 2013, the definite existence of Sumatran rhinoceros in the forests of Kalimantan was formally announced (http://www.wwf.or.id/?29561/Ditemukan-Bukti-Video-Badak-Sumatera-di-Kalimantan#).

Over 2013-2014, further survey and monitoring work was done through the north-western part of Kutai Barat District and the adjacent southern portion of Mahakam Ulu District, with additional location records being obtained through camera traps and the finding of footprints and faeces. The information obtained up to early 2014 was described in an unpublished report The report was reviewed by the authors of this report, and found to be well-structured, leading to argumentation for the various options on how to best proceed. However, several significant issues were identified as needing additional reporting or clarification, notably: (a) an overall tabulation of surveys, routes covered, and detailed description of each rhino record cross-referenced to a topographical map, (b) proof of rhino can be obtained only by clear footprints or faeces, whereas other types of signs were apparently recorded as rhino, and (c) a statement that the results "show that the numbers of the rhinos are estimated at 7 – 15 individuals including 3 calves", suggesting a small breeding population, whereas no definite signs of calves were noted (only one record of a sub-adult rhino) in the text analysis, nor was it clarified that footprints or faeces were found in four separate areas between 15 and 100 km apart, representing individuals and not a contiguous population. The report has long sections on potential habitat and habitat suitability. In reality, it is not possible for anyone

to determine what habitat is suitable for Sumatran rhino, and the remaining scattered wild rhinos apparently do not represent a viable breeding population.

Three issues of concern became apparent as survey work continued. One was that the total area within which scattered rhinos might still exist was large (an area in excess of 450,000 ha), with a variety of vegetation types, topography and accessibility, and the task to survey the entire potential area would be costly and time-consuming. Secondly, it became clear that different rhinos are far apart and are unlikely to be in contact with each other. Thirdly, camera trap images retrieved on 14 November 2015 showed that at least one rhino had the remains of a snare embedded in her leg. The last concern prompted a decision at end of 2015 to initiate capture of rhinos, commencing with the rhino with the snare wound.

APPENDIX 3. History of captive breeding efforts

WWF was founded in 1961, at a time when the purpose was to prevent the extinction of endangered species, and when governments had either no funds or no inclination to do so. Initially, methods for preventing extinction were not circumscribed. However, within 20 years, there was apparently a strengthening mood globally to save highly endangered species in the wild, rather than to bring them into fenced, managed conditions.

The first serious recognition that Dicerorhinus was likely heading for extinction and that a captive propagation program should be undertaken came from Thomas Foose in 1982 in his capacity as American Association of Zoological Parks and Aquariums (AAZPA, now AZA) conservation coordinator. Following a series of networking and field visits by Foose and his co-workers, the IUCN Species Survival Commission convened an ad hoc meeting in Singapore, 3-4 October 1984, with participants from Governments of Indonesia, Peninsular Malaysia and Sabah, together with US, Singapore and British zoos, and independent individuals.

Most participants agreed, however, to a three-part program of enhanced protection of wild populations, awareness, and development of a global captive breeding population of rhinos to be drawn from areas that were to be converted to plantations. The only strong dissent came from the IUCN SSC Asian Rhino Specialist Group chairman, who argued forcefully against any capture. Maguire et al (1987) elaborated on the meeting outcome, concluding that "Captive breeding is the most promising option in terms of minimizing the expected probability of extinction for the species" but concluding that "political winds are notoriously shifty, and conservation biologists must be prepared to accept the fact that today's worst option may be tomorrow's first or only choice."

Forty-five Dicerorhinus were captured from the wild between 1984-2014, with only five captive births, all descendents from a rhino pair in Cincinnati Zoo. Of the forty-five, 39 had died by 2013. It was only in the mid-1990s that the key elements of Dicerorhinus reproductive behaviour had become clearer (Zainuddin et al, 1990, 2005; Bosi, 1996). But by the end of 1995, 4 captive Dicerorhinus had died in Indonesia, 5 in Peninsular Malaysia, 4 in Sabah, and 6 in US and British zoos (Christman, 2010), and the captive breeding program had become less appealing to governments, donor and commentators.

In his 1995 polemic, Rabinowitz (1995) took the view that precious funds had been wasted on the captive breeding efforts which should, in his opinion, have been spent instead on guarding wild rhinos. His reasoning did not address the implications of the Allee effect on the miniscule wild concentrations of rhinos, and made no analysis of the particular faults and problems that were associated with the captive breeding attempts between 1984-95. There was also a dubious assumption that there is a certain limited amount of money available for either protecting wild animals or managing the same animals in captivity, a fallacious argument that is still heard today. This paper had the unfortunate effect of dampening enthusiasm for further capture of rhinos amongst the relevant governments and NGOs. Instead, the mood turned towards formation of "rhino protection units" (RPU), a politically safer option which would protect wild rhinos, even though they were not viable and would eventually die of pathology and age-related causes. The

switch to funding for RPU and abandonment of serious captive breeding efforts was a feature of a Global Environment Facility project that commenced in 1995.

There were two exceptions to that switch. Department of Wildlife and National Parks of Peninsular Malaysia captured a healthy, mature male rhino in August 1994, the first capture since 1988. However, due to subsequent disagreements on management of the captive facility, Sungai Dusun Rhino Conservation Centre (SDRCC), the centre manager was moved in 2001, leaving the rhinos under less skilled staff. All six rhinos remaining at SDRCC in 2003 died in that year. Aidi et al (2004) reported that the SDRCC rhinos died as a result of trypanosomiasis, supposedly originating from buffalo on private land nearby. Monthly monitoring of blood for parasites and blood parameters had been done for all captive rhinos at SDRCC for almost a decade prior to the deaths of the six in year 2003, however, and no trypanosomes had been detected. Blood was taken from the buffaloes living near to the SDRCC facility after the six deaths in 2003, and inoculated into mice, but no trypanosome infection was detected. In only two of the total of seven rhinos that died at SDRCC were trypanosomes detected, while abundant pure bacterial growth was found post-mortem in the vital organs, mucoid *Escherichia coli* in five animals and *Klebsiella* pneumonia in four animals. Seven years later, between 17-29 September 2010, at the same facility, seven Malayan tapirs died from mucoid *E.coli*, and only one of the tapirs showed trypanosomes in the blood. The conclusion that trypanosomes were the cause of the SDRCC rhino deaths was evidently reached erroneously, in order to allow parties involved to avoid responsibility for chronic poor hygiene in the facilities (Ahmad, Payne and Zainuddin, 2013).

Cincinnati Zoo was the only other facility that persisted after 1995 with captive breeding efforts, utilizing a compatible, relatively young pair of rhinos, and eventually succeeded in the first captive birth through zoo mating, in 2001.

The collaboratively-managed global population imagined by AAZPA and the 1984 IUCN group was never achieved, and breeding did not occur (before 2001) because of a combination of the following reasons (Ahmad, Payne and Zainuddin, 2013) :
(1) Insufficient knowledge of key elements of Sumatran rhino breeding biology (now largely rectified);
(2) inadequate constant, high-quality veterinary care and husbandry in captive facilities (rectified at Sumatran Rhino Sanctuary in Indonesia and Borneo Rhino Sanctuary in Sabah by full-time presence of experienced veterinarians employed independently of government bureaucracy);
(3) unsuitable diet in some facilities, with insufficient attention paid to the risk of iron ferritin disease (Dedi et al, 2012);
(4) stress on rhinos due to weaknesses in facilities design and poor visitor control (rectified at Sumatran Rhino Sanctuary in Indonesia and Borneo Rhino Sanctuary in Sabah);
(5) low reproductive potential in many – possibly most of the rhinos, because they were “doomed” individuals with uncertain breeding potential drawn from small, reproductively isolated groupings; while all breeding rhinos in protected areas were left in the wild. Close to 80% (15 out of 19) of all the female rhinos captured had reproductive tract pathology or difficulty in conceiving, making natural breeding difficult or impossible in these females. Some of the males may have never bred due to an absence of females, and either lacked experience to court and mate, or had low sperm counts due to chronic total lack of breeding activity;

(6) Only the last rhino captured (in 1994) in Peninsular Malaysia was a mature male;
(7) probably, some males in Sabah with low or no sperm production (of 10 rhino captured in Sabah, eight were mature or old males);
(8) rhinos not shared between Peninsular Malaysia and Sabah due to fears over "different sub-species" (Groves, 1965), a fear now discounted (Amato et al, 1997; Goossens et al 2013);
(9) rhinos not shared between Peninsular Malaysia and Indonesia due to loss of trust after the initial exchange;
(10) rhinos not allowed to USA due to governmental decisions within Malaysia;
(11) some pairings involved inexperienced or incompatible rhinos;
(12) knowledge of the potential application of advanced reproductive technology, even artificial insemination, was too rudimentary.

Although there was clear knowledge well before 1980s that Dicerorhinus live in closed-canopy forest and that wild Dicerorhinus typically wallow in clean mud for 5- 6 hours daily (Ng et al, 2001), most Dicerorhinus rhinos were kept in conditions of exposure to sunlight and in some cases without access to clean mud wallows. Dicerorhinus rhino skin condition declines drastically when this species is provided only with water or watery mud in which to wallow, leading to poor condition and stress. Frequent sunlit conditions have been linked to partial and complete blindness in some captive Dicerorhinus rhinos (Kretzschmar et al, 2009). Most egregious of all, basic hygiene was generally poor, with at least some Dicerorhinus rhinos kept for long periods in facilities that lacked basic hygiene protocols and biosecurity measures, and lacked experienced veterinary care so that identification and treatment of disease came too late or not at all. In summary, many Dicerorhinus rhinos were kept during 1984-95 in conditions which facilitated poor health and stress.

The failure of the 1984 – 2000 captive breeding efforts should help to inform us of what should now be done, rather than be viewed as a reason not to bring Dicerorhinus into fenced facilities.

