Conservation of Orangutans:
Reintroduction or Habitat Preservation?

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Abstract

Orangutans are one of the closest relatives of the human species, but their future is unclear. Population viability analyses (PVA) suggest that orangutan populations are declining in size and number. Many populations are already below the minimum viable population (MVP) number. The main cause for this decline are these two human-induced threats: hunting and habitat loss.

Fortunately, there have also been incentives by people to conserve orangutans and counteract these threats. There are two main strategies for orangutan conservation. The first, rehabilitation & reintroduction, aims to take care of orangutans who were freed from captivity and prepares them for a return to forest life. The second strategy is habitat preservation, which aims to protect (forest) areas that are suitable for wild orangutan populations to thrive.

Both strategies have their own strengths and weaknesses, thus an optimal strategy does not exist. However, in terms of cost-effectiveness and conservation timeframe, habitat preservation has a clear edge over rehabilitation & reintroduction. So, for long term conservation of orangutans, it is most effective to invest more into habitat preservation rather than rehabilitation & reintroduction.

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1 Introduction

Anthropogenic climate change remains one of the most relevant issues nowadays and not only for us humans. Animals have to endure a lot from anthropogenic pressure too. One of them is a close relative of the human species: the orangutan. Like humans, the orangutan belongs to the taxonomic order of *Primates* and the family *Hominidae*. However, whereas humans belong to the genus *Homo*, orangutans belong to the genus *Pongo*. And whereas the conservation status of humans is of least concern, the same cannot be said about orangutans.

Once habitant of a wide distribution throughout the mainland of South-East Asia (including parts of present-day Vietnam, China and India), their habitat is now restricted to two islands: Sumatra (Indonesia) and Borneo (divided into a Malaysian and an Indonesian region, the latter also known as Kalimantan)(1). Figure 1 shows their distribution on the aforementioned islands. Until recently, each island was thought to have one representative of the *Pongo* genus – the Sumatran orangutan (*Pongo abelii)* and the Bornean orangutan (*Pongo pygmaeus*). However, the score may well have become two against one as research suggests the discovery of a new species residing on Sumatra: *Pongo tapanuliensis*(2,3).

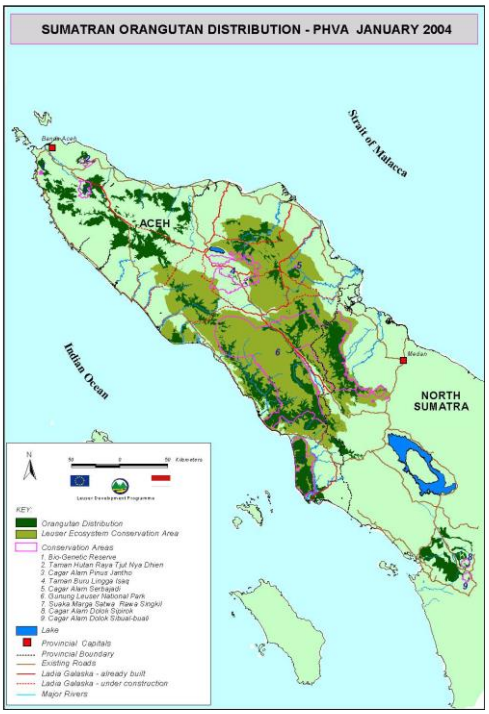

Fig 1.1 Orangutan distribution in Aceh, the most populous orangutan province of Sumatra (Source: *Singleton et al, 2004*) (4)

Though they may differ slightly from a morphological and genomic perspective, the three orangutan species all belong to the genus *Pongo*. Unfortunately, all three species are also listed as Critically Endangered by the IUCN (IUCN, 2020). A population viability analysis (PVA) performed by *Singleton et al (2004)* demonstrated that many orangutan populations have been driven below the minimum viable population (MVP) threshold. The MVP for a 1000 year sustainable population was generally 250 (4). Singleton found that in Sumatra, 7 of the 13 habitat blocks were below MVP with 3 barely surpassing it. In Borneo, similar results were found in Sabah in which 12 out of 17 habitat blocks were below MVP (the results for Borneo here are slimmed down to one of four regions because orangutan distribution over Borneo is much larger than Sumatra)(4,5).

Even though there are populations that are then theoretically viable, Singleton does stress that these could be wiped out or degraded badly if action is not taken very soon. Their models should be seen as projections of expected stability if threats such as hunting did not occur, not as predictions(4). So, what are the threats that orangutans face that put their existence into jeopardy?

Though there are many factors that add to mortality of orangutans, the biggest threats can be summarized into these two human-induced threats: **hunting** and **habitat loss**(6,7). Other such threats are e.g. disease, natural disasters and predation though these are 1) much less significant to mortality of orangutans than hunting and habitat loss and 2) beyond our reach of impact for the most part.

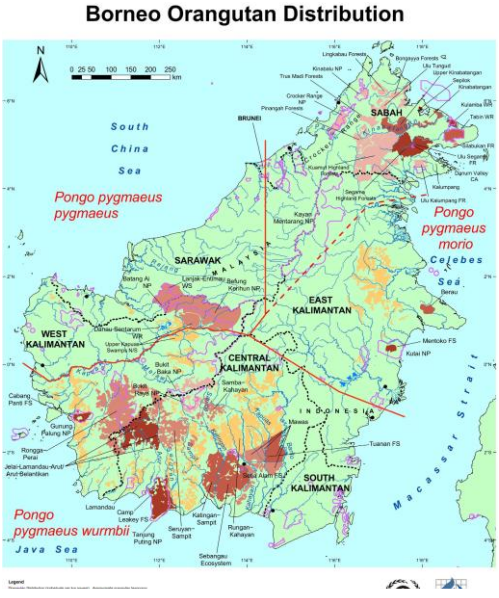

Fig 1.2 Orangutan distribution in Borneo. (Source: *Singleton et al, 2004*) (4)

1.1 Hunting

Hunting is by far the greatest immediate threat to the survival of most endangered vertebrates in South-East Asia(8). Before the dawn of the 2010s, there was no data available to substantiate that this statement also holds true for orangutans. A study performed on hunting activity by *Meijaard et al* in 2011 not only gave confirmation to this, but it also showed that the killing rates are higher than previously thought(9). Orangutans are hunted mainly as food, pests and as commodities for the black market. *Meijaard et al* (2011) continues by showing there is a correlation between human-orangutan conflict and killing, which falls under the category 'pests'(9). Other factors that have contributed to overhunting are improved access to forests and markets, improved hunting technology, demand for wild animals as pets, demand for wild meat and ignorance about legislation(8,9).

