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ORANGUTAN CONSERVATION SERVICES PROGRAM

ORANGUTAN MANAGEMENT

OUTSIDE PROTECTED AREAS

Background information on orangutan ecology and habitat in disturbed forests and plantations.

Cover photograph: The orangutan is the only extant hominoid to display bidiscoid cheek flanges or pads. The development of the cheek pad is temporally variable and its function remains speculative.

DONALD BASON

ORANGUTAN CONSERVATION SERVICES PROGRAM

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Background information on orangutan ecology and habitat in disturbed forests and plantations.

November 2009

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USAID Contract:
497-C-00-07-00016-00

This publication was produced for review by the United States Agency for International Development. It was prepared by DAI - the implementing contractor for the Orangutan Conservation Services Program.

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ORANGUTAN MANAGEMENT OUTSIDE PROTECTED AREAS




This report provides background information on orangutan ecology and how the species copes with the ecological conditions in disturbed forests and plantations.

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This is one of a number of booklets on Orangutan Best Management Practices. Other publications in the series include Management of Orangutan Habitat and Populations for Natural Forest Concessions; Oil Palm Plantations; Mining Concessions; and an Executive Summary for Senior Managers.

Abbreviations

AMDAL	*Analisis Mengenai Dampak Lingkungan* (Environmental Impact Assessment)
BKSDA	*Balai Konservasi Sumber Daya Alam* (Provincial Office of the Directorate of Forest Protection and Nature Conservation within the Ministry of Forestry)
BMP	Best Management Practice(s)
CITES	Convention on International Trade in Endangered Species
CoW	Contract of Work
CR	Critically Endangered
CSR	Corporate Social Responsibility
DAI	Development Alternatives, Inc.
EIA	Environmental Investigation Agency
EU	European Union
GIS	Geographical Information System
GoI	Government of Indonesia
GRI	Global Reporting Initiative
HCVF	High Conservation Value Forest
ICMM	International Council on Mining and Metals
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
KPC	KalTim Prima Coal
KNP	Kutai Nasional Park
MCE	Multiple Criteria Evaluation
MoU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NGO	Non-governmental Organization
OCSP	Orangutan Conservation Services Program
PA	Protected Area
PELTHR	Project, Environmental, Land Tenure and Heritage Review.
PHKA	*Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam* (Directorate of Forest Protection and Nature Conservation within the Indonesian Ministry of Forestry)
PHVA	Orangutan Population and Habitat Viability Assessment
RSPO	Roundtable for Sustainable Palm Oil
PSSF	Private Sector Sustainability Facility
RIL	Reduced Impact Logging
RKL	*Rencana Pengelolaan Lingkungan* (Environmental Management Plan)
RPL	*Rencana Pemantauan Lingkungan* (Environmental Monitoring Plan)
RTRWP	*Rencana Tata Ruang Wilayah Propinsi* (Provincial Land Use Plan)
SOP	Standard Operating Procedure
SUMUT	*Sumatera Utara* (North Sumatra)
TM	Topographic Map
TPTII	*Tebang Pilih Tanam Indonesia Intensif* (Indonesian selective cutting and intensive planting system)
U.K.	United Kingdom
USAID	United States Agency for International Development

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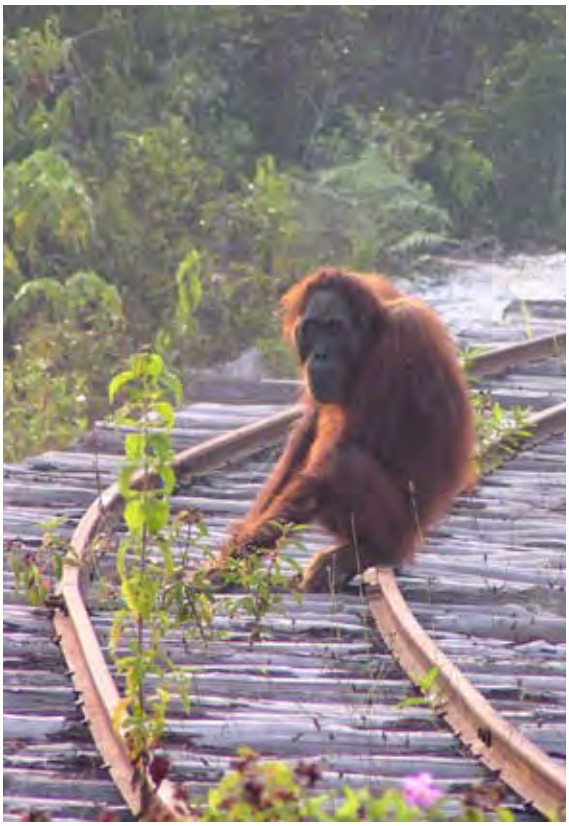
The Sumatran orangutan - *Pongo abelii* - is classified as Critically Endangered (CR) on the IUCN Red List 2007 and listed on Appendix I of CITES.

