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Habitat Loss of Sumatran Elephants (*Elephas maximus sumatranus*) in Tesso Nilo Forest, Riau, Indonesia

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ABSTRACT

Background: Sumatran elephants (*Elephas maximus sumatranus*) are morphologically, anatomically and genetically different from other sub-species of the Asian elephant is distributed only in Sumatra. Riau province has been one of the largest population pockets of elephants together with Aceh, Lampung and Jambi provinces. One of the remaining forest left in Riau province is Tesso Nilo Forest (377,387 hectares). This forest block consists of Tesso Nilo National Park, Production Forest areas belong to two companies, and a small recreation Park. This forest block contains one of the most important mixed peat swamp forests. It is home to endemic and charismatic wildlife species include Sumatran elephants (*Elephas maximus sumatranus*), Sumatran tigers (*Panthera tigris sumatrae*), and many other mammals, birds and reptiles. The forest block has been degraded by frequent burning during the dry season. The smoke from forest fires in Tesso Nilo has spread into several countries such as Malaysia and Singapore on a yearly base. For that reason, the Indonesia Government has been trying to manage this forest block to eliminate, or at least minimize, forest destruction, encroachment of settlement and consequent forest fires. **Objective:** The objectives of this study are to identify impact open access of roads to deforestation in Tesso Nilo Forest as Sumatran Elephant Habitat. **Results:** We predict that forest cover lost will increase before and after road construction by using GIS and remote sensing imagery. Deforestation rates have increased from 1.5% per year before road construction to 9.28% per year after road construction, which means that the area of forest has decreased by an annual average of 8,156 ha. Our predictions on the forest left in 2018 is only 28,017 ha. As consequences Sumatran elephants habitat will be reduced to 72% of its original area. **Conclusion:** As human populations increase and more and more forest is converted to estates and agricultural lands, and roads are built across Sumatran forest, elephants-human conflicts are on the rise.

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INTRODUCTION

Elephant survey was carried out in Sumatra in 1980 using rapid assessment method and total population was predicted around 2800-4800 individuals distributed in 44 locations (Blouch and Haryanto 1984; Blouch and Simbolon 1985). In 2000, surveys in Lampung extensively found that 9 out of 12 locations found in 1980 were disappeared (Hedges *et al.*, 2005). In Riau, survey of elephant population has been carried out by WWF (2013) and found that the population declined very sharply. The culprit is not only of habitat loss due to expansion of agriculture plantation but also the killing of elephants by farmers.

The primary reasons for the dramatic loss of forests in Sumatra are logging (legal and illegal), forest fires, and the clearing of large forest areas in order to plant oil palms, rubber trees and pulpwood. Since the early 1970s, Sumatra has lost 6.6 million ha of forest or 557,000 ha per year due to legal and illegal logging, conversion of natural forests to industrial plantations, and forest encroachment by communities. Of this total, 2.6 million ha were natural tropical rain forest (Margono *et al.*, 2012). The largest area, about 30% (about 5 million ha) was lost from Riau Province. Riau Province has approximately 8.6 million ha of forest remaining (Pemerintah Provinsi Riau, 2010) but also the highest rate of loss, about 42% between 1990 and 2010 (Margono *et al.*, 2012). Within Riau Province, the Tesso Nilo Forest block is the largest block of forest remaining

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(377,387 ha) consisting mainly of lowland tropical rain forest, heat forest and peat swamp forest (Mariati, 2004).

The Tesso Nilo Forest harbors very high biodiversity. The lowland forest is an important habitat for endangered species such as the Sumatran tiger (*Panthera tigris sumatrae*) and Sumatran elephant (*Elephas maximus sumatranus*). However, as large areas of this habitat have been converted into oil palm and pulp wood plantations, and settlements, conflicts between humans and biodiversity protection have increased exponentially (Margono *et al.* 2012).

Serious conflicts between production and the protection of wildlife and ecosystem functions and cultural values began after the construction of two road corridors, Baserah and Ukui, started in 2000 and 2012 respectively. Illegal logging in the Tesso Nilo Forest is increasing after roads built primarily in conservation areas, since these areas have better timber potential than production areas. Ministry of Forestry stated that the main actors in illegal logging are: (a) Trained workers whose selected from communities in the forest areas and also many of those who are brought there originality from other areas, (b) Investors; including traders, concession holders, or holders of legal timber cutting permits, and buyers of illegal timber whose from processing industries; and (c) government officials (both civilian and military), law enforcement personnel, and certain legislators (Ministry of Forestry, 2002).

