Species Conservation Action Plan

Compiled by: Harry Hilser, Helen Sampson,Vicky Melfi and Johny S Tasirin

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Glossary

AZA: Association of Zoos and Aquaria
BIMP-EAGA: Brunei Indonesia Malaysia Philippines East Asian Growth Area
BKSDA: Balai Konservasi Sumber Daya Alam (Natural resources conservation agency)
CITES: Convention for International Trade in Endangered Species
IUCN-CMP: Conservation Measures Partnership
EAZA: European Association of Zoos and Aquaria
EEP: European Endangered Species Programme
GDP: Gross Domestic Product
GSMP: Global Species Management Programme
IUCN: International Union for Conservation of Nature
ISIS: International Species Information System
KEK: KawasanEkonomiKhusus(Special Economic Zone)
MNP: *Macaca Nigra* Project
NGO: Non-Governmental Organisation
NHP: Non-Human Primate
Pers. comm.: Personal Communication
PHKA: Direktorat Jenderal Perlindungan Hutandan Konservasi Alam (Directorate General of Protection and Nature Conservation)
PVA: Population Viability Analysis
PPS: Pusat Penyelamatan Satwa (Wildlife Rescue Center)
SAP: Species conservation Action Plan
SSC: Species Survival Commission
Tangkoko: Tangkoko Duasudara Nature Reserve
TCE: Tangkoko Conservation Education
TCSA: Taronga Conservation Society of Australia
TIES: The International Ecotourism Society
UNEP: United Nations Environment Programme
USA: United States of America
WCMC: World Conservation Monitoring Programme
WCS: Wildlife Conservation Society
WWCT: Whitley Wildlife Conservation Trust
ZAA: Zoos and Aquaria Association

Foreword

[To be completed by Dr. Jatna Supriatna and Ibu Noviar Andayani]

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Executive Summary

[To be completed following full conservation recommendations and framework for action from workshop]

Species Conservation Action Plan
Sulawesi crested black macaques (*Macaca nigra*)

Section I: Status Review

CHAPTER 1. Introduction

The need for biodiversity conservation to adopt a more systematic and scientific approach is well recognised (e.g. Sutherland *et al.,* 2004; Pullin & Stewart, 2006). This can be achieved by sharing information, experiences and resources among conservation practitioners and using a consultation process to plan conservation priorities within standardised frameworks (Salafsky *et al.,* 2001, 2002).

A Species Conservation Action Plan (SAP) provides background information about the target species, a summary of past and current conservation activities undertaken, and an overview of the 'threats' considered to be causal in the species' population decline. With due consultation, recommendations and framework for conservation activities to mitigate these threats are developed. SAPs aim to provide an authoritative source of species-related conservation information available to natural resource managers, conservationists and decision makers. The International Union for Conservation of Nature (IUCN) with the Species Survival Commission (SSC) describe the process of developing a SAP as fundamental in "*prioritising recommendations specifically designed for key players*" (IUCN/SSC 2002).

Figure 1. The Sulawesi crested black macaque (*Macaca nigra*), a charismatic and iconic species.

This action plan is developed with a single species focus; Sulawesi crested black macaques (*M. nigra*). As a flagship species, conservation of the Critically Endangered *M. nigra* is important for the target species, and will also make a significant and positive contribution to biodiversity conservation in an area of high endemism. Sulawesi is regarded for its remarkable species biodiversity, boasts the highest level of endemism within Indonesia, an area already recognised for its rich biodiversity and endemism. Data compiled by Holmes and Philips (1996) identified 88 out of 328 (27%) bird species and 79 out of 127 (62%) mammal species to be endemics to Sulawesi; the latter rises to 98% if only flightless mammals are considered. Seven endemic macaque species have radiated throughout Sulawesi, including the target species *M. nigra*, which are a key species within the North Sulawesi ecosystem (Riley, 2010). Other species of note in North Sulawesi include the anoa (*Bubalus depressicournis*), babirusa (*Babyrousa babyrussa*), maleo (*Macrocephalon maleo*), Minahasa masked-owl (*Tytoinex spectata*) and the satanic nightjar (*Eurostopodus diabolicus*). At the time of writing this document, species action plans have not been developed for other species in North Sulawesi.

It is hoped that this *M. nigra* SAP document will facilitate an evidence-based approach to inform and guide future conservation activities for *M. nigra*, and contribute to the conservation of their sympatric biodiversity.

1.1 Development of the Species Action Plan

A fundamental component of a comprehensive Species Conservation Action Plan (SAP) is to review the current information available as a foundation for further research investigations and conservation activities for the species. This may then be utilised to assess the situation facing the species and develop an appropriate strategy for its conservation. This approach and some of the principles of the *M. nigra* SAP will be transferrable to other regions and/or species, in particular, to other Sulawesi macaque species.

This *M. nigra* SAP is intended to be a 'living document', to be inclusive of all stakeholders, to promote broad ownership and responsibility for the conservation of the *M. nigra* and its habitat. Stakeholders include local village and district representatives, local and national government employees from the natural resources conservation agency (BKSDA), East Asean Growth Area (BIMP-EAGA) and the regional development planning department (Bappeda), as well as participating research and conservation non-government organisations (NGOs) and experienced individual representatives.