The killing rates of orangutans are highly worrying. Population viability studies have suggested that if annual mortality of females is higher than 1%, the population will go extinct(10). *Meijaard et al* (2011) estimated that the annual female take off rate by killing alone could be between 0.9 and 3.6%(9). Clearly, the impact of hunting is highly detrimental for the species.

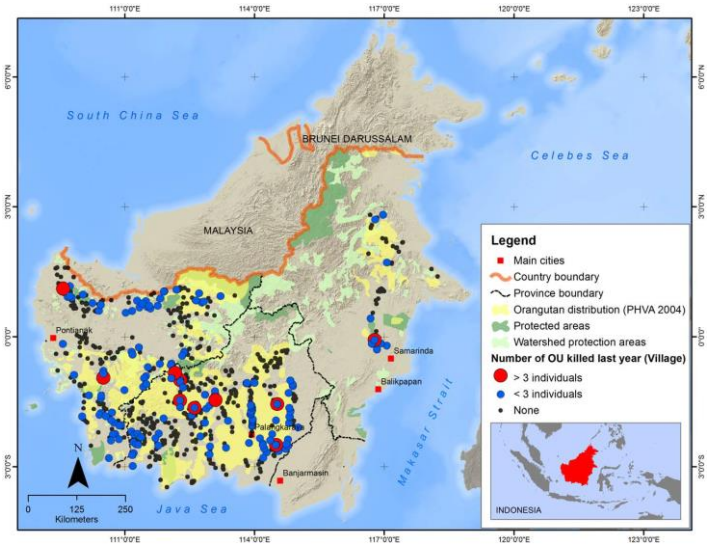

Fig 2. Reports of orangutan killings in Kalimantan; blue = low intensity, red = high intensity (Source: *Meijaard et al, 2011*) (9)

1.2 Habitat loss

Conflict tends to occur when humans and ape favor the same habitat. With the speed at which the Indonesian population grows, from a mere 10 million to a current population of over 200 million people in little over a century, things are not looking very prosperous for the apes(1). That is just one way to look at the problem. Another reason humans are continuously invading the orangutan's habitat is the global need for resources. In principle, the term "habitat loss" is virtually synonymous with deforestation and to a certain extent logging. Logging for timber is the main reason for deforestation and consequently for orangutans losing their habitat. However, deforestation may also happen to make room for something else such as mining (e.g. bauxite), palm oil cultivation and gas extraction(11). In addition, forest may be burnt in preparation for oil palm plantations eliminating the possibility of reforestation(12).

The loss of habitat indirectly causes a great number of orangutan deaths. This can happen in various ways. First and foremost, it forces orangutans to flee into habitats that are very likely less suitable for their survival. At the rate this is happening, it is not hard to imagine that the little habitat that they will have left will become overcrowded. Many may die from starvation(13). Additionally, as orangutans are frugivores (fruit-eaters), deforestation will likely degrade their source of food(13). These examples are only a few of many on how habitat loss can cause depletion of orangutan populations.

There are not many reports that quantify the correlation between habitat loss and orangutan deaths. One study performed by *Meijaard et al* in 2017 has attempted to give some insight about the impact of deforestation rates as a result of palm oil cultivation on orangutan populations. They found that from 1999 until 2014, there has been a steady decline of orangutan populations at an annual rate

of 2% in areas that were deforested for palm oil cultivation(14). This is a very serious decline that makes the future of orangutans even more uncertain.

It is evident that orangutans have to endure a lot of pressure from humans. Fortunately, there have been good incentives from humans as well that aim to counteract the threats that are imposed on them. In the next chapter, I will present the two major strategies that are being applied in orangutan conservation: rehabilitation & reintroduction and habitat preservation. Subsequently, I will draw comparisons and formulate an argument on which method is the most efficient and cost-effective. Additionally, I will offer a suggestion on how I think the conservation of the orangutan should be handled and discuss how realistic the suggestion could be.

2 Conservation strategies

2.1 Rehabilitation & Reintroduction

The terms 'rehabilitation' and 'reintroduction' are sometimes used interchangeably in orangutan context, however they are two different things. *Beck et al* (2007) defines **rehabilitation** as "the process by which captive great apes are treated for medical and physical disabilities until they regain health, are helped to acquire natural social and ecological skills, and are weaned from human contact and dependence, such that they can survive independently (or with greater independence) in the wild"(15). In that same article, **reintroduction** is defined as "an attempt to establish a species in an area which was once part of its historic range, but from which it has been extirpated or become extinct"(15). Since 1995, Indonesian law has required rehabilitant orangutans to be released only to areas where no wild populations exist (unless out of absolute necessity)(16).

It is important to realize that though these terms are not synonymous, reintroduction to the forest is almost inconceivable without some form of rehabilitation, meaning they are intrinsically linked. Exceptions could be down to individuals that were already old and competent enough to survive on their own, however this is quite rare(16). The reason behind this is clarified further on in this paragraph.