In addition to the pulp industry, there are many other activities that drive the deforestation and degradation of Tesso Nilo Forest. Demand for land for palm oil plantations has been very high, making Riau one of the largest producers of palm oil products in Sumatra (WRI, 2002; WWF, 2004). Tesso Nilo Forest is the only large block forest left in Riau Province. However, the land is in demand by others, among others by communities for timber, or conversion for agriculture, and for palm oil plantation. As a result, more than 3.4 million hectares in this province alone had been deforested by mid 1990s, which is 29% of Riau's original forest land. The lowland and peat forests are threatened specifically by small and large-scale forest conversion (Uryu *et al.*, 2007).

Information on the amount of forest lost in Riau Province has been gathered by government agencies, both central and local, NGOs, and scientists, but it has not been used yet to predict accurately rates and total amounts of forest lost. Here we describe the rate of deforestation in the Tesso Nilo Forest by mapping its extent and by calculating the rate of deforestation post road construction. We describe possible impacts of forest lost on wildlife especially elephants and the interactions between companies, communities and government agencies and propose some policies and actions to help mitigate forest loss.

Methods:

Study Area:

The Tesso Nilo Forest (formerly Langgam Forest) covers an area of 377,387 ha and is located in the Pelalawan, Kuantan Singingi, Kampar and Indragiri Hulu Districts, in the Riau Province in the central part of Sumatra (ca. 102°E and equator). The forest block is surrounded by *Acacia* plantations (80%), palm oil estates (13%) and village gardens (7%) (Pemerintah Provinsi Riau, 2010). This forest is about 3 hours drive south of Pekanbaru, the capital of Riau Province.

In 1984, the Ministry of Environment planned to convert some of the area to an elephant sanctuary but it was not until 2001 that the Ministry of Forestry agreed to allocate 153,000 ha for such a sanctuary. Even so, it was not until 2004 that the Ministry of Forestry declared the former logged-over area of Inhutani as the newly established Tesso Nilo National Park, consisting of only 38,576 ha. In 2009, more land was added to the park by converting the Nanjak Makmur logging concession of 44,492 ha, so that the total area of the park is now 83,063 ha. Existing forest adjacent to the National park are the logging concessions of Siak Raya (40,600) and Hutani Sola (36,185 ha). The remaining adjacent land consists of Industrial Forest Estate or pulp and paper company forest (Mariati, 2004) (Fig 1).

The roads crisscrossing the Tesso Nilo forest were built by the pulp and paper industry because their plantations are located on both the western and eastern sides of the forest block. In 2001-2002, the Baserah road, along 50km, was built from north to south with an average width of approximately 20-25 m; while Ukui road, along 30km long, was built from west to east also with an average width of 20-25m in 2004-2005. (Fig 1).

Spatial Planning:

Landsat image interpretation and overlay and calculation of the average deforestation rate using the equation (Puyravaud, 2003) were the primary methods used. Percentage calculations of deforestation (P) of the concession area and National Park were made using the Ministry of Forestry formula (Departemen Kehutanan, 2008). The method used to predict the pattern of trends in deforestation to 2018 was the *Idrisi* software tool Land change modeler.

We are using a *Land Use and Land Use Change Cover* on the analog format at the scale of 1:250,000 from 2000-2012. This source originally came from satellite images and then was validated using Google map and ESRI online base map. Database was analyzed by *software* Arc GIS 10.

Results:

1. Forest Lost and Elephant Habitat:

Between 2000 and 2002, Tesso Nilo Forest had lost forest area to legal and illegal logging, settlements, oil palm and pulp wood plantations and other forms of agriculture. At that stage, forest loss was concentrated mostly in the logging concessions. However, the rate of loss increased significantly especially when access to the middle of the forest block was opened up by construction of Baserah and Ukui roads.