Executive Summary

Orangutans are among the most threatened large mammal taxa in the world, and the Sumatran species is thought to be the great ape species most likely to become extinct in the wild in the near future. Many are concerned about this, but few have found effective solutions that counter the causes of orangutan population declines. The problem of orangutan conservation is confounded by the fact that most orangutans live outside protected areas. Even though the animals themselves are protected by Indonesian (and Malaysian) law, their forest habitats can be legally degraded or converted as long as animals are not directly killed in the process. This has resulted in the rapid reduction of remaining orangutan habitats, and the animals in these increasingly small habitat patches are forced to survive on diminishing food resources. This situation leads to conflicts when orangutans feed on commercial crop species such as oil palm, acacia, or village fruit trees. In many situations these conflicts lead to the death of orangutans.

In this difficult conservation framework, the Indonesian government has committed itself to stop the decline of wild orangutan populations. By 2017, all remaining populations have to be stable. This also means that by 2017 all remaining populations have to be viable, because if they are not, they would further decline. The viability of a population is largely determined by its initial size (a minimum population size of 250 is often used), the availability as well as temporal and spatial variability of food resources, gene flow within the population, and birth and mortality rates. The commitment from the Indonesian government implies that all these factors have to be carefully managed to ensure that all populations are stable and viable by 2017. The question is how to do this.

SERGE WICH



In protected areas, management of orangutan habitat is relatively straightforward and firmly embedded within the Indonesian legal framework: forests are protected and hunting is prohibited, and the main concern is to ensure that these laws are effectively implemented.

Outside the protected area network, the situation is different. For example, how does one reconcile the legally licensed forest clearance for developing an oil palm plantation with the need to retain enough resources to ensure that orangutan populations don't dwindle? Apart from an obvious recommendation to refrain from converting orangutan forest habitat, there is little guidance to either government or industries regarding how their management and planning could be adapted to ensure that the government meets it 2017 commitment.

Orangutan conservation ultimately relies on improved management of forest habitats that is balanced with both social and economic development needs. Given that the majority of orangutans live outside of protected areas, private sector engagement is particularly important to achieve impact in biodiversity conservation.

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Juvenile orangutans are 1.5 to 2 kg at birth and remain under 25 kg for the first 6 to 7 years of their lives. Orangutan young have the longest immaturity of all apes lasting 9 to 12 years. A female orangutan reaches adulthood upon the birth of her first infant, around the age of 14 to 16 years old and she will normally give birth to only one offspring at a time. Baby orangutans stay with their mother for 7 to 8 years during which time she will not reproduce again. This slow reproduce rate results in fierce competition for males to find females and means that it can take decades to replace population loss.

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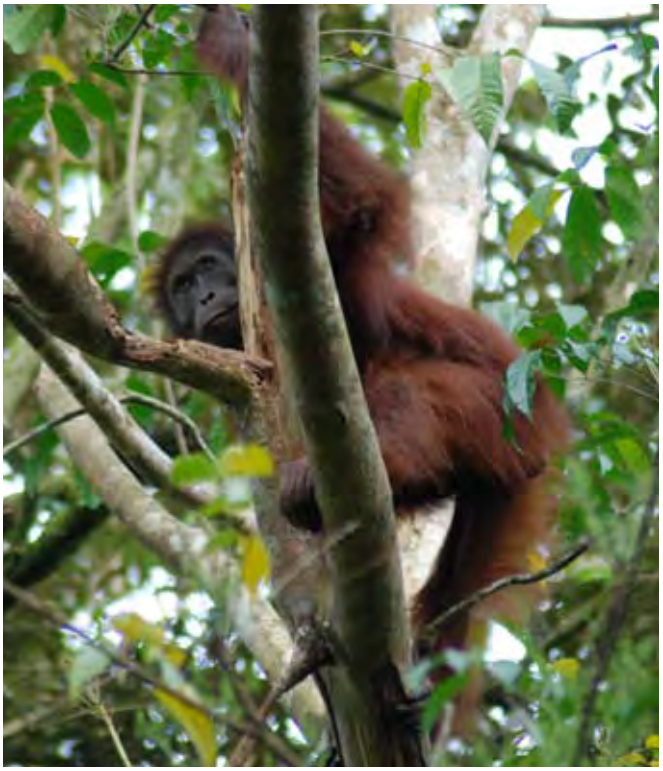

Orangutans are rarely seen in elevations that exceed 500 meters. In Sumatra, orangutans are entirely arboreal because of the large predators (such as tigers and leopards) that patrol the forest floor. Borneo contains fewer large predators so males will travel terrestrially and feed on the ground, but females will generally remain in the trees because of their smaller size.

Background Information on Orangutans

Orangutans (*Pongo* spp.) are confined to the islands of Borneo and Sumatra. Serious downward trends in the integrity of Indonesia's forest estate has occurred over the last two decades due to widespread logging and conversion for plantation agriculture, although protected areas were, in retrospect, left relatively unscathed. Since the change in government in 1998, however, conservation in Indonesia has seen a virtual collapse and deforestation has been enormous regardless of the legal status of the land. As a result, wild orangutans are in steady decline due to logging, habitat conversion, fires and poaching, and both the Sumatran and Bornean species are now considered to be highly threatened by extinction in the wild.