Rehabilitation projects have been going on since the 1960s. The first rehabilitation center was established in 1961 in Sarawak, Malaysian Borneo. Many followed, with 1971 marking the establishment of the first rehabilitation center in Sumatra(17). In those earlier years, the primary goals of these rehabilitation centers were to establish self-sustaining populations in the wild, providing legal holding facilities for orangutans that were freed from illegal captivity (as pets) and enable these so-called ex-captives to resume independent forest life. Other conservation-based goals were secondary, such as supplementing supposedly depleted wild populations, promoting conservation funding and education as well as providing welfare for ex-captives(16). By the end of the 1980s, the goals of rehabilitation projects had somewhat refocused. Most notably, while the return of ex-captive orangutans to forest life remained central, supplementing wild populations did not. Since 1995, rehabilitants were only reintroduced into areas with no existing wild orangutan populations. Experts concluded that supplementing wild populations with ex-captives likely did more harm than good on them(16). It was interpreted that it put more stress on the wild populations who were probably already at their capacity limit. Moreover, the rehabilitants may also pose disease threats(16).

In total, twelve rehabilitation projects have been launched. Today, eight of those remain active (see figure 3) (16). All rehabilitation projects follow a general design that looks like this: ex-captives *arrive* at rehabilitation centers where they will be *nurtured* until they become independent. After this, they will be *released* back into the forest where their progress *post-release* is kept track of.

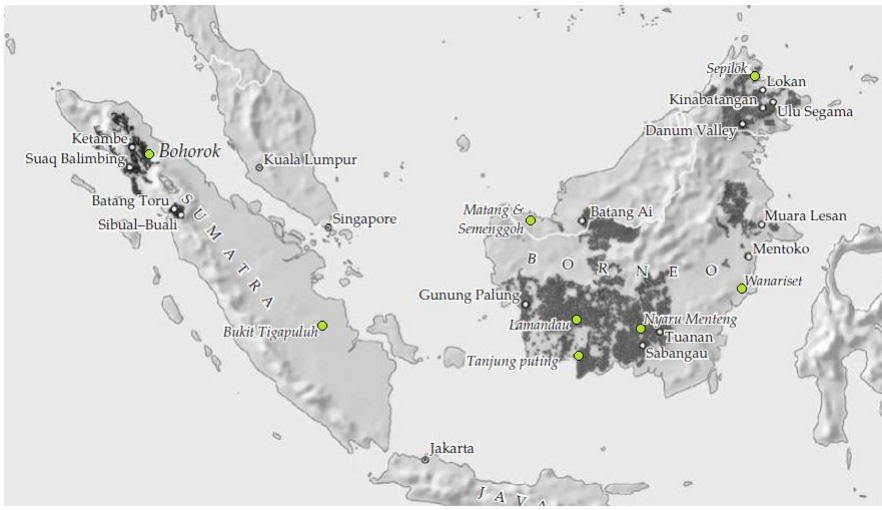

Fig 3. Orangutan rehabilitation centers and wild sites in Sumatra and Borneo. Those that are still active are highlighted in green (Source: *Russon et al, 2011*) (16)

Arrival stage

The duration of captivity varies widely among individual orangutans. Some ex-captives arrive in rehabilitation centers after years spent in captivity while others are welcomed only days after they were captured. Most arrivals are predominantly young, probably because infants are most attractive to have as pets(16). Captives arrive in a wide range of abusiveness level, but inadequate care under poor conditions is the most prevalent. Physical damage includes disability, wounds as a result of gunshots or chaining, paralysis, but also significant loads of parasites (nowadays, all newly arriving ex-captives are quarantined). Moreover, most of them deal with behavioral and psychological damage e.g. from physical and sexual abuse or from prolonged isolation as young infants. Additionally, many of them have become attached to humans and have acquired abnormal experiences that subvert them from survival competencies they should be having. It is for this reason that rehabilitation of ex-captives is almost always necessary, as these individuals just do not have the physical strength and the skillset to survive in the wild(16).

Nurture

In this phase, the orangutans are taught the necessary skillsets in order to survive in the wild. This behavioral rehabilitation has two essential dimensions, an ecological and a social one. In the former, the development of competencies for surviving independently in natural habitat (foraging, ranging, predator avoidance, nesting) is central. The latter aims to teach orangutans social competencies (relationships, social structures, communication etc.) and discourages involvement with humans (16,18). Typically, the nurture phase is divided into age-graded groups (e.g. "young infant", "juvenile", "adult"). Very young infants receive parent-like care from humans but care shifts to conspecifics as soon and as much as possible to prevent them from becoming too dependent and attached to humans(16).

Release

Orangutans are deemed ready when they have met certain criteria. Most importantly, they must have reached a suitable age, they must have acquired all age-appropriated survival competences and they must be indifferent or afraid of humans. If they pass, they become eligible for release. There are two release approaches that rehabilitation centers retain to: the voluntary approach and the formal approach. In the **voluntary** approach, the orangutans are rehabilitated in a forest that is already suitable to begin with but limits them to a 'learning area'. The definition of release in this case is that the candidates are allowed to disperse far outside the learning area. This approach has mixed results. While reports indicate that most orangutans have dispersed by adulthood, there are some who resist independence. Sometimes individuals had to be lured away by placing feeding sites far deeper into the forest(16). In the **formal** approach, the chosen individuals are transferred to

forests far from where they were rehabilitated. There are also two options here: most releases are soft, in that there is still little provision and support some period after release, but sometimes centers use hard releases where no provision is given at all. This approach, especially the hard one, has been criticized for possibly creating social and ecological stressors that would seriously deteriorate survival chances(16).

Post-release analysis

Post-release monitoring is the only way to keep track of individual progress, discover potential shortcomings and to analyze success. Post-release analysis is met with mixed results, mostly because it is extremely difficult with orangutans. Their lifestyle is slow and semi-solitary, and their distribution wide (16). Additionally, expensive advanced equipment (e.g. telemetric devices with extremely strong transmitters and long lasting batteries) is necessary to effectively monitor orangutans(16).