APPENDIX 4. Report on reproductive pathology in captive bred and wild Sumatran rhinos captured in Malaysia and Indonesia; by Dr. Nan Schaffer and co-authors (March 2017)

Summary

The Root Cause of the Sumatran rhino species decline is a lack of successful reproduction. Although decades of uncontrolled poaching and habitat loss led to the population's initial decline, the current conservation strategies of protection and habitat restoration are necessary, but no longer sufficient to ensure the Sumatran rhino's survival.

Today, the most critical threats to this species' survival are the demographic and genetic hazards inherent in small, fragmented populations. The results of these hazards are demonstrated by fewer reports of offspring in each population, which indicates the loss of fertility and/or the production of unhealthy offspring with high juvenile mortality rates. The occurrence of reproductive pathology and conception problems in Indonesia's remaining wild animals are signs of a loss of fertility. Problems with conception have been unapparent until bred animals in captivity have been analysed. Management interventions have been necessary to address these issues and will be required for wild populations to increase reproduction rates by ensuring that reproductively viable animals have the opportunity to meet, mate and breed or contribute their genetic resources. These interventions will not be possible if animals are merely transferred to IMZ.

Conditions and Causes

The occurrence of reproductive problems in the Sumatran rhinos is well documented. Females have demonstrated tumors; cystic endometrial hyperplasia and EED (early embryo death), while reduced libido and abnormal sperm production have been identified in males. These problems have occurred in the young and old animals of both Indonesia and Malaysia. (1, 2) The frequency of problems observed since 1984 has been similar for Indonesia and Malaysia. (Tables 1 and 2 below). Table 2 shows the occurrence of reproductive pathology and problems with conception in Indonesia. Only three records were not obtained for Indonesia. Eighty-two percent (82%) of the mature Indonesian female animals had problems with conception and/or had evidence of significant reproductive pathology. This data set pertains to captive animals, but most of which have been captured from the wild and not captive bred. Similar problems would be prevalent in wild populations.

Compromised fertility was a significant problem that negatively impacted the success of the captive breeding program initiated in 1984 when only "doomed" isolated rhinos were used for breeding programs. Several of the first animals from Indonesia that died during this period in captivity had already developed pathology by the time they were captured. In addition, many females were not becoming pregnant with even though they were breeding during this same time period. Fertility problems have continued in the dwindling wild populations. Before the Malaysian rhino subspecies was declared extinct in the wild in August 2015, the last three wild caught females (captured in 2001, 2011 and 2014) had extreme uterine pathology and were sub-fertile. The last female captured in Indonesia required hormone treatments in order to maintain pregnancy.

Table 1. Reproductive pathology of captive bred and wild Sumatran rhinos captured in Malaysia.

SB #	Name	Location	Capture Date	Pregnancy	Age at 1st Exam	Reproductive Analysis--Findings
1	Jeram	Malaysia	30-Apr-84	No	Old	Uterine Mass
3	Melintang	Malaysia	18-Apr-85	No	NA	NO REPORT
7	Rima	Malaysia	10-Feb-86	Yes	Adult	Gave Birth in Captivity (Minah) Non-Conceptive Breeding Developed Uterine Cysts in Later Years
11	Julia	Malaysia	6-Jul-86	No	Adult	No Pathology
12	Dusun	Malaysia	9-Sep-86	No	Adult	Uterine Tumors Eight Years Lactation Until Death
13	Panjang	Malaysia	25-Feb-87	No	Adult	Uterine Cysts & Tumors
15	Minah	Malaysia	23-May-87	No	Juvenile	Captive Born Non-Conceptive Breeding
16	Seridelima	Malaysia	1-Jul-87	No	Adult	No Pathology
19	Mas Merah	Malaysia	26-Aug-87	No	Adult	Uterine Cysts & Tumors
23	Seputih	Malaysia	11-Jul-88	No	Adult	Uterine Cysts & Tumors
26	Lun Parai	Malaysia - Sabah	22-Apr-89	No	Adult	Uterine Leiomyoma
40	Gologob	Malaysia - Sabah	17-Jun-94	No	Juvenile	Non-Conceptive Breeding Developed Uterine Cysts in Later Years
51	Puntung	Malaysia - Sabah	Dec 2011	No	Adult	Extensive Uterine Cysts
57	Iman	Malaysia - Sabah	Apr 2014	No	Adult	Uterine Tumors
NA	Wild Female	Malaysia - Sabah	2001		Adult	Uterine Tumors

Summary of analysis: Malaysia

15 Animals

1 No report

14 With Records

Of the remaining 14, only 2 did not have pathology

12/14 = 86% with Pathology

Table 2. Reproductive pathology of captive bred and wild Sumatran rhinos captured in Indonesia.

SB#	Name	Location	Capture Date	Pregnancy	Age at 1st Exam	Reproductive Analysis--Findings
5	Riau	Indonesia	23-Jan-86	No	NA	NO REPORT
10	Subur	Indonesia	22-Jun-86	No	Adult	Uterine Leiomyoma
18	Meranti	Indonesia	21-Jul-87	No	Adult	Uterine Leiomyoma

22	Dalu	Indonesia	8-Jul-88	No	Adult	Multiple Corpus Luteum Enlarged Uterus
24	Mahatu	Indonesia	22-Jul-88	No	Juvenile	Sexually Immature
25	Barakas	Indonesia	24-Jul-88	No	Adult	Cystic Endometrial Hyperplasia
27	Rapunzel	Indonesia	26-Aug-89	No	Old	Large Uterine Mass
29	Emi	Indonesia	6-Mar-91	Yes	Juvenile	5 Miscarriages Required Progesterone to Maintain Pregnancy Needed Human Intervention
32	Bina	Indonesia	17-May-91	No	Adult	Non-Conceptive Breeding, Vet broke hymen
33	Rami	Indonesia	12-Jun-91	No	NA	NO REPORT
34	Wiwien	Indonesia	17-Jan-92	No	NA	NO REPORT
43	Suci	Indonesia	30-Jul-04	No	Juvenile	Captive Born No Pathology Attempted Breeding With Brother Premature Death
44	Ratu	Indonesia	20-Sep-05	Yes	Adult	2 Miscarriages Required Progesterone to Maintain Pregnancy Needed Human Intervention
45	Rosa	Indonesia	19-Oct-05	No	Juvenile	Vet Broke Hymen Non-Conceptive Breeding Recent Development: Developed Uterine Cysts (2016)
??	Najaq	Indonesia	11-Mar-16	No	Old	No Pathology

Summary of analysis: Indonesia

15 Animals

3 No report

12 With Records

1 Immature

Of the remaining 11, only 2 did not have pathology

9/11 = 82% with Pathology

These conditions in both sexes can be from adverse effects of demographic isolation or genetic depravation. The disruption of normal behavioural patterns such as lack of regular breeding can disrupt normal hormonal processes. Isolated males of other species may exhibit reduced libido and abnormal sperm production (3). The reproductive pathology from a prolonged lack of pregnancy in the female reproductive system has been documented in other species of rhino and occurs in humans (4, 5).

Importantly, females that become pregnant as soon as they reach sexual maturity have an increased chance of producing more offspring and the occurrence of isolation-induced infertility is reduced. Conversely, if a female's first pregnancy is delayed for several years after reaching maturity, there is

a much higher likelihood that the female will experience a pathologically premature shortening of its reproductive life span. In this premature shortening, late breeders stop producing oocytes at a younger age than normal, thus producing fewer offspring. This condition, known as early senescence has been characterized in humans and other large rhino species (6). If males are hard to find in these small, scattered populations of Sumatran rhinos in Indonesia, early senescence could be contributing to the lack of their recovery.

The genetic issues associated with prolonged isolation in small populations also negatively affect reproductive success. These populations rapidly lose genetic diversity through the random process of genetic drift or through the more serious loss of biological fitness from inbreeding depression (7). Inbred animals are more likely to inherit recessive, deleterious alleles, which manifest as predispositions to disease processes such as fibrous tumors. (8) Moreover, recessive alleles can be directly expressed as difficult reproductive morphologies like abnormal male penile skin attachments observed in a male Sumatran rhino and the intact hymens in several captive female Sumatran rhinos that required perforation by a vet (7)(9).

Without physical examination and genetic testing of each remaining wild Sumatran rhino, it is impossible to determine the extent of infertility and degree of relatedness in the Indonesian population. Over 25 years have been spent developing the tools and techniques that are presently resulting in reproductive management of animals in captivity. These interventions can boost reproductive and genetic health of individual animals; otherwise what is left of the Indonesian wild rhino populations will succumb to the same fate as the Malaysian rhinos. Determining the extent of the effects of isolation and inbreeding on the population and should take place immediately since the increasing effects of these processes along with other stochastic influences is driving the species into an extinction vortex.

Required Management Intervention: Capture, Examination & Translocation

Constant information on individuals is an absolute necessity to successfully manage critically endangered species that are in crisis. Age, sex, fertility, relatedness, location are required factors. It is abundantly clear that this required information cannot be acquired with the methods currently in use for assessment of the remaining wild populations in time to save the species. We do know, for the females at least, that the longer they are isolated the more likely animals are growing older and increasingly non-productive. Also, harvesting genetic material becomes more difficult the older an animal becomes and fertility treatments less effective. (4) Further surveys of populations are not going to provide solutions to the problem.

The current practice of collecting faecal samples from the wild in an attempt to determine whether an individual rhino is cycling or pregnant is futile for several reasons and rarely successful for DNA: (1) Sumatran rhinos have a tendency to defecate in water; (2) the samples are rarely fresh and easily contaminated; (3) the samples cannot be paired with an individual; and most importantly, (4) it is not possible to determine whether an individual rhino is infertile or pathologic through hormonal analysis because infertile animals and those will pathology will continue to cycle and copulate. (11) For the Sumatran rhino, it is difficult to evaluate reproductive status even when fresh, uncontaminated, samples are collected on known animals. Ultrasound and/or behavioural observations are necessary to confirm reproductive status.