In its Indonesian Orangutan Action Plan the Indonesian government has committed itself to stabilizing all orangutan populations by 2017. That means that within the next 8 years all remaining populations and their habitats, both inside and outside protected areas need to be brought under management that ensures that their long-term viability. Considering the present rapid decrease in both habitats and populations, a rapid change is needed in management approaches of both protected as well as unprotected habitats.

Stabilizing the population by 2017 implies that each population that remains by 2017 is viable in the long-term (if it weren't viable it would eventually decline and thus cannot be termed "stable"). **Identifying the key requirements for population viability and maintaining these through good habitat and population management is therefore crucial for reaching the objectives of the Indonesian Action Plan.**

Population and habitat management will vary depending on the kind of use permitted in orangutan habitats. Within the protected area network, the management of populations is relatively straightforward: habitats need to be protected and sufficient food for orangutans guaranteed. An estimated 75% of all orangutans, however, occur outside the protected area network, mostly in natural forest timber concessions, planted forests and other plantations, agro-forestry lands, and other used forests.

The management of orangutan populations in such a way as to ensure their viability is a challenge for managers of production forests, mines and plantations, because there is little guidance on how such management needs to be done. Management requirements will vary with different land uses, e.g. an oil palm plantation that offers little in terms of orangutan food resources will need much more active management than a selectively logged natural forest where the habitat's carrying capacity can be relatively easily maintained through normal sustainable logging practices.

The question that any concession manager needs answered is what are minimum requirements of a viable orangutan population and how can these requirements be met in their concession.

General Orangutan Ecology

To understand the specific management needs of orangutans and their habitats one much first understand the ecological needs of the species. In their natural forest habitats, orangutans rely to a large extent on a wide range of fruit trees. These include species well known to people such as durian, rambutans, mangos, jackfruit, as well as a large number of forest fruit rarely seen on markets. Figs (*Ficus* spp.) are particularly important because of their year-round availability. In addition, orangutans consume the leaves, seeds and bark of various tree species, as well as a range of invertebrates, such as termites, or their products, like honey. Depending on the seasonal changes in local availability of these items, orangutans either choose to change their diet when certain preferred foods are not available, or they change their location and look for better foods elsewhere.

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Captive orangutan eating sugarcane. When orangutans are not resting or sleeping during the day, they forage for food. This is necessary because orangutans have a high caloric need and good quality food is not always readily available. Orangutans possess 32 teeth (the same number as in humans) and belong to a group of primates that crack open hard-coated fruits for food.

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Orangutans in Natural Forest Concessions

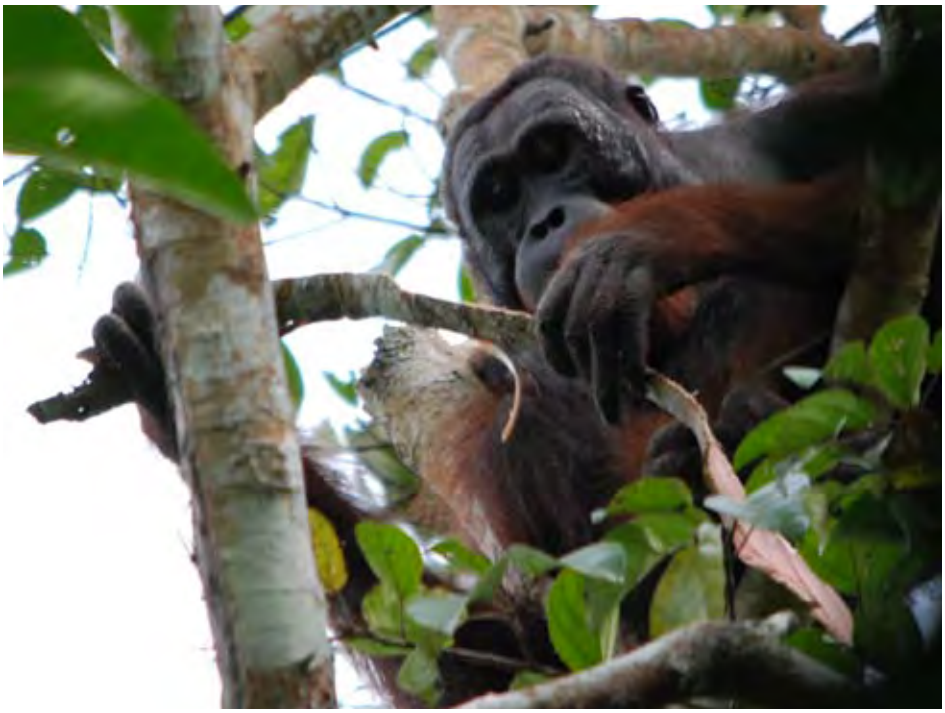
When forests are degraded through selective logging, the food availability can change dramatically. The extent to which this happens depends on several factors. If logging practices and concession infrastructure are poorly planned, high volumes of timber are extracted, and silvicultural treatments such as removal of strangler figs and lianas take place, the food resource base and structural characteristics of the forest (many gaps between trees) can have significant impacts on local orangutan densities. Following such logging practices, density declines of up to 30% have been reported in Kalimantan, and much higher ones on Sumatra. The severity of the decline will also depend to a considerable extent on whether logging crews were hunting orangutans during felling operations. Even where no hunting takes place, orangutans will tend to avoid logging crews and their activities and move away from active logging areas. They will eventually return to selectively logged forests if the local situation supports that, e.g., there are few or no people in the area, and fragmentation from roads and tracks is minimal. Once such forests are left alone, as they should be according to rotational felling guidelines, regrowth of fruiting pioneer species can also boost the food resource base and orangutan densities can bounce back to near or even more than original densities within one or a few years, assuming no hunting or other causes of increased mortality (disease, starvation, conflict with humans etc.) took place. Although, selective timber harvest seems to have a mildly negative impact on orangutan densities, especially for the ecologically and socially for sensitive Sumatran orangutan, it should be possible to retain medium-high densities in such forest to maintain viable orangutan densities, providing appropriate sustainable forest management practices are employed.