Review

Rehabilitation & Reintroduction has many benefits, most obviously providing welfare for ex-captives and training them for a return to forest life. In addition, they are being reintroduced into areas from which they went extinct in the first place. Benefits that are side effects of rehabilitation programs are protection of habitat by legal conservation status, increased public awareness which attracts large financial support and improved enforcement of protection laws.

However, this strategy also has some major drawbacks. First of all, it should be clear that rehabilitation is an extremely costly procedure. It requires a lot of time, effort and money to nurture these apes into an independent lifestyle. On top of that, it is not always successful. Sometimes the orangutans may never recover from their experiences as captives, both physically and psychologically. It has even led to a pretty unique additional problem, in that rehabilitation centers are becoming overcrowded with orangutans ineligible for return to free forest life(16). Additionally, the success of rehabilitation is very difficult to measure. As discussed, post-release monitoring is not up to par to gather the results necessary to give a formal answer on successes. The equipment needed is too expensive and not there yet, and with the slow lifestyle of orangutans it becomes very arduous(16). One problem that exposes this strategies' weakness is that after reintroduction, the orangutans may still be vulnerable to the main threats. Rehabilitation & reintroduction focuses on making up for the orangutan losses owed to hunting and habitat loss. Its main concern is not to directly tackle the source of the problem, thus it allows the problem to still thrive. To be fair though, it has helped indirectly by stimulating enforcement of protection laws and a bit more directly by providing legal conservation status(16). However, this applies exclusively to forest that is set aside as legally protected. Another drawback is that rehabilitants could pose a disease threat for wild populations however chances of this happening are quite small, as rehabilitants are released only into areas where no orangutan populations exist(16).

One particular problem that deserves its own paragraph is tourism. On one hand, tourism is recognized as a factor that holds back the effectivity of rehabilitation(16). Where rehabilitation aims to discourage orangutans from interacting with humans, tourism may counteract this process. The concern lies in the fact that tourism is increasing. The government of Indonesia even ordered several rehabilitation centers to be closed from the public because they had become overrun with tourists(1). Some rehabilitation centers are still closed to the public(19). On the other hand though, tourism is beneficial to conservation as it offsets some costs of orangutan rehabilitation. For some projects, tourism remains their main source of income(16). So, while the concerns for the negative effects of tourism are justified, so too are its benefits.

2.2 Habitat Preservation

As opposed to reintroduction, habitat preservation focuses on persisting wild populations. *Wilson et al* (2014) defines habitat preservation as "to ensure that the quantity and quality of habitat remains sufficient for long-term population viability, without necessarily requiring that an area is legally set aside for conservation"(20). Before getting into examples, it should be stressed again that habitat loss is virtually synonymous with deforestation. To get a full understanding on how we must deal with deforestation, we must clarify the causes. Deforestation is roughly categorized into three proximate causes: agricultural expansion (AGRO), wood extraction (WOOD) and infrastructure extension (INFRA).(21)

AGRO

Agricultural expansion includes all forms of agricultural cultivation and cattle ranching. The most relevant cultivation for orangutan habitat is definitely the cultivation of palm oil (see figure 4). There is great global demand for palm oil, mainly as cooking oil and potential biofuel. It is estimated that 55% of palm oil expansion between 1990 and 2006 came at the expense of natural forest, of which much used to be prime orangutan habitat. In absolute numbers, this would be close to 25,000 km^2(22).

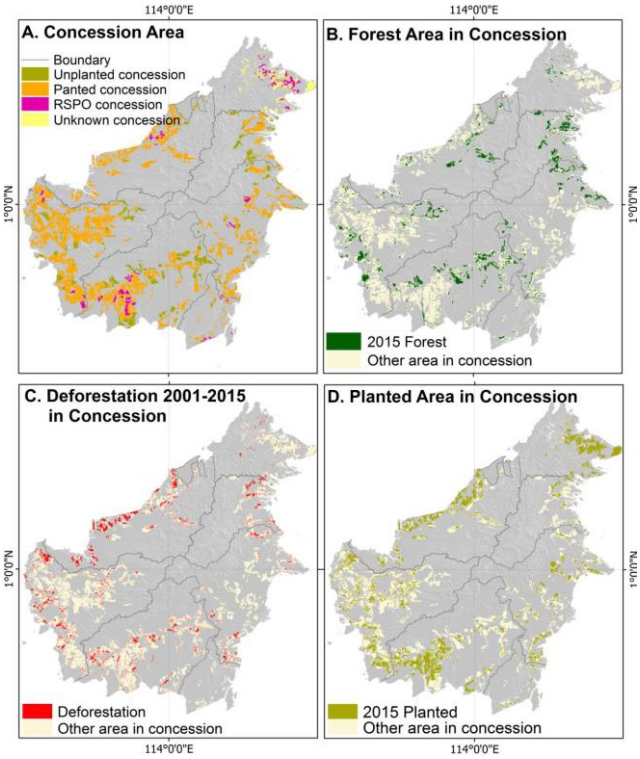

Fig 4. Palm oil concessions on Borneo. All zones are highlighted in A). Areas that were cleared of forest due to concession are highlighted in red in C). (Source: *Meijaard et al, 2017*) (14)

In the context of palm oil, conservationists take an interest to counteract economic factors that may bias against habitat preservation. Preservation of habitat is conflicted with so-called "opportunity costs", which are the profits that could have been made if a certain area was converted to more profitable crops (in this case, palm oil). It is a function of the size of cultivatable area, palm oil yield and profitability of palm oil – which is essentially dependent on the market price(22). A typical Malaysian palm oil plantation can rake up between US$528 and US$790 profit per ha per year(22). To outbid this expansion, orangutan conservation must be able to generate benefits that can compete with this. Unfortunately, apart from tourism, the orangutan in itself has little direct use value. In fact, tourism is generally accepted as detrimental to orangutan survival, so much that also certain habitats have been made inaccessible for tourists(16). The best position that conservationists can take here is to either to lower the opportunity costs of palm oil expansion, deflect expansion off or to protect primary rainforest. Here are a few examples of how conservationists try to achieve this.