A biological assessment of *M. nigra* and an overview of their habitats is provided in Chapter 2. Thereafter, a systematic approach is taken to identify and prioritise the threats which endanger them and their habitats (CHAPTER 3. Threats). An overview of some of the previous conservation activities undertaken are listed in Chapter 4, along with a summary of data which are needed to further our understanding of this species and their habitat (See 4.4 Past, Current and Projected Conservation Action). Finally, this information is used to determine mitigations which if implemented will reduce the threats facing the survival of this iconic and important species (Chapter 5).

1.2 Vision, Mission and Goals

The vision for a species describes the desired future state for the species, based on an assessment of its current status and a detailed consideration of its conservation needs. For *M. nigra*, this represents a range-wide, long-term outlook. The mission describes the processes by which the vision may be developed, culminating in a set of site-specific measurable goals derived from these processes in operational terms. Goals are presented in both mid-term (5 years) and long-term (15 years) periods.

1.2.1 Vision statement

M. nigra flourish as self-sustaining populations in their native habitat within healthy, balanced and well-protected ecosystems and are recognised as a symbol of local and national pride.

1.2.2 Mission

Self-sustaining populations of *M. nigra* are ensured in their native habitat through reduction of threats, protection of their habitat and connectivity between populations. People throughout Indonesia, particularly in Sulawesi, are made aware of the ecological and cultural importance of *M. nigra*.

1.2.3 Goals

1. The conservation status of *M. nigra* and the extent of suitable habitat within their native range has been quantified by 2018.
2. A minimum of five significant *M. nigra* populations are stable or increasing within their native range by 2028.
3. Net annual loss of habitat occupied by *M. nigra* is reduced by 50% by 2028.
4. A minimum of five significant *M. nigra* populations are potentially connected to at least one other population within their native range by 2028.
5. Seventy-five percent of adults living near to significant *M. nigra* populations recognise that the species is globally threatened and protected under Indonesian law by 2018.

1.3 Location and Scope of M. nigra SAP

The scope of this SAP covers the distinct native range of *M. nigra*, including areas where they have been historically relocated to; Minahasa (North Sulawesi) and Bacan Island (Moluccas). The native range of *M. nigra* spans Minahasa with reported hybridization zones with *M. nigrescens* crossing into Bolaang Mongondow (see 2.4 M. nigra Population Status, Current Distribution and Demography). *M. nigra* are also present on Bacan Island, but the viability of this population is questioned. Therefore, along with the boundary of true range as far as the *M. nigrescens* zone into Bolaang Mongondow, although considered for future research and conservation activities conservation recommendations provided here are specifically applicable for Minahasa. As identified in the threat analysis in chapter 3, gaps remain in our

understanding of the distribution of the species, therefore more comprehensive census records are recommended in
to be sought as a priority.

1°29'35"N 124°50'29"E – Manado, the capital of North Sulawesi.

0°37'S 127°31'E – Bacan Island, South Halmahera, Moluccas.

CHAPTER 2. Biological Assessment of *Macaca nigra* and Its Habitat

M. nigra represents one of 22 species of the *Macaca* genus; the most ecologically diverse and geographically widespread of nonhuman primates (NHPs), within the Cercopithecidae family (see Table 1; Fooden, 1980).

Table 1. Taxonomic classification of *Macaca nigra* (Fooden, 1980; Lang, 2006).

Taxonomic group	Taxonomic nomenclature
Suborder	Haplorrhini
Infraorder	Simiiformes
Superfamily	Cercopithecoidea
Family	Cercopithecidae
Subfamily	Cercopithecinae
Genus	*Macaca*
Species	*Macaca nigra*

Currently seven macaque species are recognised on the island of Sulawesi, which represent a rapid diversification due to range restriction and fragmentation (Riley, 2010) despite comprising just a small fraction of the massive macaque range. This prominent example of speciation has been investigated by various researchers with suggestions that Sulawesi macaques originated from two colonisation events of *M. nemestrina* stock originally from Kalimantan (Fooden, 1967; Evans, 1999; 2003). However, the quantity and detail of the dispersal events has been long debated (Riley, 2010).

In addition to range restrictions, the social system of these macaque species (females philopatric, males obligate dispersers) is expected to strongly affect the dispersal and thus genetic variation within the Sulawesi macaques (Evans, 2003). Aside from the insular species *M. brunnescens,* hybridization occurs among all parapatric species of Sulawesi macaque (Groves, 1980; Supriatna, 1991; Watanabe & Matsumura, 1991; Bynum *et al.,* 1997). Although the location of current contact zones of *M. nigra* with adjacent populations of *M. nigrescens* are uncertain, individuals with intermediate characteristics, presumably hybrids, have historically been seen where the ranges of the two species meet (Sugardjito *et al.,* 1989).