Within the Indonesian selective timber harvest regulations, concession-holders are legally required to repeatedly slash all undergrowth and climbers for several years after felling (such treatment is called 'liberation' and 'thinning'). The intention is presumably to control aggressive 'weeds' and encourage regeneration; in practice, though, this has a deleterious effect on many plant species, including rattan and timber seedlings, and may destroy important food items for orangutans. Although this issue requires further study, minimizing this practice should boost the carrying capacity of logged forests, without having much impact on forest regeneration.

New ideas to intensify the production of timber from natural forest concessions include a new system called TPTII. This involves clear cutting strips of forest and replanting these with commercial timber species. Generally orangutans make little use of the dominant timber species (mostly *dipterocarps*) and although the impact of TPTII on orangutans remains untested, it is expected that compared to normal **Reduced Impact Logging** (RIL) practices the negative impact on orangutan populations will be much more severe.

Orangutans in Soft Wood Plantations for Pulp and Paper Productions

The development of plantations for the production of pulp and paper generally involves the clearance of remaining forest and scrub vegetation, after which fast-growing trees are planted for the production of tree fibre. Such mono-cultural plantations generally offer little or nothing in terms of orangutan foods, effectively reducing the carrying capacity of such areas to zero. Some plantations, however, may provide food resources for orangutans, at least in the short term. The inner bark of *Acacia mangium*, for example, appears to provide significant nutritional value to sustain orangutan individuals, and animals appear to like the sugary taste of the tree sap. Unfortunately, because orangutans strip the bark and kill the trees when feeding on sap, this leads to crop losses and potential conflict with concession management. One pulp and paper company with *Acacia mangium* plantings reported that orangutans regularly feed on the bark of 2-3 year old trees and in the process kill trees in some 300 ha per year.



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Male orangutan stripping and eating bark. When fruit is scarce, orangutans will regularly eat leaves and bark and can do considerable damage within a plantation.

There are hardly any ecological studies of orangutans in tree plantations. One study investigated orangutan densities in *Acacia mangium* plantations and found remarkably high orangutan densities. Densities within planted areas could be 2 animals/km^2 or higher, which is not unlike the densities found in natural forests. This suggests that potentially an acacia plantation mixed with natural forest types with orangutan food species could sustain relatively high densities, although it is unclear whether these orangutan populations would be viable in the long term. Much remains to be learned however about how to best design and manage such landscapes, maximizing survival chances of orangutans and minimizing economic losses to companies (and surrounding communities), but it is likely that the more general food species and nest tree species are retained with the plantation matrix, the more resources there are for orangutans. Whether this would also reduce the extent to which orangutans destroy acacia stands is unknown.

Bark stripped from an *Acacia* tree in an East Kalimantan Pulp and Paper plantation. Orangutans frequently eat the inner bark of *Acacia mangium* trees as it appears to provide significant nutritional value to sustain them if there is little other food available.

Very little is known about orangutan survival in plantations of other crops, such as *Albizia falcataria*, or *Eucalyptus* spp. It is expected, however, that these trees provide less of a resource to orangutans than *Acacia mangium*. Records of significant bark stripping by orangutans in *A. mangium* suggest that the inner bark and likely sap provide the main food source for orangutans in these plantation concessions. The sap of *A. mangium* contains sugars, and these appear to be absent or less palatable in other tree crops. Further studies are needed to determine to extent to which orangutans use non-Acacia tree crops, and also the extent to which orangutans can survive in a matrix secondary forest and Eucalyptus and Albizia monolcultures.