Conservationists have tried to deflect expansion off of orangutan habitat by suggesting that non-forested lands could be used for cultivating oil palm. *Imperata cylindrica* grasslands have been noted as alternatives(22). Things to consider are the quantity of grasslands that is available, the suitability of grassland for palm oil cultivation, the hindrances and definitely how it can be motivated. Unless an edge in profitability can be shown, the conservation of orangutans is most likely not enough motivation. Especially considering there are some major drawbacks. Because *Imperata* is flammable, the ground must be prepared very intensively to weed out all grass from the soil. A further obstacle to grasslands is that there may be a number of claims over them. Claims are laid more often on low altitude grasslands than on forests(22).

Another way to deflect expansion off is by increasing the per-hectare oil palm yield. It is presumed that this lessens pressures to open up newer lands. On average, the annual yield of palm oil amounts to under 4 tonnes/ha. The theoretical yield is claimed to be 18.6 tonnes/ha, a yield% of 21% meaning there is big room for improvement, a fact that has been recognized by the industry(22). Yields can be increased by using higher-yielding and resource-efficient seedlings and by improving plantation operations like harvest time, fertilizer quantity (and quality) and actively replanting to replace older palms(22). Overall, this means labor becomes more burdensome but it is definitely in the interest of plantation owners as well. Still, there are some complications to this. Very high yields are not realistic, plus it is highly dependent on the quality of the soil. Therefore, yield improvements may not be very uniform. Moreover, smaller private enterprises may not have the resources to make these changes a reality. All in all, it is difficult to state that palm oil yield augmentation can significantly diminish the rate of oil palm expansion. In fact, reports of palm oil yield increases may also tempt more entrepreneurs to invest into palm oil cultivation.

Conservationists have also considered taking advantage of REDD to compete with the palm oil industry. REDD stands for "Reducing Emissions from Deforestation and Degradation" and is an initiative of the UNFCCC (United Nations Framework Convention of Climate Change) to mitigate climate change by reducing net emission of greenhouse gasses(23). One of the most direct and cost-effective ways to achieve significant emission reduction is by preventing tropical deforestation(24). To put it simply, REDD is a way in which countries (usually developed) can pay other countries (usually undeveloped) to *not* cut down their trees. This payment can be done in the form of so-called "carbon credits", which is basically a permit that allows the party that holds it to emit a certain amount of greenhouse gasses. One carbon credit is equal to the emission of one ton of carbon dioxide(25). To put it in an example, Indonesia may have a budget of 1M carbon credits. The Netherlands is willing to buy 100k carbon credits and pays Indonesia a sum of money that is equal to the market value of 100k carbon credits at that time. Indonesia now holds 100k carbon credits less than it originally did. So, it must now conserve a forest area that is equal to 100k carbon credits. Thus, REDD can be regarded as a 'carbon market'. If Malaysia and Indonesia would take this initiative by heart, the habitat of major orangutan populations could serve as node points for REDD investment. In other words, prime orangutan habitats can be conserved by REDD (22). The essential part of this strategy is that REDD must be economically attractive. If the price of palm oil increases relative to the price of carbon credits, REDD will probably be less attractive. However, I think this strategy can be useful for conservation –if implemented correctly- as it could stimulate protection of forests by the governments.

WOOD

The extraction of timber is by far the greatest cause of habitat loss. Some 29% of orangutan habitat in Kalimantan is allocated to timber(11). Conservationists usually take one of two paths to combat wood extraction: reforestation or protection.

One of the most prominent solutions to deforestation is sustainable logging (a.k.a. sustainable forest management (SFM), reduced-impact logging (RIL)). The general idea of SFM is that logging is performed according to strict protocol and the depletion of timber is compensated for by reforestation. These protocol regulations include government-mandated cutting cycles, minimum felling diameters and per-unit-area harvest intensities(26). Other than the obvious benefit of growing back what was lost, the revenues made from timber logging can offset some of the opportunity costs. However, not everyone agrees that SFM is a (cost-)effective strategy for forest conservation. Many doubt its effectiveness for fair reasons. Due to the long life spans and slow growth rate of tropical hardwoods such as timber, losses can only be compensated after decades

(26). Even then, multiple studies also concluded that, even with SFM, most timber species will deplete hard within three cutting cycles. Furthermore, regeneration forest is known to be driven by small-scale disturbance dynamics of randomly occurring canopy gaps. In other words, for forest to be able to re-grow, there must be a specific amount and distribution of canopy gaps. If this is not the case, growth will strongly favor rapidly growing light-loving vines that easily outcompete slower-growing species(26). It is presumed that this canopy gap-specific growing condition is achievable if SFM occurs at low harvest intensity. Unsurprisingly, logging as it stands now happens at two to three times higher intensity, so the chances of the industry embracing such a large cut is minimal(26). This gives the idea that SFM is not an effective strategy at all but this is the wrong assumption. SFM being insufficient as it is implemented and enforced right now would be a more fitting description. It is a step in the right direction, but it requires a lot of improvements.

Protection of the forest can be tackled through a way that was already mentioned, by utilizing REDD schemes. Another way that appears to be very effective is active protection(27). In response to similar programs being spawned in Sumatra for rhino and tiger protection, the Orangutan Protection and Monitoring Unit (OPMU) was established in 2003 whose task is to regularly patrol forest habitat in order to prevent forest crimes (e.g. illegal logging, mining, hunting). Although conservation of orangutans is central, they also focus on combating illegal loggers and other intruders as they are well aware of their negative impact. OPMU activities in Gunung Palung National Park (GPNP) from 2004 to 2007 proved to be very successful in that there was a noticeable decrease in forest crimes(27). When OPMU is confronted with forest crimes, they always take firm action. This includes confiscation and destruction of illegal materials, legal notification and keeping out intruders. Such "on-the-spot" prosecution has been effective in a direct and an indirect sense – offenders are significantly deterred from entering the park. This does bring up an issue that was recognized, namely that its reach is limited to GPNP. Therefore, OPMU teamed up with Province Nature Conservation Agency (BKSDA) in 2006 to respond to critical orangutan habitat outside the Park(27). Indeed, there are limitations to OPMU. The OPMU team is only able to react to "on-the-spot" offenses. Nevertheless, such actions against forest crime appear to be very effective(27). Another limitation is that OPMU can only be effective in forest habitat that has not been tainted yet, mostly at high altitude. At low altitudes where much area is already converted and settlements are more common, OPMU cannot be as effective. Finally, OPMU requires personnel that must be trained. However, this could also be interpreted as a chance for job openings. Overall, active protection of the forest has a phenomenal impact on orangutan conservation and is reasonably cost-effective(20).