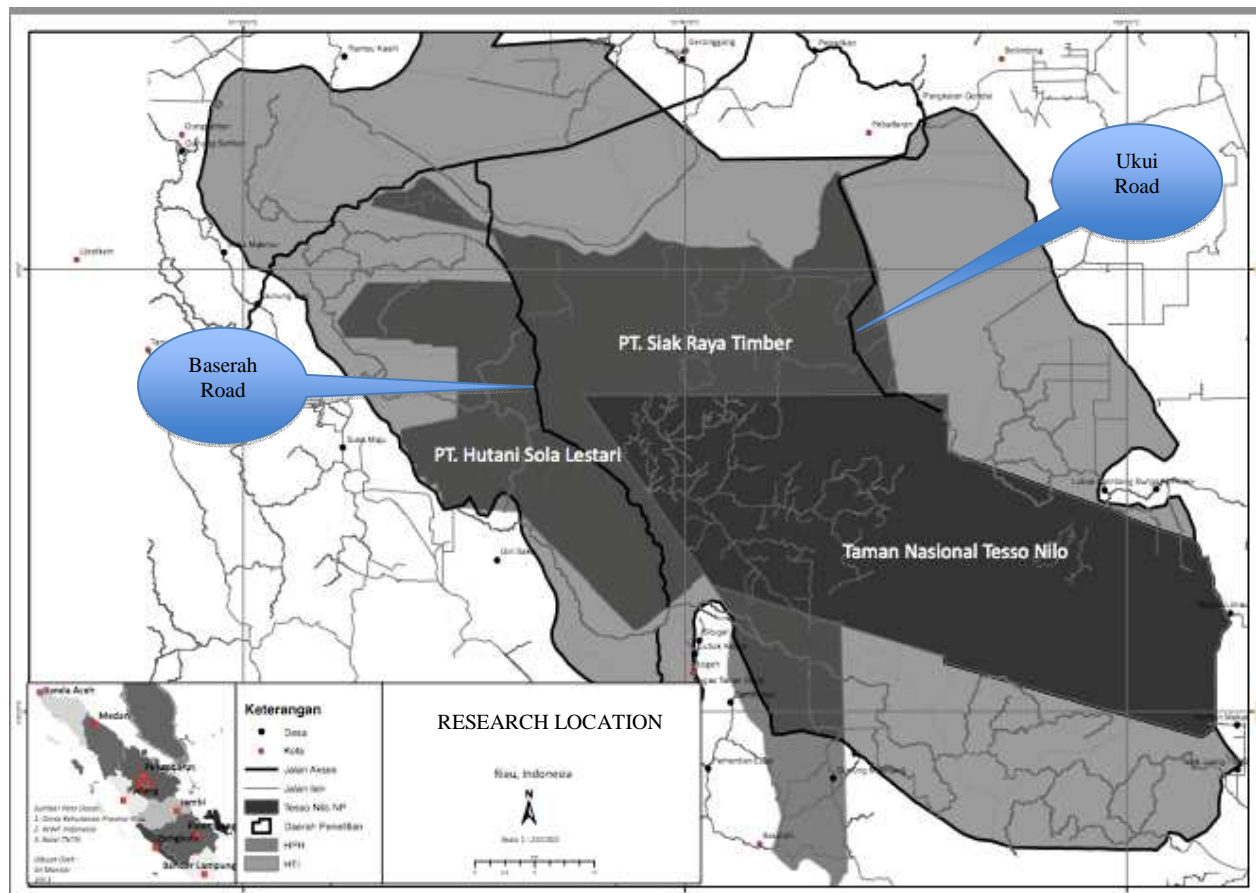


Fig. 1: Tesso Nilo Research sites, boundary of companies and national park, timber plantation, logging concessions and new roads built.

Between 2000 and 2012 the area of forest decreased by 8,156.97 ha, which represents rate of forest loss of 9.28% per year. If we break this down further the average rate of forest loss between 2000 and 2002 was 2.40% per year, between 2002 and 2004 it was 4.06% per year (after Baserah road was completed and construction of Ukui road was commenced) and the average after Baserah and Ukui roads were both completed, between 2005 and 2012, was 13.88% per year. Clearly, these two roads are important factors in forest lost (Fig 2). (Mariati *et al.*, 2013).

Based on model projections of trends in forest loss between 2000 to 2012, in 2018 only approximately 28,017 ha of the Tesso Nilo forest will remain (Fig 4). It is clear that the two road corridors have facilitated encroachment and forest conversion. Table 1 shows that the deforested area in PT Hutani Sola Lestari increased significantly from 1.70% (2000) to 17.66% (2002) after the Baserah road was built. After both roads were built, rate of converted land was 72.63% between 2000 and 2012 in this area (Fig 2).

The Forest loss based on average rates from 2002-2012 (9.28% per year), is predicted to reach more than 90% of the original Tesso Nilo Forest block, which is only covered 28,017 ha out of the original total 387,377 ha (Table 1). This yearly loss will only change if the parameters that influence the model is changed. Based on the ER mapper method, it showed that deforestation patterns in Tesso Nilo Forest were positively correlated with roads (0.546), and demographic patterns (0.049). These two parameters were predicted as the drivers of deforestation.