Research is needed on tree species that fulfil both the company needs (fibre quality, growth rates, management costs etc.) and the orangutan needs (the extent to which plantation species provide resources for orangutans without killing the trees). Fast growing species that are used by orangutans include *Anthocephalus chinensis,* a softwood that provides good timber, orangutans eat mostly the inner bark but also fruits and use the tree a lot for nesting. *Dillenia* sp. (Simpor) used by orangutans on an irregular basis, but this species is easy to propagate and fast growing. *Pterocarpus indicus* (Bayur) provides good timber, orangutans eat the bark and fruit and use the trees as nesting sites.

The best way to find out which species best fulfill company and orangutans needs is to plant different species in plantation areas with orangutans and see which species are most used (with least damage to the trees) and provide the best and fastest producing fibre.

Planting trees for both fibre and orangutans addresses part of the problem of orangutans in tree plantations, although it runs the risk of creating more problems when orangutans and people have an interest in the same species. An alternative planting scheme might be a mixed plantation of taxa that are valuable for orangutan but not people, and taxa valuable to people but not orangutans. Either way, maintaining core conservation areas (as prescribed by Indonesian law), protecting riverine forests which are important for orangutans (also prescribed by Indonesian law), and maintaining a system of forest corridors between the different forest patches are likely to increase the carrying capacity of plantation-dominated landscapes, and this should be the highest priority for any plantation manager.

The highest value forests for orangutans would be those that have not been affected by any timber removal, and retaining such patches would be crucial for orangutans. This is however rare in plantation areas, many of which are established in former timber concessions, often with a history of high timber extraction rates. In such areas the remaining conservation areas and potential corridors are highly degraded and rehabilitating these areas is needed. Ideally such areas would be replanted with fast-growing orangutan forest foods (Table 1); this list is by no means complete and ideal planting/retaining schemes require additional research to ensure a good balance between growth rates, nutritional value, value as fall back food for orangutans, and also suitability for nesting. Plantation managers should seek advice on this from qualified orangutan experts.

Table 1: Examples of various fast growing species that provide foods for orangutans and should be planted/retained in conservation set-asides in plantations.

Species	**Use by orangutans**
Anthocephalus chinensis	Bark and fruits
Artocarpus spp.	Bark, fruits, and shoots (but trees are damaged by feeding). Jackfruit *(Artocarpus heterophyllus)* should be avoided to prevent conflict with people who also eat this fruit.
Vitex spp.	Shoots, bark
Dillenia spp.	Shoots, bark
Cananga odorata	Fruit/flowers; and preferred nesting tree
Pometia spp.	Some fruit eaten
Various gingers	Leaves
Palms and rattans	Bark, palm hearts. This includes *Borassodendron borneensis*, which is protected under PP NO. 7/1999, and is an important fall back resource for Bornean orangutans.
Ficus spp.	Fruits and inner bark

In general it would be best to not plant species that are also sought after by people, such as mangga (*Mangifera* spp.), rambutan (*Nephelium lappaceum*), or marketable durian (*Durio* spp.) species. When these species fruit they will attract both people and orangutans, and conflict is likely to occur. Such species may be brought in a later stage when the conservation of orangutans in the plantation matrix is generally accepted by local communities and company staff.

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Orangutans in Oil Palm Plantations

Oil palm *(Elaeis guinensis)* has been picked up by the media and many NGOs as the industry with the highest impact on remaining orangutan habitats. Whether that is true remains debatable, but planned oil palm developments potentially affect a significant part of the remaining orangutans. A recent study found that about 1 million ha of orangutan forest habitat are earmarked for oil palm development in Kalimantan. Given the estimated orangutan densities in the planned oil palm areas, those oil palm developments could eradicate the habitat of 9,800 orangutans (of which 7,400 are on mineral soils), or about 20% of Borneo's orangutans. From the available data it is not possible to calculate the uncertainty in this figure, but in our opinion the estimate of 9,800 affected orangutans is bounded by 95% confidence intervals of 7,350 and 12,500 (± 25%).

One problem with oil palm (from the orangutans' perspective) is that it offers very little food to orangutans after the palms have grown up from seedling stage. Orangutans that have no other food choices may target the palm hearts or growth points of young palm trees in new plantings or nurseries, causing significant damage. In such situations, and despite their legal protection, orangutans become quickly seen as pest species or potential danger to humans, and are either caught and translocated, or, more commonly, killed. The development of oil palm in extensive areas that still contain orangutan populations, and its perception as a pest animal, is one of the main reasons why oil palm plantations are seen as the main threat to populations outside (and sometimes inside) the protected area network.

Malaysia and Indonesia produce 87 per cent of the world's supply of palm oil. In Malaysia, palm oil plantations have gradually taken over from rubber plantations and now directly employ more than 570,000 Malaysians and are predicted to employ 750,000 Indonesians by 2010. In 2007, Indonesia exported 16.9 million tonnes of palm oil worth US$7.9 billion, almost 7 per cent of Indonesia's exports.