INFRA

Infrastructure includes (rail)roads, private and public settlements, public services such as water & sanitation facilities and mining. Except for mining, most examples of infrastructure do not interfere with orangutans at a substantial level. Even then, the impact of mining pales in comparison to the overall area used for timber extraction(11).

Again, previously mentioned tactics can restrain the intensity of mining. REDD can protect forest from extractive industries such as mining whereas OPMU can prosecute illegal mining to a certain extent. However, mining in comparison to timber has unveiled another problem. Whereas the timber industry has a long history of trying to implement sustainable forest management, the mining industry appears to be much less regulated(11). It is probable that mining is not considered a problem as much as wood extraction is. The first step to containing the mining industry should be to provoke more involvement of the government. Spreading public awareness may trigger the government to act by, for example, imposing more regulations, stricter concessions and sanctions

for those who choose to ignore regulations (and rewards for good management). This approach is purely theoretical and ultimately comes down to willingness of the government to treat this as a problem.

2.3 Overview

In this section, the pros and cons of rehabilitation & reintroduction and habitat preservation are summarized in tables 1 and 2 respectively. In section 2.2 "habitat preservation", several methods were discussed that all share a common goal: to preserve forest (thereby indirectly aiding orangutan conservation). Each method has its own strengths and weaknesses, but table 2 reviews the pros and cons of habitat preservation as a whole and considers the individual methods only in general.

Table 1. Overview of the pros (left) and cons (right) of rehabilitation & reintroduction

Rehabilitation & Reintroduction	
+ survival and welfare for ex-captives	- extremely costly
+ increased public awareness	- not always successful
+ habitat protection (legal conservation status)	- success is very difficult to measure
+ reintroduction into areas from which they went extinct	- orangutans could still be vulnerable to the main threats after release
+ improved enforcement of protection laws	- rehabilitant could pose disease threat for wild population
	- tourism is often the main source of income, but it is also recognized as a problem for orangutan rehabilitation

Table 2. Overview of the pros (left) and cons (right) of habitat preservation

Habitat preservation	
+ long term cost-effective strategy for orangutan conservation	- willingness to comply to sustainable measures is often down to its ability to generate income. Generally speaking, the revenues from extractive industries are higher than sustainable/alternative methods and habitat preservation
+ habitat protection (sustainability and active protection)	- sustainable methods usually require more effort to implement
+ sustainable management of natural resources (timber)	- imposed measures on extractive industries are difficult to enforce
+ revenues from SFM offsets some opportunity costs	- regrowth of forest takes decades and is highly dependent on canopy characteristics that only occur at low intensity harvest
+ preservation of forest significantly reduces greenhouse gas emission resulting in increased control over climate change	- reach is only limited to areas that are not tainted yet (those that can still be preserved)
+ positive impact on business image	

3 Discussion

To summarize, orangutan conservation can be approached two ways: rehabilitation & reintroduction (R&R) and habitat preservation. R&R has the benefit of providing care for orangutans that were freed from captivity and releasing them in suitable areas where no orangutan populations are present, but struggles in cost-effectiveness as it takes a lot of time and effort while success is not guaranteed. In addition, R&R fails to directly tackle the source of the problem head on as opposed to habitat preservation, the second option. We have established that there are many

examples of how habitat can be preserved, but not every method is as realistic and/or effective as desired. There are a couple of stand-outs however, notably active protection of forests (through organizations like OPMU) and conservation through REDD schemes. OPMU's firm and direct approach shuns ill-doers from performing illegal activities in the forest, however it is limited to the areas they oversee and is limited to "on-the-spot" reactions. On the other hand, REDD can tempt governments to involve themselves in forest conservation by earning carbon credits. The catch is that these carbon credits must be able to compete with revenues garnered from extractive industries such as palm oil. Lastly, sustainable logging deserves a mention as a way to compensate for lost forest, though the way it is implemented as of now is not sufficient.

It is evident that both strategies have their pros and cons and honestly neither strategy is optimal under all circumstances. However, when it comes to overall effectiveness and cost-effectiveness, protection of habitat appears to be the better strategy for orangutan conservation. Protection of forest is a long term strategy. Reintroduction seeks to increase wild populations of orangutans by releasing them into areas where they have vanished. However, this procedure is twelve times more expensive than protection (per orangutan), meaning that less orangutans can be protected for the same budget(20). *Wilson et al (2014)* established that protection is a more cost-effective strategy when the timescale is greater than 10 to 20 years(20).

Then, should we turn our backs to R&R and solely focus on habitat preservation in the name of orangutan conservation? I think we should not. R&R is still effective as a short term strategy and brings other benefits to the table that habitat preservation does not. More importantly, some of these benefits seem to complement each other. First of all, while R&R provides welfare for the ex-captives of now and aims to release them (short term), habitat preservation aims to ensure the persistence of suitable habitat for orangutans now and generations to come (long term). Moreover, one of the criticisms to R&R has been that ex-rehabilitants are still exposed to threats after release – something R&R itself does not prioritize. However, these threats can be reduced by the various methods of habitat preservation. Reversely, habitat preservation does not necessarily focus on diminishing hunting of orangutans (except for OPMU), but R&R has by incidentally having spread a lot of public awareness and aiding in enforcement of protection laws. On the basis of these conclusions, I propose the following.