Further analysis using land change modeler Idrisi Selva 17.0, shows that this habitat loss is related to; open access for illegal poachers, law enforcement, forested land sold by communities, park management and unclear

land demarcation. Most poachers we identified were free raider persons coming from outside of communities. However, those free raiders mostly bought the forested land from local community leaders who sold it cheaply. The 16 community leaders interviewed, sold forested land belong to the companies as well as the national park. They insisted that the land belonged to their communities although community rights to that land, have not been declared. The analysis also showed that the most important factor is unclear border line between concessions of logging companies, national park and villages. (Mariati *et al.* 2013).

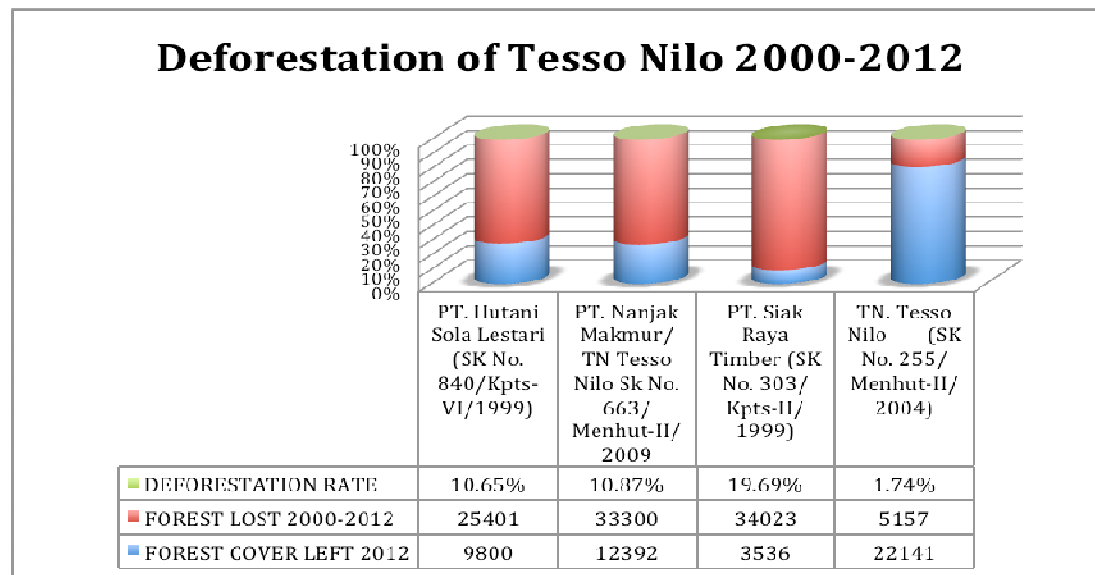


Fig. 2: Deforestation of Tesso Nilo Forest Block 2000-2012.

Table 1: Projection of forest cover loss in 2013 up to 2018.

	2013 (Ha)	2014 (Ha)	2015 (Ha)	2016 (Ha)	2017 (Ha)	2018 (Ha)
Forest	57,348	51,481	45,615	39,749	33,883	28,017
Non-Forested area	306,599	312,465	318,331	324,197	330,063	335,930

Source: Mariati *et al.* 2013.

2. Forest Lost and Elephant Population:

Based on our data on elephant distribution, primarily from WWF, and our predicted deforestation model it seems that elephant habitat will be reduced to 72% of its original area by 2018 or reduce 72,000 ha (Fig 3) (Mariati *et al.*, 2013). This reduction will be concentrated in the heavily deforested parts of the two forest concessions. If this deforestation trend continues as predicted, the Tesso Nilo National Park may serve as a safe haven to elephants. Even so, conflict between community land and national park would be increased due to a lack of clearly define in ownership. National park borders have been demarcated, but community land boundaries have not been defined and written down legally, the community land was only loosely determined by rivers and creeks.

Legally, community right has recently been recognized by Forestry law no 41 in 1999 and enforced by Constitution court 2013. However, Tesso Nilo, was not included. Of the 16 community leaders interviewed on the conflicts between elephant and villagers 15 people believe that elephants destroyed their crops and even houses. However, it was only a few who believed that elephants have to be killed. More than 10 people believe that elephant should be contained at the national parks and 6 people believe that should be transferred to other forest.