The above does not mean that oil palm companies cannot play a positive role in orangutan conservation. First and foremost, if all new oil palm was established on already degraded lands with few or no orangutans, then the impact of oil palm on remaining orangutan populations would be much reduced. Where this is not possible, and concessions have been given out in areas that still contain orangutan populations, the focus should be on retaining as much high quality habitat as possible. Unlike in the case of pulp and paper plantations, however, retaining forests for conservation purposes is not legally required in the oil palm sector (only the maintenance of riverine buffers is prescribed). This puts oil palm managers in a difficult situation, because even if they decided not to develop some key habitats in their oil palm concessions, such areas would likely be excised from the concession by the government, making it impossible for the original company to manage them. New laws and regulations are needed to address this issue.

Even though oil palm doesn't offer much in terms of food resources for orangutans, the plantation areas can provide important matrix habitat for orangutans that move between forest patches or protected areas within the larger oil palm matrix. This has been studied in some detail in Sabah, Malaysia, where orangutans use oil palm areas to move between the many protected forest patches in the Kinabatangan River area.

Orangutans in Open Cast Mining Concessions

Very little is known about survival of orangutans in open cast mining concessions. One well known mining concession, KalTim Prima Coal (KPC) in East Kalimantan overlaps with an area of high orangutan density which is contiguous with the populations in the adjacent Kutai National Park. Since the early 1990s, KPC has worked with conservation NGOs to translocate orangutans that were displaced by mining activities to the national park. In addition, they have replanted some of the reclaimed mining areas. Revegetation activities focused on the planting of local varieties found in the areas prior to the mining operations, including *dipterocarps* such as *Shorea balangeran, S. johorensis, S. mojogensis, S. parvifolia, S. pauciflora, Dryobalanops lanceolata*, and a range of other timber species. These species are not generally used by orangutans for food, but other species would likely establish themselves in these replanted areas and, if well protected, they could provide good habitats for orangutans, especially where these habitats maintain links with larger protected forests such as Kutai National Park. It remains unstudied what the impact has been of these replanting and translocation activities on the local orangutan population.

The broader context of mining in forest areas is that the areas where companies have exploration rights are much larger than the areas for which these companies later get mining rights. The remaining areas are relinquished to their previous owners (timber concession or forest department). In general, the mining concessions therefore only have management rights over a relatively small area (typically a few thousand hectares), which is considerably less than the areas used in the pulp and paper and oil palm plantation industries. Within their mining concession (as opposed to the exploration area), open cast mines will generally clear cut much of the vegetation to open the mining pits. This leaves little room for orangutan or orangutan management.

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Economic migrants. Large-scale mining operations, especially those using open-pit mining techniques, can result in significant deforestation through forest clearing and the construction of roads which open remote forest areas to transient settlers, land speculators, and small-scale miners. These settlers and miners are probably a greater threat to the tropical rainforest environment than industrial mining operations. Wildcat miners enter regions rumored to have ore deposits where they cut trees for building material and fuelwood, hunt wildlife, and trigger erosion by clearing hillsides. Miners can also bring diseases to local indigenous populations and are often the cause of disputes over land rights.

The impacts of mine development, however, go beyond the actual mine pit. Infrastructure for transportation of coal or other mining products opens up areas, generally increasing the pressure on remaining forest stand from people attracted by the economic opportunities offered by mining activities. These secondary impacts can be severe and are difficult to control by mining companies as they occur outside their area of jurisdiction.

However, mining concessions can take an active role in the management of forest areas outside their mining concessions, as is for example done by KPC (and other companies near Kutai NP) who collaborate with park management and local communities to improve the overall management of forests in and around the national park. A similar approach was initiated by BHP Billiton. BHP Billiton collaborated with several NGOs to develop a broader approach to forest management in the Murung Raya district in which they worked in Central Kalimantan. BHP Billiton also actively assisted in the release of orangutans from orangutan rehabilitation centers in the region where they were exploring for coal.

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Captive baby orangutan, East Kalimantan. As human settlements encroach on the forest, wild orangutans eat the fruit in gardens leading to conflict with the villagers who often regard the orangutans as pests. If adult females are killed the babies can be sold, though many die quickly from the poor conditions in which they are often kept in following their capture.

Human-Orangutan Conflicts

Human – orangutan conflicts are reportedly widespread. As forests are cleared for plantations, confused orangutans can be found wandering in the newly planted areas that used to form part of their range. An adult orangutan can be intimidating to humans, so it is common for them to be killed by plantation workers. With their habitat gone, hungry orangutans will turn their attention to the young palm trees or other planted trees or pulp, where they can cause considerable damage, thus exacerbating the conflict.

Recent interview-based surveys among 7,000 villagers in Kalimantan revealed how common such conflicts are in areas where people and orangutans co-exist. Analysis of this dataset is ongoing, but preliminary work suggests that there is significant regional variation in the outcome of this conflict: people in some areas accept the orangutans and the damage they cause to their crops (presumably up to a certain level), while in other areas orangutans are regularly killed as the result of such conflicts.

Whether the underlying causes of this are religious, cultural, or caused by better awareness or education remains to be investigated. It is clear however that with human activities in orangutan habitat increasing, these conflicts and resulting negative impacts on orangutans are likely to intensify and have to be addressed.