As it stands, R&R has a higher budget to work with than protection because rehabilitation centers receive substantial revenue from tourism and because of their charity-like nature(20). If it were at all possible that these principles could join forces in the name of orangutan protection and thereby merge their budgets or if we are just talking about government funding, I think it would be wisest to allocate the majority of the budget (~60%) into habitat protection. More specifically, into organizations like OPMU and those similar and perhaps even as a reward for REDD management to compensate for opportunity costs. This way, we prioritize orangutan conservation in the long term. The habitat that is saved by habitat preservation can sustain wild populations that were already living there and it can operate as areas where ex-rehabilitants can be released if wild populations were not present. In the meantime, R&R can focus on reintroducing orangutans mostly in their legally conserved forests but if necessary, reintroduce them formally into areas under habitat protection. In addition to the aforementioned preservation tactics, it may be wise to still introduce sustainable logging to areas where legal logging was happening anyway. Though its effectiveness is still something to be desired, doing nothing will get us nowhere. Since cutting cycles take around 20-30 years and really start to deteriorate after three cycles, there is plenty of time in between to improve sustainability. *Wilson et al* (2014) adds to this idea by also suggesting protection

against hunting in these logged areas, claiming this would be an intermediate strategy to R&R and habitat preservation(20).

Of course, these suggestions will always create divisions, with parties either in favor or against the proposition. Undoubtedly the most important party involved, the governments of Indonesia and Malaysia (hereafter: GOIM), may want to take interest in funding. The orangutan is not just an ape that happens to inhabit the forests of Indonesia and Malaysia, it is an icon that is inextricably linked with the identification of these countries as well as conservation itself. Besides, the forests of Sumatra and Borneo are the only places in the world where these apes naturally exist. The orangutan's low profitability is likely what shuns GOIM from putting in more effort and money, however this might become more attractive through REDD. This brings us to our next party with interests, the state members of the UNFCCC. Whether REDD can compete with extractive industries is entirely dependent on how much value industrialized (developed) countries put on greenhouse emissions. Personally, I am not convinced yet that the developed countries in their current political state are willing to invest into carbon credits. In recent years, the frequency of REDD meetings has gone downhill since 2015 up to the point that the last meeting was in February 2018 – the first meeting after a hiatus of one and a half year. To put this into perspective, each year before 2015 (2008-2015) there were at least 20 meetings per year. The interest in the project REDD seems to have faded, but there may be hope. Political situations are dynamic and may turn around for the better of the climate, plus with how fast the climate changes nowadays interest may rise once more. On top of that, as of 2020, forestry credits will be re-included in the E.U.'s emission trading scheme after dropping out in 2005(REDD+ website, 2020).

Then come the conservationist parties, the rehabilitation centers and forest protectors like OPMU. It is highly likely that a rehabilitation center would waive at the thought of being the highest 'shareholder' of a joint budget and seeing most of it being allocated to OPMU. I already deemed a joint budget to be very unlikely and assumed this would not be an option. Now imagine, if the GOIM were to assign a certain sum to orangutan conservation and would allocate it between the two parties in my suggested proportion that favors forest protection (e.g. ~60% OPMU, ~40% R&R). OPMU will probably feel advantaged whereas rehabilitation centers will be the disadvantaged party. To this I can only say, I understand. From an animal welfare perspective, rehabilitation centers are most valuable and I support their cause whole-heartedly. From a conservation perspective however, habitat protection and management is more valuable. In the end, does that not align with the cause of rehabilitation centers? Rehabilitation centers are a great way to provide welfare for orangutans that have undergone a lot of suffering, but I also believe we should put aside the emotive aspects just a little for the long-term conservation of wild orangutans. So, for the sake of conservation, I ask rehabilitation centers to understand and accept that fund allocation for orangutan conservation should focus on habitat preservation.

Some considerations

The fact that orangutans are threatened has many underlying causes. I want to shine light on one particular reason that is very relevant to the outcome of any conservation plan, including mine: corruption. Weak compliance with regulations and laws, weak enforcement of conservation laws and a weak legislative system allow hunting and habitat loss to happen almost unrestrained. The ultimate underlying cause of these factors lies in corruption(28). Indonesia has dealt with a lot of corruption since the birth of this relatively young nation and still suffers for it(29). So does the orangutan. Unless real measures are taken into rooting out this problem, any form of conservation is futile. It speaks volumes that we have to rely on charity organizations such as rehabilitation centers to take a stand for orangutans.

Something to consider for conservationists that was purposefully ignored in this thesis is to realize that we are dealing with three different species with a geographical isolation. Orangutans in Sumatra deal with and require different conditions than orangutans in Borneo. For example, unlike Borneo, Sumatra has been the playground of much civil unrest since the 2000s. This has had impact on orangutans as well, as illegal activity came at an all-time high during this time(4). In addition, conservationists may want to consider habitat conditions of each island to increase chances of survival. For example, orangutans on Sumatra will have to deal with tigers whereas orangutans in Borneo will not. To increase survival chances of ex-rehabilitants, it would be in the interest of Sumatran rehabilitation centers to make them aware of this danger and how to cope with it. For example, by teaching them to forage in trees as much as possible. On the other hand, weather conditions are usually harsher on Borneo compared to Sumatra(1). Perhaps Bornean rehabilitation centers should apply stricter physical requirements for release than Sumatran rehabilitation centers.

Another thing to consider is the following: *Marshall et al* (2009) assesses that risk of extinction is influenced by many factors e.g. small population size, large body mass, slow reproductive rate, limited geographic range and frugivorous diet(10). Unfortunately, the orangutan qualifies for all of them. In other words, these species already have some degree of intrinsic probability of extinction. It is in no way surprising that all orangutan species are listed as Critically Endangered by IUCN (IUCN, 2020) and serious measures need to be taken quickly if we ever wish to conserve this unique, iconic distant relative of ours. Whether everyone is willing to put their hands into this? To end it with a cliché, only time will tell.