This is in significant contrast to the African species where individual animals can be located and identified; and fresh samples for hormonal and DNA analysis can be routinely acquired, tested and matched with individuals. (12) This information is used to carefully monitor and manage animals that have a problem. It is important to note that larger species of rhino do not appear to have significant fertility problems in the wild (4), which helps them to recover their numbers when left alone in ideal demographic groups. The difference may be due to the Sumatran rhino's unique biology (13) that is more sensitive to the hazards of small populations.

A prime example of the prolonged development of the current methods being used is the years and funds lost to collecting the difficult to acquire rhino faces samples for DNA analysis that turned out to be from tapirs. (14) There are not enough years to refine these techniques. Even the Javan rhino is not a model, since these rhinos are in an area with naturally concentrating barriers, which allows concentrated monitoring like Africa. Continuing to solely use faces collection and camera trapping to gather information will take many more years than the scattered Sumatran rhinoceros has.

Ultrasound remains the only diagnostic tool for the assessment of fertility problems in both wild and captive Sumatran rhinoceroses. Therefore, skilled veterinarians experienced at both conducting the ultrasound procedure and interpreting the results must examine every animal directly through ultrasound. Genetic testing will be needed so they can be genetically managed for optimum production. Numbers of breeders may be so low that careful genetic mixing will be needed to maintain genetic vigor (15). Protocols for evaluation of animals must be evaluated and applied and subsequent genetically based distribution plans must be developed.

This close management of animals is more intensive than African models for IPZ or IMZ suggest and will be needed for this species which is cryptic, difficult to capture and difficult to assess without hands on. Young potentially productive females must be management's first priority. Adult females without pathology and without hymens should be productive and mated with productive males. They will have to be monitored long enough to make sure they are not losing embryos and capable of producing a calf. If not, the treatment for early pregnancy loss must be applied early before pathology sets in. These proven breeders can be returned to the wild and the calf kept to secure the captive population. Adult females with hymen will be suspect and may need inducement.

Lack of rebounding populations and indicators of compromised reproduction in the wild alone should be disconcerting and compelling managers to immediately create and secure a sufficient population of know fertility, genetics, sex ratio and whose husbandry can be managed. The last 20-30 years of research have resulted in our ability to form this core secured population. We can no longer disregard the recommendations that have called for this repeatedly since the 1980s.

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APPENDIX 5. How to distinguish Sumatran rhino and Malayan tapir faeces and footprint in the field?

John Payne, 14 February 2017

Wallows

Rhinos wallow in mud hollows that they create themselves with feet and horns. Tapirs do not make any such wallows. However, wild pigs make mud wallows which appear the same as those made by rhinos. This particular wallow (below) was made by a Sumatran rhino in Sabah, but there is no definitive way of distinguishing a wild pig wallow from a rhino wallow unless there are clear rhino footprints present(or, occasionally, by hairs – pig and rhino wallow hairs can be distinguished by observation under a simple laboratory microscope; DNA is not necessary). "Horn" marks in the wall of the wallow cannot be used as proof of rhino. The marks may equally by those of pig canine teeth. Thus, records of wallows cannot be used as a record of rhino.

Footprints

The most commonly found rhino (and tapir) signs are footprints. Sumatran rhinos have : (a) 3 toes on each foot, (b) toes which are bulky and not pointed, and (c) an adult footprint width of 19 to 24 centimeters maximum width. Malayan tapirs have : (a) 4 toes on the front foot, 3 on each hind foot, (b) lateral toes which are pointed in comparison to those of rhinos, and (c) an adult footprint width of up to 17 cm centimeters maximum width. A young rhino will typically still accompany the mother, so footprint width alone is usually sufficient to distinguish rhino and tapir.

Sumatran rhino, showing feet

(left) footprint of Sumatran rhino in riverside gravel, (right) plaster cast of Sumatran rhino footprint


(left) Four toes on the foot of a Malayan tapir, (b) the typical messy footprint of a Malayan tapir, with the four-toed front foot superimposed with the three-toed hind foot print

Faeces

The general form of Sumatran rhino and tapir faeces is similar, characterized by consisting of balls of chopped woody fibres. However, there are differences. For rhino each bolus is about 7 – 9 cm in diameter, whereas in the tapir each bolus is 4 – 6 cm in diameter. Zainuddin et al (2000) show from samples of Malayan animals that the majority of individual fibres in Sumatran rhino faeces exceed 2 cm in length, whereas fibres for Malaysian tapir are almost all less than 2 cm long. Thus, on size of bolus and length of fibres (which can be measured easily in situ with a ruler or field compass), it is almost always possible to distinguish the two species from their faeces. Zainuddin et al note that van Strien's measurements of Sumatran rhino faecal fibres in the mountains of Aceh resulted in fibres less than 2 cm long; it is not clear if the difference was due to measuring all fibres rather than the longest, or sample size, or different diet in the mountains.

Faeces of Malayan tapir

Faeces of Sumatran rhinoceros

9cm in diameter with each weighing 100–200g. A normal defecation would consist of 6 to 15 boluses. The colour is greenish to yellowish brown turning dark brown after a few days (Zainal-Zahari *et al.* 1999). Tapir faeces are similar to those of the rhinoceros but smaller with a diameter of 4–6cm (van Strien 1985). A fresh tapir dropping consists of about eight boluses. It is light brown in colour and made up of coarsely ground leaves and twigs (Williams 1978).

Techniques used during inventories of Sumatran rhinoceros by Rhino Patrol Units (RPUs) take into account both direct and indirect observations. Indirect signs that are observed and recorded include tracks, feeding signs, trails, tree markings, wallows and faeces. However, similarity in faecal boluses of the Malayan tapir and the Sumatran rhinoceros can be misleading. An in-depth study was thus carried out at the Sumatran Rhinoceros Conservation Center (SRCC), Sungai Dusun, Selangor, to determine differences between the faecal materials of the two species.

METHOD

Faecal samples were obtained from seven Sumatran rhinoceros and three Malayan tapirs and mixed separately. A 20g sample of faeces was taken from each species for analysis. A total of 68 samples were taken for each species and tested for differences in fibre length. Samples were placed in plastic containers with 15–20 holes (2–3mm diameter) and sieved using water for ten minutes. Sieving was considered complete when the drained water become clear. The fibre of stems and leaves retained in the containers were then taken out and placed on a piece of paper for sorting. Selection of epidermis coverings of stems and twigs was carried out based on the physical characteristics (elongated, smooth and tough) of the material. These were then arranged from the longest to the shortest and ten of the longest samples were selected for measurement (Plate 1) using a veneer caliper (Mitutoyo, Japan). A Student's t-test was used to stastically determine the significance of differences in the faecal fibre length of the two species.

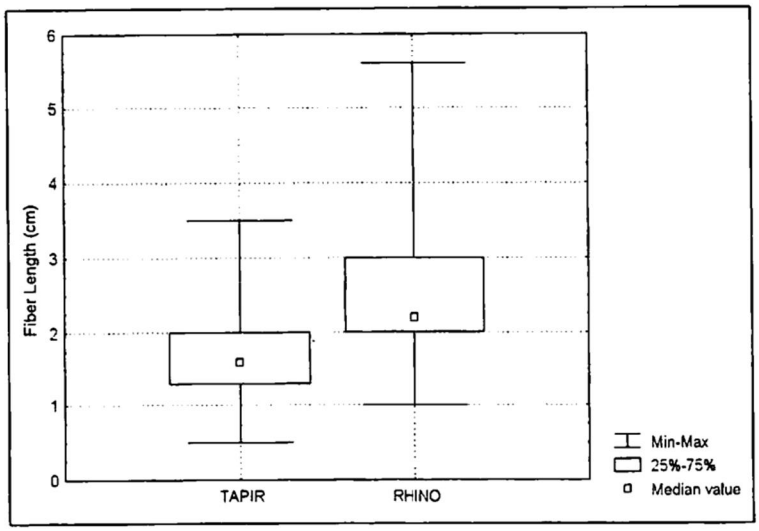
Plate 1

The dentition of both species was also measured to determine whether the size of the premolars and molars play a role in the faecal fibre length. The length and width of the premolars and molars from the mandible of the Malayan tapir and Sumatran rhinoceros were measured using a veneer caliper (Mitutoyo, Japan). The mean and standard deviation were than calculated for the premolars and molars of the tapir and the rhinoceros. A Student's t-test was also carried out to statistically determine the significant difference between the length and width of the premolars and molars of both species.

RESULTS

The average length of faecal fibres in the Malayan tapir and the Sumatran rhinoceros were found to be 1.67(±0.54) and 2.45(±0.93)cm respectively. In the Malayan tapir. the mean faecal fibre length ranged between 1.54 and 1.80cm (μ=0.05). The mean faecal fibre length in the Sumatran rhinoceros ranged from 2.23 to 2.67cm (μ=0.05). The minimum fibre length for the Malayan tapir was 0.50cm and the maximum length 3.50cm. In the Sumatran rhinoceros, minimum and maximum fibre length was 1.00cm and 5.60cm respectively. The median value for faecal fibre length in the Malayan tapir and Sumatran rhinoceros was 1.60cm and 2.20cm respectively and the variability around the central tendency (25%–75%) ranged from 1.30cm to 2.00cm for the tapir and 2.00cm–3.00cm for the rhinoceros (Fig. 1). The Student's t-test indicated a significant difference in the faecal fibre lengths between the two species.

Figure 1. Median, quantile and range for faecal fiber length in the Malayan tapir and the Sumatran rhinoceros.



Pages from Zainuddin, Z.Z., Ng, J.S.C., Aazhar, A., and Aidi, M. 2000. Faecal fibre length in the Malayan tapir (Tapirus indicus) and the Sumatran rhinoceros (Dicerorhinus sumatrensis). Tapir Conservation 54: 341-345.

APPENDIX 6. How many SRS type facilities are needed? Where? What are the specifications of the "rhino sanctuaries" and requirements of the 'interim' facilities?

The ultimate number of SRS type facilities in Indonesia should be up to the main parties involved (central and local government, the new lead organization, advised by the non-governmental organizations) to agree upon. Several points need to be appreciated, however, in order to reach a practical conclusion.