Human-orangutan conflicts are least likely to occur within a natural forest concession where human population densities tend to be low, and are more likely in an oil palm or pulp and paper plantation setting which are often developed in areas with good access or infrastructure, and require large numbers of workers. Also, the plantation development can involve destruction of orangutan habitat compressing remaining population into a smaller area and making it more likely that the orangutans will be forced to come out of the forest and look for food in village gardens.

Little is known about mitigation of human-orangutan conflicts. A project in North Sumatra, where a small population of orangutans has been isolated in a landscape dominated by oil palm and agriculture, tried various mitigation techniques. This included the following methods:

- Barriers on orangutan crop-raiding routes. The best way to stop an arboreal primate from raiding fruit trees is by closing off their travel pathways. Therefore, 5cm x 5cm square mesh nylon rope barriers were designed and placed around jengkol (Archidendron pauciflorum) trees as farmers identified these as the most important crop.
- Chilli grease. A mixture of used engine oil and ground chilli was applied to a small sample of the square mesh nylon ropes and placed around certain jengkol trees in the focal farmlands.
- Noise deterrents; Three types of deterrents were employed:
    - o Firecracker cannons. Hand-held bamboo firecrackers produce a loud noise when detonated by lighting the calcium carbide present within the tin cans. The

community enumerators where equipped with these cannons and took them into the farmlands on a daily basis. They would only be detonated if orangutans were found crop-raiding within the trial focal farmlands.

- Bamboo drums: Hand-held bamboo drums produce a loud noise when struck. These were also used on a daily basis. However, the community enumerators would only use them if the firecracker cannons were unsuccessful.
- Tin chimes: Tin chimes were fixed to a small sample of the square mesh nylon rope as an early warning system.

Direct protection of crops appears the most effective way to deter crop raiding, but is expensive and labour-intensive. The traditional crop protection methods such as shouting and throwing appear to be effective in the community but only serve as temporary deterrents and only work in conjunction with physical guarding (which unfortunately only a small proportion of farmers at this study site do). The problem with any of these methods is that if orangutans are deterred from raiding crops in one location, they will move to another one to feed; if this is in natural forest then there is not problem, but if it is someone else's garden, then the problem is simple displaced.

Public awareness campaigns are also needed that ensure that local communities are aware of the protected status of orangutans, and know what they need to do when crop raiding takes place.

Importance of Controlling Hunting

Because of their low fecundity orangutans are very sensitive to hunting. It appears that any population will go extinct eventually if hunting increases annual adult mortality by >1% (see below). Such local extinctions have been demonstrated by Pleistocene and Holocene orangutan remains found in caves in parts of Borneo where orangutans no longer occur, although suitable habitat remains. Thus, in many areas, orangutans had already become extinct or reduced to very low population levels by the time of the first island-wide distribution assessments.

In areas where the carrying capacity of orangutan habitat is reduced by removal of food trees, the impact of hunting is even more severe. Any concessions implementing best management practices for orangutans should have a no-killing policy that is strictly enforced.

What is a Viable Orangutan Population?

Viability in environmental conservation indicates the ability of a conservation target to persist for many generations or over long time periods. A lot of research has been done to work out what this means for orangutans. What are the key characteristics that determine whether a particular orangutan population will survive or not?

Viability of populations is generally assessed through computer modelling. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA).

One of the results of a PVA is the minimum population size at which there is a high likelihood that orangutans will survive in the long-term giving a set of particular habitat characteristics. Determining this minimum population size and circumstances under which it can be maintained is crucial in the light of the Indonesian government's commitment to stabilize all orangutan populations by 2017. The logical consequence of this commitment is that all orangutan populations have to be viable by 2017, i.e. they have to exceed the minimum population size.

To clarify the present discussion on viability we should define two terms:

Population: We define an orangutan population as any number of animals living in an area that is bordered by rivers that are not normally crossed by orangutans (>20 m wide), or other landscape features that prohibit the migration of orangutans (e.g., wide open areas)

Viability: Orangutan populations are viable when there is a 0% risk of extinction over 1000 years.

Populations without Additional Threats

The viability of species is normally investigated with the simulation software program Vortex. The program begins by creating individuals to form the starting population and stepping through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities.

As populations become smaller, they become more susceptible to the negative effects of inbreeding and chance events. The baseline model is used to assess the relatively viability of orangutan populations of varying size independent of human threats.

As an example, Table 2 gives the probability of extinction, mean population size, and proportion of genetic diversity obtained from 500 iterations for populations of each tested initial size after 50, 100 and 1000 years. Density-dependent reproduction and mortality rates in combination with the effects of inbreeding, disease and stochastic events leads all populations to decline substantially below carrying capacity in a relatively short period of time. Smaller populations remained more vulnerable to these effects over the long-term.