Discussion:

1. Forest Loss in Tesso Nilo:

Roads that were built by pulp and paper companies to transport timber from logging concessions to mills have also provided access for both illegal loggers and people seeking land for settlement. In addition, existing communities around the forest have used the roads to gain access to new small areas deep within the forest. So the deforested area now looks like honeycomb, a pattern that has been found in many other tropical countries. The accessibility of forest areas is the most important variable in the pattern of the deforestation (Etter *et al.*, 2006).

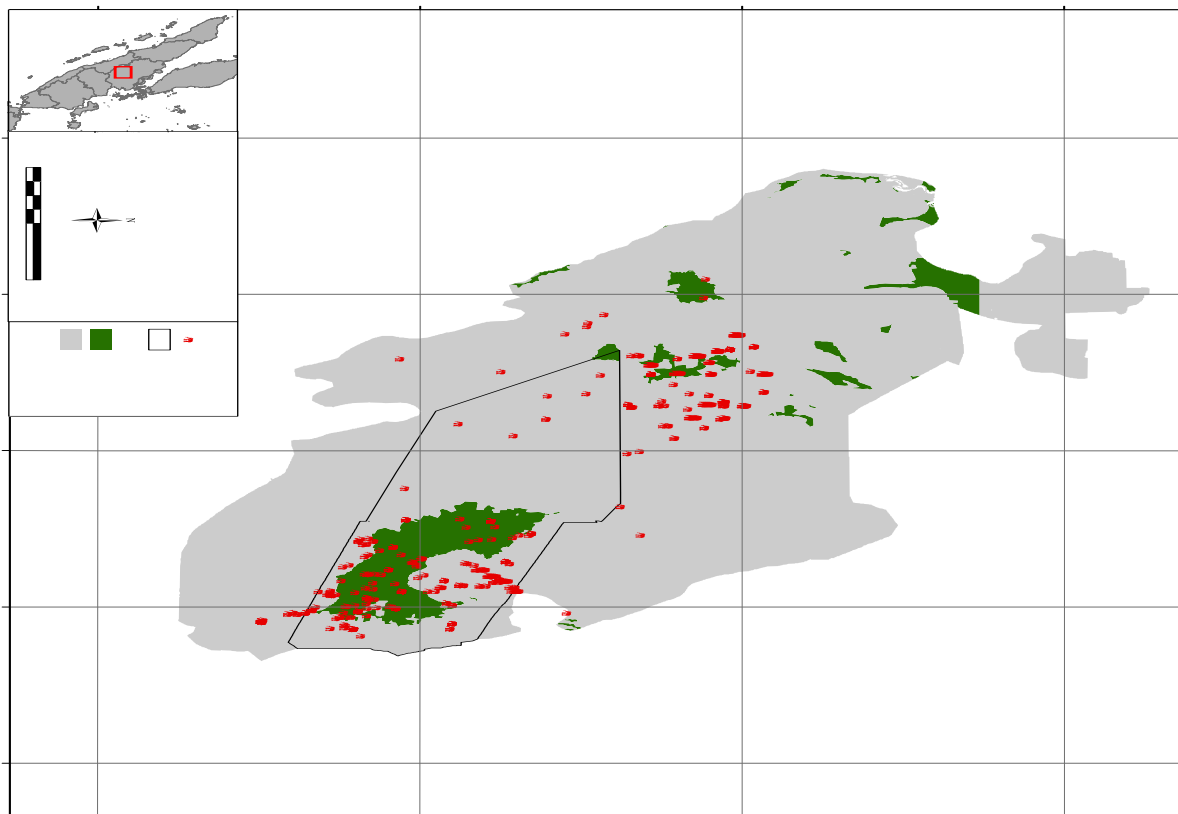


Fig. 3: Projection Model of Deforestation in 2018 and Elephant Distribution (Source: Mariati *et al.*, 2013).

In general, the cause of deforestation is the land use change due to the conversion of the forested land for agriculture, plantation and timber extraction (Geist and Lambin, 2001; Scotland *et al.*, 2000) but the one of the most detrimental factors is road construction (FWI, 2001). In every case, road construction followed by community encroaching is the driver of deforestation (Carr and Burgdorfer, 2013) The pulp and paper industry causes very challenging problems in Sumatra, especially in Riau. Sumatra's largest pulp and paper company, not too far from Tesso Nilo, used 6.8 million cubic meters of pulpwood in 1999, about 87% of which was mixed tropical hardwoods, or wood cut from forests, not from its plantations. The company's available sources of hardwoods will decline sharply to less than two million metric tons in 2001 and be exhausted by 2005. To fill that gap, the company planned to use plantations. Volumes harvested from the plantations are expected to grow from 1.3 million cubic meters in 1999 to 4.4 million cubic meters in 2005 which meets only half the needs of the mill. The remainder will come from existing forests. This company's situation is similar to virtually all other pulp and paper operations in Sumatra. Their collective need for wood is approximately eight times the available plantation supply. Transporting this timber requires wide long roads such as those across Tesso Nilo (Barr, 2001; Barr, 2002).