Ideal number: Probably an ideal number would be two SRS type facilities. The main reasons are: (1) the total number of rhino captured from 2017 onwards will be small, because there are very few rhinos left alive in the wild, and some will not be captured due to remoteness of their location, and (2) it is difficult to assemble and sustain the competent and disciplined team needed to maintain an SRS type facility over many years.

Two well-functioning facilities exist already, at SRS (Lampung, Indonesia) and BRS (Sabah, Malaysia). At 800 km, Sabah is much closer than Lampung to East Kalimantan, and Sabah has vacant rhino facilities and an operational programme (http://www.borneorhinoalliance.org/). We assume that Indonesia wishes to retain rhinos borne within its borders within Indonesia, but undoubtedly Sabah would look favourably on a request to use its rhino facilities as a temporary measure, pending facilities being ready in Indonesia.

Two long-term facilities in Indonesia are better than one, in order to reduce risk of impacts of any kind of catastrophe if all are held at one facility. Viewed in a wider context, expansion of rhino facilities at SRS would not necessarily be favoured because this location is in the heart of the last lowland costal non swampy forest left in Sumatra, and the site should be left for wild tigers, elephants and tapirs. However, a policy decision has been made at all levels to expand the SRS at the same location and we presume that cannot be changed.

Given that (a) probably not more than 10 - 15 rhinos are likely to be brought into fenced, managed facilities in total after year 2016, and (b) one of the limiting factors to managing the facilities to the necessary high standards will be availability of experienced veterinarians to live on site, there is actually no need for more than two SRS type facilities to be built. Having more than two will bring extra costs (each rhino will need two full time keepers, but other operational costs are much less dependent on number of rhinos), risks (the one with the weakest management might not offer adequate sustained care) and complexity (loaning rhinos, transporting gametes, exchanging staff etc).

It should be borne in mind, however, that local governments tend to object to moving rhinos out of the kabupaten in which the rhino is captured. If this is a reality, it might be better to live with and act now, rather than spend further years of discussion between local government, central government and NGOs. The most important point is to get all rhinos into conditions where they can be examined, and best use made of their individual ability to procreate.

Reproductive condition of rhinos: Most adult female Sumatran rhinos are reproductively compromised (Appendix 4, including Rosa at SRS, although it not clear if this has been made known to WWF or government) and older males may lack adequate quantity and quality of sperm (J. Payne,

personal observations of Tanjung, Torgamba and Tam, 2005 to present). The expectation that all that is required to breed rhinos is to put females and males together is breathtakingly naïve. A large part of the reason why Dicerorhinus is critically endangered is down to the inability or low probability of the remaining live rhinos to reproduce naturally. Actual numbers and proximity of rhinos are only a part of the problems to be addressed.

Details of design: The basis of an SRS type facility is: one rhino lives in one paddock, with an individual night stall incorporated within or adjacent to the paddock, and a "crush" in which each rhino can be fed and monitored as often as necessary to sustain health and reproductive potential. The paddocks must be under full or partial tree cover, because Sumatran rhinos are susceptible to damage to the eyes seemingly linked to ultra-violet light. Except during periods of illness that need close and constant treatment, Sumatran rhinos have to wallow for many hours every day in order to maintain body temperature (risk of over-heating is always a concern), maintain good skin condition, secure adequate sleep and minimize stress, including psychological stress.

Beyond that, details of design will depend on local topography and budget available. The people managing SRS (Way Kambas) people believe that each rhino needs two 10-hectare paddocks for keep rhinos healthy, with each rhino moved between paddocks every few months in order allow plant regrowth and to help suppress parasites. BRS in Sabah has three rhinos in three paddocks, each paddock less than 1 hectare in extent. The solution for the smaller paddock model is to provide at least 99% of each rhinos' food by daily harvesting form nearby forests (compared to the 70% provided at Way Kambas) and to monitor for parasites very frequently, as part of routine biosafety measures, and treat rhinos with parasites as needed. Both options work, but designers of SRS type facilities in Indonesia are likely to believe that two x 10 ha paddocks are needed for every rhino. SRS has seven rhinos (one still immature) and ten paddocks, so currently can take in three additional rhinos without the urgent need to build more. Specifications of fencing can vary according to whether or not elephants exist locally; the specifications in SRS and Sabah are set to prevent elephants from destroying the fence, but simpler and even radically different designs (e.g. three horizontal galavanised iron pipes, as used to keep rhinos in some zoos) could be used where no elephants are present. Night stalls may be solid with sturdy walls (Sabah) or tarpaulins over a concrete base (Way Kambas), either located centrally (Sabah) or peripherally (Way Kambas). Design depends largely on local topography, and slopes or broken topography will essentially determine alignment and size of paddocks.

Details of design should depend almost entirely on the experience and opinions of the local level decision-makers, who must be veterinarians with experience at caring for Sumatran rhinos, and not architects, engineers, biologists or bureaucrats. Equally importantly, the workers building the facility must be supervised by a veterinarian, and shoddy workmanship not tolerated. All concrete surfaces most slope smoothly. Small chronic puddles can lead to chronic foot health problems. Spacing between vertical posts in the crush can mean the difference between whether or not a rhino gets its head stuck and dies form asphyxiation, and whether or not a keeper is trapped and seriously injured.

Location – general criteria: The five key and necessary criteria for selecting the location of any rhino holding facility (whether temporary or long term, small or big) are: (i) ample tree cover, (ii) all-year road access, (iii) all-year clean water supply, (iv) availability of rhino foods harvestable locally (50 kg per rhino per day, of many plant species), and (v) willingness of an experienced and passionate

veterinarian to live on site. Regarding the critical fifth criterion, if a decision is made by government to build more facilities than the number of qualified veterinarians available, one could imagine an arrangement of one or two veterinarians moving between more than one or two facilities, with no more than 1 week absence from any facility.

Location – specific sites: In addition to the existing SRS at Way Kambas, and the expectation that additional holding facilities will be built soon nearby, one additional site will be needed elsewhere. Table 1 below outlines the options that have been mentioned to the authors of this report.

Table 1. Options for a second SRS type facility

Attribute	Aceh	BBS	Kerinci-Seblat	Kutai
Has a specific site been determined?	No. Three general locations have been proposed; none examined in detail	Unknown	No. A general location has been proposed	Two specific locations have been proposed: Ex PT. Kelian Mining concession (by WWF) and ex PT. ITCI logging concession (by an interested corporate individual)
Ample tree cover for paddocks	Can be found, pending identification of exact site	Unknown	Can be found, pending identification of exact site	Ex PT. Kelian Mining concession: Yes Ex PT. ITCI logging concession: yes
All-year road access	Can be found, pending identification of exact site	Unknown	Can be found, pending identification of exact site	Yes
All-year clean water supply	Can be found, pending identification of exact site	Unknown	Can be found, pending identification of exact site	Ex PT. Kelian Mining concession: To be determined. Ex PT. ITCI logging concession: can be found, pending identification of exact site
Availability of rhino foods harvestable locally	Yes, pending identification of exact site	Unknown	Yes, pending identification of exact site	Ex PT. Kelian Mining concession : To be assessed? Ex PT. ITCI logging concession : yes
Suitable for experienced veterinarian to live on site	Yes, pending identification of exact site	Unknown	Yes, pending identification of exact site	Yes
Are there wild rhinos nearby (within 200 km)?	To be determined; depends on precise location chosen	Unknown	Probably not	Yes

Land management status and rights	To be determined, pending identification of a specific site	Unknown	Hak Guna Usaha (HGU, right of cultivation) owned by a company, on government land	HGU on Hutan produksi for both sites
Possibly topographical limitations?	Possibly, as all proposed sites involve slopes, but that narrows precise location to fewer options	Probably yes, as BBS is almost entirely sloping land	Possible	No
Are design plans advanced?	No	Unknown	No	Yes for the ex PT. Kelian Mining site; not for the PT. ITCI concession

Although nothing is known by the authors regarding a possibly BBS site, this seems the least attractive, not least because the existing SRS is relatively close and within the same province of Lampung and therefore offers a good existing alternative. Also, possibly only one or two rhinos remain alive in BBS. Aceh has good prospects because there are likely to be several rhinos available for capture, ample options, and indications of local interest. The main attraction of the Kerinci-Seblat site is the fact that the HGU-holder has an interest in Sumatran rhino and has offered the site to be considered. Kutai Barat has good prospects because WWF is more advanced in planning than at any other site, there is also a second option for location nearer to Balikpapan, and either site would presumably be attractive to local government and local sentiment.

It may be best to acknowledge the likely sentiments of local governments, and support the development of SRS type facilities in both Aceh and Kutai Barat.

Interim facilities: It must be appreciated that Dicerorhinus is on the verge of extinction, and that three contributory factors include (a) number of rhinos alive now, (b) their location and (c) their reproductive condition. The absolute priority now is to aspire to get every rhino into a situation that can enhance and maximize its potential to contribute to the genus' survival. The idea that more, expensive facilities built for long-term use need to be in place before capture can start is a false premise. A case in point is the Borneo Rhino Sanctuary in Sabah. The period between design and handover of the custom-built facility was six years. The facility has yet to be used, however, due to shoddy workmanship that is the responsibility of the financier and supervising consultant. Instead, Borneo Rhino Alliance is retaining three rhinos in three facilities that were built on an ad hoc basis, between 2008 and 2012, based on a combination of need and amount of funds available. Each of the three facilities cost about US$ 40,000 to build, excluding costs of staff quarters. Road access was already available to each paddock site.

In summary, lack of funds to build large long-term facilities should not be used as a constraint to starting capture. Once the organization and individual(s) who will take the leadership role have been established, all the above issues can be assessed, discussed and resolved.

APPENDIX 7. More background on Dicerorhinus

The Sumatran rhino is the most ancient line amongst the five living rhinoceros species, now on the brink of extinction. A few centuries ago found throughout Southeast Asia, all literature on this species shows that its distribution and numbers were severely depleted by the mid 20th century.