Although short-term projections (i.e., for 50-100 years) under baseline conditions show almost no probability of extinction, this time period encompasses only 2-3 generations for this long-lived species, making it difficult to observe population trends. Projections for 1000 years allow us to better evaluate these trends and those factors that influence them. Populations of 50 and 100 have a high probability of extinction over 1000 years; those that survived were greatly re¬duced in size and genetic diversity. Although populations of 250 have a very small probability of extinction, they declined on average to almost one-half of their original size and lost substantial genetic diversity. Populations of 500 or larger were demographically stable and retained over 90% of gene diversity, a common genetic goal for managed populations.

Table 2: **Effects of initial population size (NINIT) on population viability in Sumatran orangutans**

	50 years			100 years			1000 years		
NINIT	PE	N	GD	PE	N	GD	PE	N	GD
50	0	41	96	1	36	92	99	7	40
100	0	83	98	0	78	96	64	28	59
250	0	210	99	0	203	99	2	142	85
500	0	417	100	0	404	99	0	342	93
1000	0	839	100	0	808	100	0	732	97
1500	0	1269	100	0	1206	100	0	1149	98
2500	0	2085	100	0	2020	100	0	1947	99

PE = % probability of extinction;
N = mean population size;
GD = % of initial gene diversity

Overall, simulation results suggest that orangutan populations of about 250 have a very high probability of survival in the absence of human-related mortality, habitat loss or unforeseen catastrophic events, but will be significantly reduced in size and genetic variation. Populations of 500 are more demographically and genetically stable and may contribute to the long-term conservation of this species. Smaller populations that are linked by occasional exchanges of animals could also contribute to the overall stability of a larger meta-population.

Impact of Habitat Availability and Natural Mortality Rates

One major concern for developing and implementing best management practices is how orangutan populations can continue to persist and thrive in forests that are reduced in extent and fragmented, and where natural mortality rates are higher than normal. This is modeled by trying different scenarios in which carrying capacity of remaining habitats is decreased. The resulting models suggest that populations of Bornean orangutans of about 1000 orangutans are fairly stable. Populations of 250 also appear to be demographically stable, although they show greater relative fluctuations than do the larger populations. The smallest populations tested, in habitats limited to 50 animals, are not demographically stable even with the best mortality schedule. Such small populations experience large relative fluctuations and sometimes went extinct.

Overall, with the values we estimated as typical for orangutans on Borneo, the results suggest that populations of about 250 would be considered to have long-term potential to contribute to the conservation of the species, and populations of 500 or 1000 would be more robust even if habitat quality is partly degraded, assuming no hunting occurs. It should be noted, however, that smaller populations that are linked by occasional movements of animals could contribute to the overall stability of a larger metapopulation.

Impacts of hunting

Orangutans are a long-lived, slowly reproducing species, so even very low rates of hunting (or other causes of killing) might strongly threaten population growth, stability, and persistence. Models examine this by assuming additional annual mortality of all age classes of 1%, 2%, and 3%. The analysis shows the impacts of these levels of hunting on populations in habitats capable of supporting 250 orangutans. With the best natural mortality, a removal due to hunting of 1% of the orangutans per year does not cause population extinction but does lead to depressed population size, while even this low level of hunting can cause declines to extinction if natural mortality is at the levels estimated for less than optimal habitat. Higher rates of hunting are unsustainable even under the best assumption for natural mortality.

The conclusion from these models is that a population size of 250 animals is a bare minimum if stabilization is the target (i.e. population has to be viable in the long term). With a population size of 250 animals, however, hunting and other causes of increased mortality have to be controlled to ensure that the population does not further decline. This sets a very high benchmark for any orangutan populations in plantation settings where killings of orangutan occur frequently.

Glossary

Biodiversity: The variation of life at all levels of biological organization, usually within a given ecosystem or region. Biodiversity is often used as a measure of the health of biological systems.

Landscape: Spatially heterogeneous geographic areas characterized by diverse interacting patches or ecosystems, ranging from relatively natural terrestrial and aquatic systems such as forests, grasslands and lakes to human-dominated environments including agricultural and urban settings.

The Ramsar Convention: The Convention on Wetlands of International Importance is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Negotiated through the 1960s by countries and non-governmental organizations that were concerned at the increasing loss and degradation of wetland habitat for migratory waterbirds, the treaty was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975.

Silvicultural: Combines the harvest of timber with the re-establishment of the forest. It is concerned with sustained yield and keeping the forest productive through multiple rotations (lifespan of trees) and is used to help mitigate potential negative impacts such that the values of the forest are maintained in perpetuity.

Spatial planning: An interdisciplinary and comprehensive approach that includes all levels of land use planning and is directed towards a balanced regional development and physical organisation of space according to an overall strategy.

Tebang Pilih dan Tanam Intensive Indonesia (TPTII) - Indonesian selective cutting and intensive planting system **:** A new silviculture approach that is a modified system of TPTJ *"Tebang Pilih dan Tanam Jalur"* (Selective cutting and row planting). The modification to the system involves the use of a more intensive planting area or row every 20 meters with a distance of 2.5 m between trees planted. In common practice, TPTII sets the cutting limit at 40 cm diameter, although 45 cm is sometimes used.

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