4 References

1. Rijksen H, Meijaard E. Our vanishing relative. 1999;(90):25–6.
2. Nater A, Mattle-Greminger MP, Nurcahyo A, Nowak MG, de Manuel M, Desai T, et al. Morphometric, Behavioral, and Genomic Evidence for a New Orangutan Species. Curr Biol. 2017;27(22):3487-3498.e10.
3. Reese A. New orangutan species identified. Nature [Internet]. 2017;551(7679):151. Available from: https://search.proquest.com/docview/1963073556?accountid=44396
4. Singleton I, Wich SA, Husson S, Atmoke SU, Leighton M. Population and Habitat Viability Assessment, Final Report. J Chem Inf Model. 2004;53:160.
5. Wich SA, Meijaard E, Marshall AJ, Husson S, Ancrenaz M, Lacy RC, et al. Distribution and conservation status of the orang-utan (Pongo spp.) on Borneo and Sumatra: How many remain? Oryx. 2008;42(3):329–39.
6. Pandong J, Gumal M, Aton ZM, Sabki MS, Koh LP. Threats and lessons learned from past orangutan conservation strategies in Sarawak, Malaysia. Biol Conserv [Internet]. 2019;234(September 2018):56–63. Available from: https://doi.org/10.1016/j.biocon.2019.03.016
7. Meijaard E, Wich S, Ancrenaz M, Marshall AJ. Not by science alone: Why orangutan conservationists must think outside the box. Ann N Y Acad Sci. 2012;1249(1):29–44.
8. Harrison RD, Sreekar R, Brodie JF, Brook S, Luskin M, O'Kelly H, et al. Impacts of hunting on tropical forests in Southeast Asia. Conserv Biol. 2016;30(5):972–81.
9. Meijaard E, Buchori D, Hadiprakarsa Y, Utami-Atmoko SS, Nurcahyo A, Tjiu A, et al. Quantifying killing of orangutans and human-orangutan conflict in Kalimantan, Indonesia. PLoS One. 2011;6(11):1–10.
10. Marshall AJ, Lacy R, Ancrenaz M, Byers O, Husson SJ, Leighton M, et al. Orangutan

population biology, life history, and conservation: Perspectives from population viability analysis models. Orangutans Geogr Var Behav Ecol Conserv. 2009;311–26.

11. Meijaard E, Wich S. Extractive industries and orangutans. Occas Pap State Apes Extr Ind Ape Conserv. :1–47.
12. Wich SA, Singleton I, Utami-Atmoko SS, Geurts ML, Rijksen HD, Van Schaik CP. The status of the Sumatran orang-utan Pongo abelii: An update. Oryx. 2003;37(1):49–54.
13. Husson SJ, Wich SA, Marshall AJ, Dennis RD, Ancrenaz M, Brassey R, et al. Orangutan distribution, density, abundance and impacts of disturbance. Orangutans Geogr Var Behav Ecol Conserv. 2009;77–96.
14. Meijaard E, Morgans C, Abram NK, Ancrenaz M. An impact analysis of RSPO certification on Borneo forest cover and orangutan populations Executive summary. Borneo Futur. 2017;1–38.
15. Beck B, Walkup K, Rodrigues M, Unwin S, Travis D, Stoinski T. Best practice guidelines for the re-introduction of great apes. Best practice guidelines for the re-introduction of great apes. 2007.
16. Russon AE. Orangutan rehabilitation and reintroduction: Successes, failures, and role in conservation. Orangutans Geogr Var Behav Ecol Conserv. 2009;327–50.
17. Lardeux-Gilloux I. Rehabilitation centers. Neglected Ape. 1995;61–2.
18. Rijksen HD. A Field Study on Sumatran Orang Utans (Pongo pygmaeus abelii, Lesson 1827). Q Rev Biol. 1978;53(4):493–4.
19. Smits WTM, Heriyanto, Ramono WS. A new method for rehabilitation of orangutans in Indonesia. Neglected Ape. 1995;69–77.
20. Wilson HB, Meijaard E, Venter O, Ancrenaz M, Possingham HP. Conservation strategies for orangutans: Reintroduction versus habitat preservation and the benefits of sustainably logged forest. PLoS One. 2014;9(7).
21. Geist HJ, Lambin EF. What Drives Tropical Deforestation? Biol Lett. 2009;5(2):207–10.
22. Swarna Nantha H, Tisdell C. The orangutan-oil palm conflict: Economic constraints and opportunities for conservation. Biodivers Conserv. 2009;18(2):487–502.
23. Griffiths T. Seeing "REDD"? Forests, climate change mitigation and the rights of indigenous peoples and local communities. 2008;(December).
24. Laurance WF. Can Carbon Trading Save Vanishing Forests? Bioscience. 2008;58(4):286–7.
25. Fairbairn EMR, Americano BB, Cordeiro GC, Paula TP, Toledo Filho RD, Silvoso MM. Cement replacement by sugar cane bagasse ash: CO2 emissions reduction and potential for carbon credits. J Environ Manage [Internet]. 2010;91(9):1864–71. Available from: http://dx.doi.org/10.1016/j.jenvman.2010.04.008
26. Zimmerman B, Kormos C. Prospects for Sustainable Logging in Tropical Forests. Bioscience. 2012;62(5):479–87.
27. Sugardjito J, Adhikerana AS. Measuring Performance of Orangutan Protection and Monitoring Unit: Implications for Species Conservation. Indones Primates. 2010;9–22.
28. Yarrow Robertson JM, Van Schaik CP. Causal factors underlying the dramatic decline of the Sumatran orang-utan. Oryx. 2001;35(1):26–38.
29. Robertson-Snape F. Corruption, collusion and nepotism in Indonesia. Third World Q. 1999;20(3):589–602.