Pressure from hunting of rhinos for their horns (a mainstay of ancient Chinese medicine) has likely been on-going for over a millennium. Rabinowitz's (1995) polemic on "helping a species go extinct" identified hunting and habitat loss as the causes of the Sumatran rhino's decline. Cranbrook (2009) points to the long inter-birth interval of these taxa, and refers to Brook & Johnson's (2006) modelling of different levels of off-take applied to large mammals, whereby a small increase in juvenile mortality can hold recruitment rates below a level needed to replace breeding adults. The idea that hunting by humans, whether using traps, spears or blowpipes, could have been the sole or main factor that caused the extermination of the ecologically-similar Javan rhino and (non horn-bearing) Malayan tapir from the entire island Borneo is difficult to imagine, however, especially while the Sumatran rhino, also persecuted for its horns, survived. The extinction of these two related species from Borneo when the human population was tiny and scattered, and before the advent of firearms, suggests that natural factors may have played a role in the low population density of rhinos. Disease might have played a role, although this is difficult to imagine for a sparsely-distributed solitary animal in a high-rainfall environment.

The Faunal Survey of Sabah estimated that 15-30 rhinos remained in Sabah in 1982, with the only evidence of breeding at that time found in and around the Tabin river catchment in the Dent Peninsula. A recommendation to establish a conservation area, Tabin Wildlife Reserve, was approved by Government of Sabah in 1984, and a plan to capture and utilise the scattered rhinos outside that area as part of a globally managed captive population was pursued by Sabah Forestry Department and WWF-Malaysia with the American Association of Zoo Parks and Aquariums. In 1984, the IUCN Species Survival Commission Captive Breeding Specialist Group, on behalf of the IUCN, convened a 3-day meeting in Singapore to "formulate an acceptable plan for a captive propagation project as part of the overall strategy for the conservation of the Sumatran rhino". Twenty participants representing governments of the three main Sumatran rhino regions (Indonesia, Peninsular Malaysia and Sabah), zoos and others, agreed to a plan to, firstly, prioritise conservation of wild Sumatran rhino populations and, secondly, form a loosely-coordinated global captive population drawn from rhinos outside protected areas.

Eight natural forest habitats containing Sumatran rhinos were protected in the three main Sumatran rhino regions, and 40 rhinos were captured for the captive breeding programme between 1985 and 1995, from areas being converted to plantations. Subsequently, the wild populations in the 8 areas mostly have stagnated, declined or gone extinct. The captive breeding was a failure, except in Cincinnati Zoo (in collaboration with several other US zoos), where three young were born at intervals of 2 years and ten months between 2001 and 2007. Contrary to the adverse assessment of some observers (notably Rabinowitz, 1995), the failure of breeding in captivity was due to a combination of bad luck (many of the rhinos caught were either old, injured by snare traps prior to capture, infertile or sub-fertile) and bad decision-making by the various parties involved (not mixing rhinos from the different regions of capture, poor sharing of information, and poor management and veterinary care in some of the facilities involved).

Rookmaaker et al (1998) report that Skafte (1964) caught nine rhinos within the Siak River area, Riau, Sumatra, in 1959, of which only one was a male. No similar story has been reported before or since. In retrospect, it seems most plausible that Skafte happened to locate one of the very last places where the Sumatran rhino existed in a relatively non-depleted state, with a higher population density there than has been otherwise recorded. Presumably, the skewed sex ratio may have reflected a reality of more females than males in one locality. A severe bias in sex ratio in the opposite direction was observed in Sabah where, between March 1987 and November 1995, a total of ten rhinos were captured. Of those, nine were caught within an area of about 100,000 hectares which would up to around 1980 have been contiguous forest cover. Of the nine, one was a mature female and eight were mature males. There are unlikely to have been many, if any, rhinos not located during the conversion of this 100,000 ha of forest. Thus, the remnant rhinos in this small population were almost all mature males. The only rhino caught outside that zone, in April 1989, was a young female that had arrived near a major road and which may have come from Tabin Wildlife Reserve, the nearest large block of forest some 25 km away in a straight line.

In September 2005, two immature female rhinos were caught in Sumatra, each having apparently moved into inhabited semi-forest areas from Bukit Barisan Selatan and Way Kambas National Park. Not much can be gleaned from these records, and as rhino numbers continue to decline, similar records will never be made again. It is clear, however, that a biased sex ratio may occur in very small populations of Sumatran rhino. The observations from Sabah also suggest that female rhinos, potentially easier to locate than males because of their smaller home ranges (van Strien, 1985), had already been selectively taken by hunters before the start of trapping for the global captive breeding programme. Also, despite the very small sample size, the three cases of young female rhinos moving out of forest into areas inhabited by humans suggests that young adult rhinos may tend to move far from their natal area.

Most or all wild Dicerorhinus populations may have been “doomed" to extinction before the 1980s. Unfortunately, members of voluntary societies, academics in fields other than biology, politicians and journalists became attracted the to the plight of the Sumatran rhino in Sabah in 1984, and in public debate on the species issues such as definition of “doomed” took precedence over rational decision-making.

Based on examination of the skulls of a total of only thirteen Dicerorhinus rhinos from Borneo, Sumatra, Malaya and Burma, Groves (1965) concluded that the Borneo form is “markedly smaller” with a forward-sloping occiput (back end of skull), and therefore ranks as a distinct sub-species (D. r. harrissoni), with D. r. sumatrensis regarded as a single form occurring in Sumatra and Peninsula Malaysia. Despite the small sample size and subjective nature of the judgement, this publication was used amongst various reasons for Indonesia, Peninsular Malaysia and Sabah to not exchange rhinos in the 1984 IUCN agreed global captive breeding programme. Zainal Zahari Zainuddin (pers. comm.), however, noted that of the 12 Sumatran rhinos captured in Peninsular Malaysia between 1984-94, there was considerable difference in body size, with adult rhinos from the peat swamp of northern Selangor being generally smaller than those from mineral soils elsewhere. Cranbrook (1986) indicated not only that the Sumatran rhino in both Sumatra and Borneo has diminished in size by between 10-20% since the Pleistocene but, in numerous papers and discussions, that Borneo, Sumatra and Peninsular Malaysia would have been linked by land traversable to large mammals until

around 20K years BP. Based on mitochondrial DNA, Amato et al (1995) concluded that all Sumatran rhinos in Indonesia and Malaysia should be regarded as a single conservation unit. These results are of great significance: the Sumatran rhinoceros is so highly endangered that mixing of Bornean and Sumatran subspecies in captive situations represents a potentially significant means to increase the number of births. Unfortunately, Groves' 1965 paper successfully kept rhino "experts" squabbling for 48 years on whether to mix rhinos from different regions for captive breeding purposes, until Goossens et al (2013), using only a review of old data, concluded that the basis for sub-specific separation is weak. But in the meantime, 39 of the 40 rhinos caught between 1984-94 had died and only one pair had bred, in Cincinnati Zoo.

By 2013, however, the number of wild Sumatran rhinos remaining was too small for a reliable estimate to be made of numbers at any one area. The low number at any one area suggests that not all will have access to fertile mates. Thus, even if not poached, wild Sumatran rhinos are likely to die of old age without breeding. Wild rhinos with reproductive tract pathologies may be potentially fertile, but need special treatment in managed conditions to allow successful pregnancies to occur. The only way now open to preventing the species' extinction is by a truly collaborative global programme of captive breeding. The situation of the Sumatran rhino is approaching that of the European bison, which almost went extinct during the First World War, but was saved by the lucky fact that a few tens remained in zoos (all descended from 12 individuals) and that in 1923 an International Society for Protection of European Bison was founded in Germany to promote international collaboration on captive breeding for re-introduction to forest areas (Puce et al, 2004).

In 2009, Government of Sabah approved Borneo Rhino Sanctuary programme, involving capture of wild rhinos for translocation to fenced breeding facilities in Tabin Wildlife Reserve. This is in many ways modelled on the pioneering Sumatran Rhino Sanctuary, established in Lampung province, Sumatra, Indonesia in the late 1990s. The pace of the Sabah programme has been slow, for several reasons, including the local extinction in recent years of rhinos from the targeted capture areas, including inside Tabin, from where the last known wild rhino was caught in 2011. At time of writing, captive rhinos in Sabah consist of one mature male, one post-reproductive old female, and one sub-fertile female with reproductive tract pathology. The non-availability of governmental funds between 2009-12 for building permanent facilities to hold rhinos also acted to slow progress of the programme. The programme has survived and been operational only through grants, collaborative discussion and technical assistance from Sime Darby Foundation, WWF-Germany and the Leibniz Institute for Zoo and Wildlife Research (Berlin).

By 2012, the only known location containing wild Sumatran rhinos in Sabah (and Malaysia) was Danum Valley Conservation Area. Government approval was given in 2013 to build holding facilities for rhinos at Danum Valley, and to capture wild rhinos from Danum Valley. Government also endorsed the idea to develop rhino reproductive laboratory facilities in Sabah, and to exchange of gametes (sperm, eggs and other reproductive materials) between Sabah and other countries. In essence, Government of Sabah has agreed to not be concerned exactly where rhinos are managed, or by whom, but instead that all rhinos should be managed to maximize their contribution to preventing extinction. Such rational thinking is essential when a species reaches very small numbers, and when emotion and national pride may dominate decision-making.

An international meeting on Sumatran rhinos held in Singapore Zoo, 31 March-4 April 2013, named Sumatran Rhino Crisis Summit, involving about 100 participants from governments, NGOs, zoos and various relevant institutions, repeated the 1984 calls, but emphasized Indonesia-Malaysia collaboration, a need for detailed information on wild populations in Indonesia, and use of advanced reproductive technologies for rhinos in fenced, managed facilities.