The Tesso Nilo Forest complex, especially its lowland and peat forests, has come under heavy pressure from rapidly advancing, largely industry-driven deforestation and forest degradation. In many other parts of Sumatra, and Riau in particular, large areas of natural forest have been clear-cut and planted with hundreds of thousands of palm oils and fast-growing trees for the pulp and paper mills (Carr and Burgdorfer, 2013). Until recently, that appeared to be Tesso Nilo's future as well. Since 1985, the forest has lost over 300,000 ha to the palm oil and pulp and paper industry, so that only about 190,000 ha main today (Supriatna, 2009). In Tesso Nilo alone, forest conversion for palm oil by community had reached to 28,000 ha in 2004 (Mariati, 2004).

2. Elephant Habitat and Wildlife conflicts:

The total number of elephants was estimated to be between 2800 and 4800 animals at that time, scattered in 44 fragmented populations. However, data collection was limited to short field visits and interviews with local people and forest authorities thus, the estimates were little more than educated guesses. The quality of Sumatran Elephant surveys hasn't changed much over the years, and a reliable estimate of the total Sumatran elephant population remaining in the wild is currently not possible. However, the distribution of most of the elephant populations is roughly understood. The habitat of the remaining populations is restricted to relatively small

areas. Many of the elephant populations living in very small and isolated forest patches may be gone during the next decade.

In Riau Province there is no more big forest available for elephants when their populations in the group are increased. When their population increased their daily home range also enlarged. Home range of Asian elephants is around 105-320 km (Sukumar, 1989). In Tesso Nilo the forest is fragmented and so the elephants will have to split into several groups. The elephants pushed in to pocket habitats, and called pocket-herd. This phenomenon happens in many other areas such as in India and Ceylon (Oliver 1980). According to Seidensticker (1983), those small elephant herds can come to the gardens and destroyed very massive crops. Home range of Asian elephants is around 105-320 km (Sukumar, 1989).

Tesso Nilo was thought to be home to 150 to 200 elephants in two groups, one in the north and one in the south (WWF, 2009). According to WWF (2013) that number had dwindled to only 142 elephants split into 3 groups through lost or fragmented habitat. It showed that elephant killing by community poisoning has been alarming. At least 26 elephants died from 2010 to 2013. All casualties occurred at the edge of the forest in new plantations or new crops of mixed gardens (table 2).

Table 2: Elephant-human conflicts in 2004-2010.

No	Years	Elephant killed	People died	People hurts
1	2004	16	2	0
2	2005	6	4	1
3	2006	24	1	0
4	2007	5	2	2
5	2008	9	4	2
6	2009	8	2	0
7	2010	13	2	4
8	2011	10		
	Total	91	17	9

(Source: WWF Indonesia-Project, Riau, 2012)

With their habitat declined (see Fig 4), Tesso Nilo's elephants are increasingly forced to raid plantations and village gardens that surround the forests, in search of food and safety. Direct damage caused by elephants (trampling of houses, injuring and killing people and damage to small and large scale plantations) in and around Tesso Nilo was estimated at US\$ 3.5 million over the period 1997-2000 (WWF, 2001).

Conclusion:

As human populations increase and more and more forest is converted to estates and agricultural lands, and roads are built across Sumatran forest, elephants-human conflicts are on the rise. This is due to many families were attracted by the financial success of some settlers, and followed in order to convert the forest to cropping land. This process is still continuing, although governmental funding is rare nowadays and people increasingly move between provinces instead of between islands. As a consequence, many elephants were forced to suddenly share their territories with people. The resulting conflict between people and elephants (human-elephant conflict) quickly escalated, and many elephants were killed illegally.

Using GIS and remote sensing imagery, we found deforestation rates have increased 6 fold after road construction that crisscrossed the Tesso Nilo Forest block, which means that the area of elephant habitat decreased significantly. Our predictions on the forest left in 2018 is only 28,017 ha. As consequences Sumatran elephants habitat will be reduced to 72% of its original area.

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