As an interesting additional note, Piper and Cranbrook (2008) have alluded to the potential of large forest or plantation areas for the secure reintroduction of Borneo's lost 'megafauna', the most obvious of which is the Malayan tapir. It is clear that the tapir went extinct in Borneo in recent times, possibly as recent as the early twentieth century (Cranbrook, pers. comm.). Thus, bringing Malayan tapirs to Borneo from Peninsular Malaysia or Sumatra via a managed programme can be viewed as re-introduction. If tapirs are to be brought back to become a member of the Bornean fauna, the potentially ideal habitats are now available in abundance: heavily logged forests with pioneer regrowth, and plantations. The idea of having large mammals living wild in plantations is one that is confined more by mind-set than by rational thought. If left without weeding, woody undergrowth can become abundant under both oil palm and industrial wood plantations, thereby providing a potentially suitable tapir diet.

APPENDIX 8. Unpublished information on Dicerorhinus in East Kalimantan

(Unpublished paper, Resit Sozer, personal communication, 2012)

Upper Belayan River

On the 4th of January 1996, Pak Ruslan (age ca. 50), a Kutai man from the village of Kahala, claims there are still rhinos in the Belayan river area, near the village of Matukung (Uma Tukung) in the Tabang district area near Muara Melinau (M. Bilinau). Mostly Kenyah Dayaks and Punan Naput live in this area. The Naput Dayaks are known as notorious and skilled rhino hunters. This area was not surveyed by the author.

Upper Medang/ Boh Rivers

On the 21st of January 1996, Pak Husin (age 67), a Bakumpai Dayak from Muara Ratah, informed us that he has found fresh tracks and mud wallows of more than one rhino in the upper Medang river area in the early 1990's, and that he is positive that at the time there were still rhinos in this area, just before the logging concessions moved in.. River (Sungai Boh?????)

Ratah River area

On the 21st of January 1996, Pak Husin, a Bakumpai Dayak and hunter-gatherer from the village of Muara Ratah in his early sixties, informed us that rhino is now probably totally extinct in the Upper Mahakam regi¬ons. However, he has personally observed tracks the size of a dinner plate in 1964 and 1973 in the area between Ratah River area and Central Kaliman¬tan border (coordinate), which he himself identified as those of rhino. Pak Husin has joined our expeditions on several occasions and became known to us as a highly reliable informant and dilligent observer.

On the 31st of January 1996, Pak Artinsyah (born in 1952), a Punan tribesman from the village of Danumparoy claims that rhinos still live in the remote high and long mountain chains which border the Central and East Kalimantan provinces, at the headwaters of the Ratah river (coordinate). Accordingly, rhinos do not favour flat lowlands, are nowadays very rare and give birth to only one young at a time. The footprints are as large as a dinner plate [ca. 25cm diameter].

On the 28th of October 1996, Pak Japri (born 1954), a Punan from the village of Danumparoy, informed us on his experiences. In 1993 he and two other Punans of this village were sent by the local government to the border area between Central and East Kalimantan to construct concrete border pillars. The trip to the work area took about one week by foot, and the work in the forest lasted for about three months. During this trip they encountered the tracks of two rhinos which had crossed a river (coordinate). The tracks were follo¬wed into the forest but were lost in the rockier terrains. Being experienced hunters, the tracks were readily identified as belon¬ging to rhino. They described the tracks to us as round shaped prints with three toes, about the size of a plate. The tracks were found at the headwaters of the Batu river, a tributary of the Ratah, near the summit of a small mountain called 'Burung Ayuk' (coordinate) not the same as the mountain with a similar name described by Meijaard (1996). The area is situated north of the Pt KEM gold mining concession.

Kedangpahu River

On the 14th of December 1995, a Tunjung Dayak (in his early 50's) from Muara Pahu village along the Kedangpahu River, informed us that about one week earlier a rhino was killed near the headwaters of the Kelau river (tributary of Kedangpahu), and its remaining were brought to the village of XXX downstream. The horn was sold to a chinese trader from Samarinda. This area lies just XXXX KM south of the Ratah area across the mountain range, and can be considered one continuous area with the former.

This record was also known to Dr Chandra Boer, Teacher at the Biology faculty of Universitas Mulawarman, Samarinda.

A similar record from the Kedangpahu River was published in a newspaper: in Januari 2002 a Rhino was shot by loggers in field 8 of the PT Rimba Karyatama (RKR) logging company, near Bermai Village, Kecamatan Damai, Kabupaten Kutai Barat [Gatra 17 July 2002]

(Kalimantan Tengah)

Until 2005, Rhino tracks (track as big as plates) were often encountered on the ex-logging road around km 12, going into the direction of Sungai Sepan (location of saltlick). Sungai Sepan is a tributary on the right hand side of Sungai Beren when going upstream. The forest area is ca. 1,300 ha, and the location where the saltlick is situated is until present still intact, because it is a sacred site to the Dayaks, called “Lapangan Rambang” (ca. 400ha). The remaining part (900ha) is planned to become an agricukltural area of the village’s farmers group.Orangutan and Gibbon are still present here. The regulation which forbids anyone to hunt near the saltlick is called “Puruk Kerutup”. The area is declared Hutan Adat by the Dayak community, and Hutan Lindung by the local government. This area is ca. 20 km NW of Kuala Kurun.

[Pak Acil (Bambang; Mentri Adat) and Pak Kacung Jawan (Mentri Adat) , Ngaju Dayaks, Kasintu Village, Kec. Tewah, Central Kalimantan, 23 Sept. 2011]

APPENDIX 9. Sumatran rhino reproduction notes from Nan Schaffer

Unlike larger species, no sub-population of Sumatran rhino has been proven to be increasing in numbers. Although poaching and habitat loss have been recognized issues in the decline of these numbers, the problems that are reducing fertility in captivity have been noted in the dwindling wild populations of both Malaysia and Indonesia. Although, these problems have not been seen in the wild for the other rhino species, the same problems have interfered with their production in captivity.

(If 30+ unrelated, reproductively viable (via ultrasound for females) Sumatran rhinos of breeding age with a 50/50 ratio were…

Occurrence in the wild of this rhino's reproductive problems may be a result of this species' unique biology exacerbated by the effects of the very small populations now occurring. This ?? Pressure added to the several still uncontrolled other pressures on this species would have a devastating effect on recovery unless dealt with directly. This effect has played out tragically in Malaysian populations that are now gone and is due to eliminate the populations of Indonesia.

Fertility problems have occurred in both males and females. The symptoms of females include gross pathological findings in the uterus as well as early embryo deaths. In males low libido, low sperm quality and testicular fibrosising have been recognized. Abnormal reproductive morphologies have been reported for both sexes.

Prolonged isolation and genetic depravation of animals are recognized agents of many of these symptoms in both sexes. When animal populations decline below viability, expression of regressive alleles from inbreeding result in reduced fertility. The collective signs of fertility loss from reproductive problems in this species could be that expression, particularly when many of them have hereditable components.

The demographics resulting from small populations can likely cause isolation of individuals for prolonged periods. This disruption of normal breeding patterns can cause hormonal issues. Isolated males can have reduced libido and abnormal sperm production. The effect of hormonal imbalances from prolong lack of pregnancy on the female reproductive system occurs in humans and has been documented in other species of rhino. The same signs of these imbalances occur in the Sumatran namely fibrous tumors, cystic endometrial hyperplasia and EED (early embryo death). Isolation also reduces the chances of young females entering the breeder pool at the appropriate time. Late breeders can have a pathologically premature shortening of their reproductive life span. Late breeders stop producing at a younger age than normal. This condition called early senescence has been characterized in humans and large rhino species. All of these effects are inherit is small populations and none have been determined unless the animal was captured and examined.

While prevalence of these conditions in wild is unknown, we do know for the females at least, that the longer they are isolated the more likely they will develop problems.

All of the last females from the wild in Malaysia had extreme uterine pathology resulting in infertility; the population is now extinct in the wild. Animals that have most recently come from Indonesia have had to be treated to enable them to maintain pregnancy. This suggests a growing

problem in dwindling populations. There is a high likelihood that this was a significant problem that impacted the success of the captive breeding program initiated in 1985. The animals captured during the 80s and 90s were retrieved from doomed small populations and thus, were already compromised. (been a problem in the 80s and 90s when animals were taken from the doomed small populations that were already compromised.) Additional complicating factors are the evidence that the Sumatran rhino is the only rhino in the world that does not have proven rebound in any protected area.

These conditions in the Sumatran rhino remained unrecognized until the advent of ultrasound on the reproductive system. And is the only tool that can monitor the effects of treatment. As was the case in captivity before ultrasound none of these continuous could be diagnosed with hormonal evaluation, particularly since animals continue to cycle and will breed even with pathology. Hormone levels in feces from the wild are not revealing, since they are easily contaminated with water and results cannot be paired with an individual. In addition, animals can enter false pregnancies. Even now with fresh, uncontaminated, dry, serial samples on known animals (parameters only occurring in captivity) assessment is prolong and marginally relative to pregnancy loss. Even cycling events are difficult to determine with comparison to ultrasound. Ultrasound remains the only diagnostic tool at this time for pathology and pregnancy determination.

Animal numbers are so low and scattered they much be physically helped so their genetic contribution is not lost. Animals should be caught and examined as soon as possible so they can be genetically managed for optimum production. Age, sex, fertility, relatedness, location are required parameters to successfully manage a critically endangered species in crisis. Not only is information vital, but also immediate action is needed on animals that are likely growing older and increasingly non-productive. The treatment for early pregnancy loss must be applied early before pathology sets in. And harvesting genetic material becomes more difficult the older an animal becomes. Delay is increasing the loss of reproductive and genetic resources of animals in the wild.

Captivity vs. wild

Such that some behavioural and nutritional problems were suffiently over come to produce offspring in a few individuals, but required treatment with progesterone to resolve abortion issues.

APPENDIX 10. SUMATRAN RHINO CRISIS SUMMIT (April 2013): An assessment of progress 18 months later. Report prepared by J. Payne, Executive Director, BORA. October 2014.

Objectives and excerpts from the SRCS invitation flyer

Objectives

1. To forge a global Sumatran rhino conservation plan.
2. To seek new impetus (via new potential financing sources, influence and partnerships) to support the goal of preventing the extinction of the Sumatran rhinoceros.
3. To lift the conversation from local, national and Sumatran rhino specialist levels to a broad, global platform.
4. To seek ways to help those working on the ground secure enhanced governmental, political and financial support.
5. To initiate a process to raise Euro 30 million for the prevention of the extinction of the Sumatran rhinoceros.

Key text excerpts from the SRCS flyer

"What needs to be done? Review the situation and our existing strategies. Identify key issues on which action has to be taken. Craft an ambitious yet achievable plan. Source financing to realize the plan. Seek strong governmental commitment and support for implementing the plan.

The 1984-2012 strategy of trying to protect them in the wild has not resulted in increasing their numbers except in Way Kambas. The past population estimates are debatable, but specific numbers do not really matter. Any species numbering less than 200 and declining is in very serious trouble.

The essence of the problem now is that there are only a few breeding females. This applies to wild and captive Sumatran rhinos. The species may go extinct even if all poaching can be stopped. A conservation programme now needs to put in place measures that significantly boost rhino birth rate in captive conditions."

Media statement on final day of SRCS

On the final day of SRCS (4 April 2013), a media statement was crafted and agreed by a majority of the participants, including governmental participants present, and released by IUCN. Key parts of the text are:

"With population estimates of Sumatran rhinos (*Dicerorhinus sumatrensis*) reduced to less than 100 individuals, a ground-breaking agreement to save the Critically Endangered species was reached today between representatives of the Indonesian and Malaysian governments. The agreement was formed at a summit convened by the International Union for Conservation of Nature's Species Survival Commission (IUCN SSC), involving a wide range of international and national organisations.

This is the first time the two countries join their efforts to address the dire state of the species, of which the last wild populations are believed to survive in Sumatra, western Indonesia and Sabah, Malaysia. The two governments now need to formalize the collaboration and agree on the next steps to tackle the Sumatran rhino crisis. Experts gathered at the summit have made a proposal for a two-year emergency action plan as an immediate follow-up to the event.

"Serious steps must be taken to roll back the tide of extinction of the Sumatran rhino," says Widodo Ramono, Executive Director of Yayasan Badak Indonesia (YABI). "This could be our last opportunity

to save this species and, by working together as a collaborative unit, internationally and regionally, with an agreed vision and goals, a glimmer of hope has been clearly demonstrated. We need to act together urgently, hand in hand, replicating some of the inspirational successes of other conservation efforts and aim to stop any failures that might impede progress."

"We would like to reiterate Sabah's commitment and our willingness to further discuss with Indonesia opportunities to exchange reproductive cells of the species, move individual rhinos between our countries and to employ advanced reproductive technology (ART) as a parallel initiative in the Sumatran rhino captive breeding programme," says Datuk Dr Laurentius Ambu, Director of the Sabah Wildlife Department, Sabah, Malaysia.

"The Sumatran Rhino Crisis Summit has been transformational by bringing together the two governments whose representatives committed to positive and proactive bilateral collaboration which is critical for saving this enigmatic species," says Mark Stanley Price, Chairman of the IUCN SSC Species Conservation Planning Sub-Committee. "Huge progress has been made in specifying the resources needed to improve rhino surveys, security and monitoring. We have also explored the potential of new technologies and the role of integrating the management of wild and captive individuals."

Were the Objectives achieved?

The following is a subjective assessment based on text in the SRCS flyer.

1 "To forge a global Sumatran rhino conservation plan"

Materials to provide the basis for a plan were the written outcomes from each discussion group, compiled within two days of SRCS by the SRCS independent facilitators and LEAP staff. Mark Stanley Price (IUCN) drafted a "Sumatran Rhinoceros Draft Emergency Plan Framework", that captured well all views expressed at SRCS, with a four-page summary completed on 8 July 2013 (this document is the basis for the Scorecard, section 6 below). At least one participant did provide email endorsement of this document (J. Payne) but seemingly there was no firm feedback from most other parties. Eighteen months after SRCS, therefore, there is no formal, jointly agreed global Sumatran rhino conservation plan.

Several other participants prepared additional texts as a basis for or components of the envisaged plan. Based on the SRCS discussion group written notes, J. Payne also compiled a 15 page initial "Strategic Emergency Plan" document on 15 April 2013. In June 203, Susie Ellis (IRF) completed a document "Status and Recommended Conservation Actions for Rhinos in Indonesia". In June also, J. Payne prepared a simple 3-page table with three headings, which focused only on actions needed, and not on issues of fund-raising, awareness etc.: Intensive Management Zones (a concept from Africa, embraced in Indonesia, but not applicable in Malaysia); Captive breeding with advanced reproductive technologies; and Wild rhinos in situ". In July 2013, Barney Long (WWF-USA) finalised an "Emergency Proposal to Identify the Population Size, Distribution and Structure across the Range of the Sumatran Rhinoceros" (for SR in the three relevant Sumatran National Parks).

When a species is declining in numbers, and when there are (even in the absence of any new surveys) a very few tens of fertile females remaining, scattered in each of several places, then it would seem a fundamental element of any conservation plan to address the question of how to boost reproduction of rhinos before those few females die of poaching or old age, or become infertile due to lack of breeding. In fact, this was a fundamental reason for initially calling for a "crisis

summit". This fundamental need turned out to be just one element of the sum total of discussions, with eventually (implicit, and not evident in any agreed wording) four categories of participant opinion discernible :

(a) no consensus can be reached yet on how to boost SR numbers until after much more accurate information is available on actual numbers, locations, sex ratio and breeding (championed primarily by WWF-US and IUCN),

(b) the priority is to protect SR in the wild in the expectation of enhanced natural breeding (not stated explicitly, but seemingly a consensus view in Indonesia),

(c) initiate capture of wild SR soon, and bring at least some into managed fenced facilities, with ART having a key role to play (Government of Malaysia, BORA and IZW); and

(d) a mix of approaches is necessary (IRF and many others).

With such a wide range of positions, and most participants only implicitly stating a view, rather than being allied strongly to any one of them, it is perhaps not surprising that no conservation plan emerged from the SRCS discussions.

2 "To seek new impetus (via new potential financing sources, influence and partnerships) to support the goal of preventing the extinction of the Sumatran rhinoceros."

Efforts from 1990s to date (to (a) protect wild Sumatran rhinos, that seemingly have not led to an increase in numbers, and (b) hope for natural breeding in fenced facilities where there has been only one birth (Andatu in June 2012) in 32 "female rhino-years" between 1998-2014) suggests that what is being done now is failing, and that a new approach is needed urgently. Every female Sumatran rhino in fenced facilities (currently five of them) can supply oocytes theoretically up to 12 times per year (and between them the five females could probably supply about 100 oocytes per year using established oocyte pick-up procedures). There are four male Sumatran rhinos in fenced conditions. At least two produce sperm. The first "test tube" human baby was formed in 1978 and now there are over 5 million such people in the world. In vitro fertilization results in births of thousands of domestic mammals annually. The potential implications for work to prevent the extinction of SR should be obvious. However very few of the persons involved in discussion on SR are veterinarians. Most are field biologists, academics, administrators and bureaucrats.

On 29 April 2014, J. Payne joined IZW and WWF-Germany to discuss the case for ART as the key means to prevent extinction of SR. Subsequently, IZW has approached the European Association of Zoos and Aquariums (EAZA) to be able to make use of zoo rhinos (any species) to gain experience and practice of ART techniques (e.g. notably harvesting and preparation of oocytes, and intracellular sperm injection, ICSI). There is some interest from about ten zoos, but to date none from the mainstream wildlife conservation NGOs apart from WWF-Germany.

Many parties involved in discussion on SR have little or no direct experience of SR, yet they are advocating for "business as usual". For example, the scientific officer of the IUCN SSC African Rhino Specialist Group has written to EAZA and the SSC Asian Rhino Specialist Group stating : "Assisted reproductive techniques may well prove to be a very useful tool for conservation of some species but I feel any such efforts with rhinos should focus on common species such as white rhino or other types of (non-rhino) species rather than the rarest rhinos." SR is on the verge of extinction. Until there is a consensus on a single goal of boosting production of SRs by all possible means,

continuation of the impetus such as that initiated by IZW is not possible. Although in a minority, parties with in-depth experience of SR, including Sabah Wildlife Department, BORA (whose veterinarian is Asia's most experienced SR veterinarian), IZW (world leaders in rhino reproductive biology) and also Nan Schaffer (an experienced US-based rhino reproduction veterinarian) do advocate ART.

Overall, the new impetus and partnerships envisaged by BORA have yet to emerge.

3 "To lift the conversation from local, national and Sumatran rhino specialist levels to a broad, global platform."

Indonesia has indicated a preference for forging a SR programme that is based in Sumatra, specifically at Way Kambas, with international assistance to support that programme. Malaysia favours the ART approach, in large part because that is the only remaining option other than abandoning the species to extinction. If Indonesia takes a leadership role, with clear goals and actions, it is likely that Malaysia will be willing to support Indonesia in any way that is possible, as long as all steps are done transparently and based on rational debate supported by information from experienced SR "practitioners". At time of writing (October 2014), none of the Indonesian NGOs seems interested either in ART or in taking on a leadership or advocacy role.

4 "To seek ways to help those working on the ground secure enhanced governmental, political and financial support."

See sections 2, 3 and 5. Government of Malaysia seems in principle to be open to doing whatever is necessary for SR.

5 "To initiate a process to raise Euro 30 million for the prevention of the extinction of the Sumatran rhinoceros."

Malaysia

WWF-Malaysia has declining funds for monitoring at Danum Valley. BORA has adequate funding from Yayasan Sime Darby (YSD) until June 2015. YSD has indicated that a request for an additional three-years funding (2015-18) may possibly be considered, but only if (a) the justification is strong and (b) the annual amount requested is reduced from previous years. Sabah Wildlife Department, BORA and WWF-Malaysia are currently seeking to secure formal Malaysian governmental support at national level for work on ART for SR. Until Malaysia's ART efforts become part of a bilateral or global SR plan, it will be difficult to secure much additional financial support.

Indonesia

Financing for SR conservation work in Indonesia has relied heavily for many years on International Rhino Foundation (IRF) and fund-raising in USA. Save the Rhino International (UK) and Asian Rhino Project (Australia) channel funds via IRF (USA) to Indonesia, on the understanding that YABI and IRF will play a lead role to determine activities and funding needs in Indonesia.

Following advocacy work in USA to secure new funds for SR work in Indonesia, a new allocation of US$11.9 million has been secured for Sumatran rhino and Sumatran tiger conservation, based on the "debt-for-nature" concept and an amendment to the US Tropical Forest Conservation Act. It is anticipated that the funds will be channelled starting end of year 2014 via Conservation International (in USA) to Yayasan Kehati (in Indonesia). BORA is informed that, as at October 2014, a panel consisting of US Department of State, US-AID and Yayasan Kehati is overseeing channelling and allocation of the funds. It has been indicated that the maximum amount of a grant provided

might be limited to US$500,000 per NGO, and that only Indonesian NGOs will be eligible to receive grants. No other information has been provided to BORA, but feedback suggests that application for the funds is largely competitive, with elements of sustaining existing programmes and staff, and using "Sumatran rhino" as a flagship for "landscape" work and "forest restoration".

A note on SR Population Modelling – projections from after SRCS

Within two weeks after SRCS, two SR population modelling texts were prepared by SRCS participants.

Caroline Lees (IUCN SSC Captive Breeding Specialist Group Australasia) prepared "Sumatran Rhinoceros Crisis Summit: DRAFT Interim Wild Population Modelling", with some key points including :

"Due to risks related to genetic impoverishment and demographic stochasticity, simulated populations numbering 10 individuals or fewer struggled to recover solely through protection, whereas those numbering 30 or more showed convincing recovery in all cases. The future of populations numbering between 10 and 30 was more variable and may hinge on population-specific characteristics such as age-structure, sex-ratio, and individual reproductive competence.

Female inter-birth interval was found to be the single most important predictor of population performance.

Populations of more than 20, if otherwise healthy and completely protected, should be able to tolerate a harvest of 1-2 females at year 5"

Andrea Putnam (San Diego Zoo Global) prepared "Captive Sumatran Rhinoceros Population Modelling" with some key points including :

"***Given the reproductive problems seen in the current captive Sumatran rhinoceros population, there is an 85%-98% probability that the captive population will go extinct in 50 years if no additional wild-caught animals are brought into captivity.***

To reduce the captive population's extinction probability below 10%, approximately 16 adult wild-caught rhinoceros need to be transferred into captivity … with an inter-birth interval of 3 years (i.e. no fertility problems). If significant fertility problems persist in the captive population then more than 16 wild-caught rhinoceros are necessary ..

Reproductive problems are currently the most significant impediment to captive population growth. "

Both these models (for wild and captive rhinos) suggest that SRCS failed to generate an adequate basis for action to prevent the species extinction. A key point made by some participants with long experience of SR is that a percentage of female SRs suffer from significant reproductive tract pathology that prevents or severely limits chances of breeding. Apart from 1990s data that more than 50% of female SRs have this limitation, and the fact that the last three females captured in Sabah (including the one poached in March 2001) exhibited severe reproductive tract pathology, no-one can guess the significance of the problem for SRs in Sumatra. The current captive population is also clearly not viable (even more so post-SRCS, as Suci has died, and the three female at Way Kambas remain without embryos through natural breeding after the June 2012 birth of Andatu). The

implications of female SR reproductive pathology remain insufficiently appreciated except by SR specialists.

Even if work is done to obtain better information on wild SRs, capture and examination of individual SR is to only way to reveal their reproductive health. Camera trapping and faecal DNA results will not be sufficient to aid decision-making on exactly what needs to be done. Even if compiled data supports removal of wild SRs for managed fenced breeding, it may be logistically impossible to capture and translocate targeted individuals, unless they are in accessible lowland sites. For captive SR, the combined potential breeding years of Rosa, Ratu and Bina while at Way Kambas is 32 years (= 384 months), yet the programme has produced only 1 baby. If a programme to fast-track ART for SR is agreed and established in Indonesia, with the Sabah rhinos as a supplementary source of gametes, one can imagine a potentially much better rate of production.

Thus, the stark choice in October 2014 is this :

Trajectory 1: Continue with a generally "business as usual" approach, and perhaps new wild SR population data available over the next three years, with no clear policy decisions and programme to bring wild rhinos into captive conditions, then SR (both wild and captive) continue to decline to extinction

Or

Trajectory 2: Focus on a single goal of boosting production of SR embryos by all possible means; this entails capture of wild rhinos in Indonesia; those found to have reproductive problems have to be brought into the captive population for ART work; fully fertile might be released, but would better be retained for continued attempts at natural breeding as well as for regular oocyte harvesting for intracellular sperm injection (ICSI); and by provision of gametes from three captive rhinos, Malaysia would contribute in a supplementary way to an essentially Indonesian programme.

Since many people responsible for Sumatran rhino, both in government and NGOs, remain unable to fully endorse Option 2, then as of October 2014, Option 1 continues by default.

Some conclusions

- SRCS was probably doomed to result in a wide array of rather generic recommendations, due to the sheer number and wide variety of backgrounds of participants. To expect very specific, mutually-agreed actions was probably overly optimistic.
- The view of some participants in the pre-SRCS planning phase that SRCS had to be convened by IUCN because that was the only way to obtain governmental "buy-in" remains unproven.
- Malaysia has a detailed plan underway for SR, lacking only rhinos in order to effectively implement it.
- Up to time of this report, there is no bilateral agreement for collaboration between Indonesia and Malaysia.
- There is no international level plan for preventing the extinction of SR.

APPENDIX 11. A Comparative Assessment of Possible Lead Agencies

A comparison of four organizations that might take the lead in implementation of a Sumatran rhino recovery strategy.

	Characteristic	WWF-ID	WCS	YABI	New organization
1	Commitment to preventing extinction of Sumatran rhino	A small element in a big organization, and not a top priority species	A small element in a big organization, and not a top priority species	A main aim of its existence, but its mission is broad and not explicitly focused on preventing extinction of Sumatran rhinoceros: "to participate in preserving Javan and Sumatran Rhinoceros through protection and monitoring on population and habitat, breeding improvement, research and development, raising community awareness on presence and necessity of conservation efforts of Javan and Sumatran Rhino, collaboration and fundraising for the continuation of program and rhino conservation activity"	The new organization established with an explicit aim to prevent extinction of Sumatran rhinoceros

	Characteristic	WWF-ID	WCS	YABI	New organization
2	Existing staff competent to work and advise on Dicerorhinus	Two or three mammal specialists, none with experience in Sumatran rhino capture, translocation, husbandry or reproduction	Several large mammal specialists, none with experience in Sumatran rhino capture, translocation, husbandry or reproduction	All staff have some involvement with rhinos, but none have experience in Sumatran rhino capture and translocation; knowledge of reproduction aspects weak; information presented in quarterly reports, on the website and elsewhere reveal much optimistic guess work and no hard data or analysis of data	The new organization could potentially recruit experienced staff to work specifically on the aim to prevent extinction of Sumatran rhinoceros
3	Organisation recognised by government	Yes	Yes	Yes	Establishment might need national level political support
4	Ability to operate at national level	Yes	Yes	Yes, although YABI has seemingly excluded itself from roles in Aceh and Kalimantan	Could be written into the constitution
5	Able to source adequate funds	Potentially yes, at least from outside Indonesia	Potentially yes, at least from outside Indonesia	Uncertain. Almost all funding to date has come from or through US-based International Rhino Foundation, and the future security of this source is unclear.	Not until formed. The new organization would do well to focus on funding from Indonesian sources as well as from overseas, as overseas sources cannot be guaranteed

	Characteristic	WWF-ID	WCS	YABI	New organization
6	Ability to act as a leader	Yes, but would need endorsement by the WWF-Indonesia Board and senior management team, as well as support from the WWF network	In theory yes, but has not shown an inclination to do so	In theory yes, but has not shown an inclination to do so	Could do, if the founders are serious and committed
7	Its policy and by-laws allow work to be conducted on Sumatran rhino	Yes	Yes	Yes	Would need to be fundamental elements in the founding policy, statutes and governors
8	Governance structure is functional and supportive	Yes, but would need endorsement by the WWF-Indonesia Board and senior management team, as well as support from the WWF network	Not clear	Not clear	Would need to be fundamental elements in the founding governance model and founding Board
9	Necessary authority to coordinate rhino captures and translocations across district and state borders	No	No	No	Yes, if the new organization is established by the government through an act of parliament or a presidential decree
10	Credibility is generally high	Yes	Yes	Yes	Not applicable

An assessment of capacity gaps in WWF-ID, WCS and YABI to become the lead agency

Current capacity gaps	**WWF-ID**	**WCS**	**YABI**
Experienced senior leader with a vision to save the Sumatran rhino	Currently not prominent	Currently not prominent	Currently not prominent
Field team leader with experience in seeking wild rhinos	Moderate	Not clear	In theory good
Field team leader with experience in capture and translocation of wild rhinos	Currently absent, but being developed	Currently absent	Currently absent
Experienced veterinarian able to lead removal of rhinos from traps, translocate, care for and enhance reproductive potential	Currently absent	Currently absent	One veterinarian, with experience in captive husbandry
Rhino capture and translocation team	Currently absent	Currently absent	Currently absent
Rhino reproduction specialist	Currently absent	Currently absent	Currently absent
Fund raiser for Sumatran rhino recovery programme	None specific	None specific	Current fund raiser has no success; relies on US-based fund raisers
Senior officer able to liaise with and advocate the Sumatran rhino story to government	None specific	None specific	Present, but not supportive of capture of wild rhinos or use of reproductive technology

K - KNOWLEDGEABLE

Science and fact based,
wise/smart, intelligent, expert

O - OPTIMISTIC

Inspiring, positive, ambitious,
successful

D - DETERMINDED

Passionate, urgent,
result-oriented

E - ENGAGING

Open, available, accessible

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony and nature.