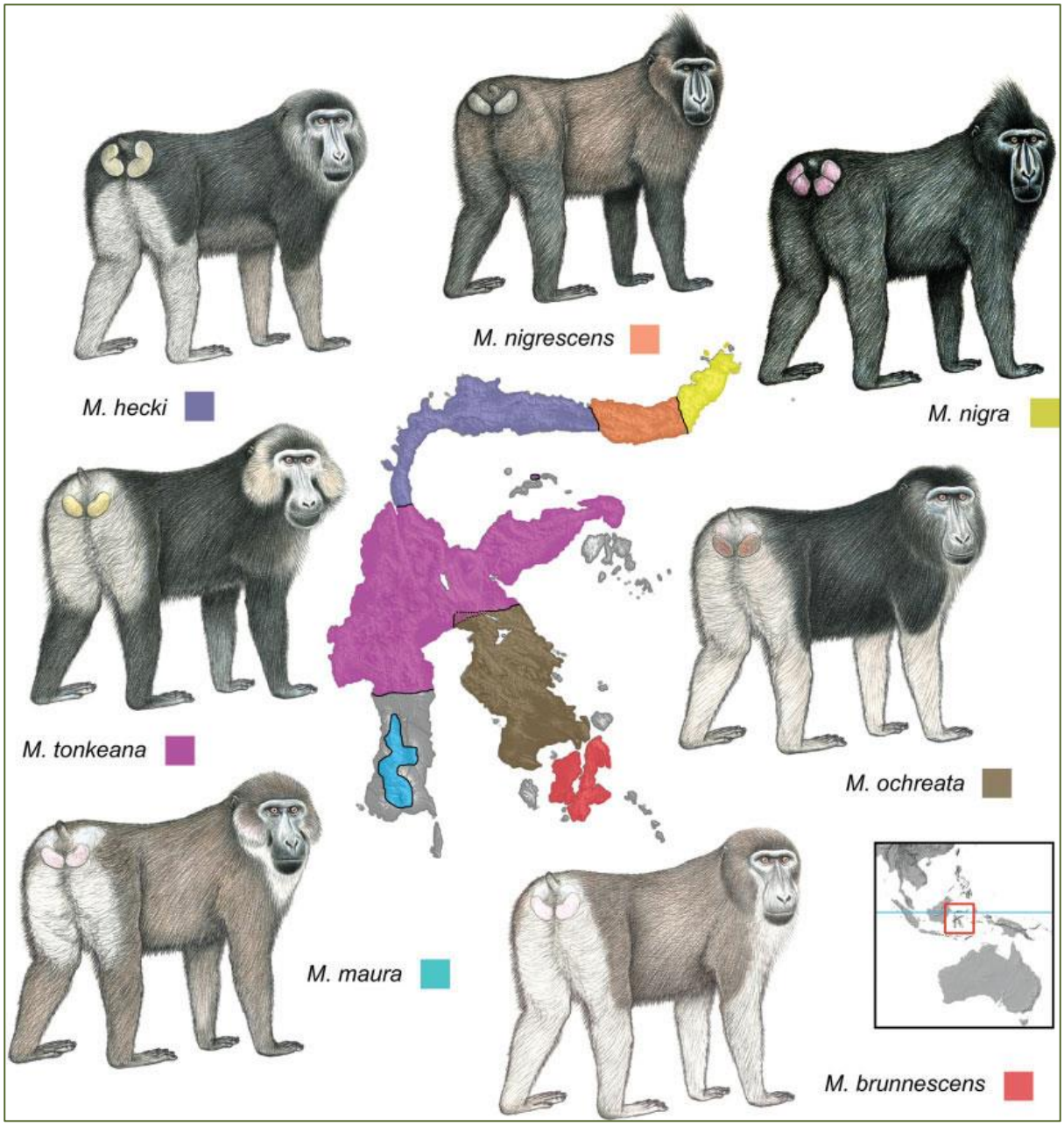


Figure 2. The diversity and distribution of the seven extant Sulawesi macaque species. Source: Riley *et al.,* (2010). Drawing courtesy of Stephan Nash and Erin Riley.

2.1 Species Characteristics

M. nigra have long narrow faces, with an elongated snout, a prominent brow and high bony check ridges (Groves, 2001). Initially thought to be without a tail, hence initially referred to as Celebes apes, *M. nigra* do in fact have a very short, hairless tail about 20mm long (Bynum, 1999). Juveniles are paler in colour than adults, and adult females are paler in colour than adult males (Fooden, 1969).

Table 2. Descriptive characteristics of *Macaca nigra* (Fooden, 1969; Thierry *et al.*, 2004; Lang, 2006).

Species characteristic	Value
Size (head and body-male)	520-570mm
Size (head and body-female)	445-570mm
Weight (male)	9.9kg
Weight (female)	5.5kg
Life span	18 years

M. nigra are distinct from the other Sulawesi macaques due to the crest of hair on their heads and pink ischial callosities; the latter are hairless skin pads on the rump which appear heart shaped in males and immature females, but after maturation and repeated tumescence this shape is often lost in older females. The oldest individual in captivity survived 34 years (Schulz, 2009). Average body morphometrics are summarised in table 2.

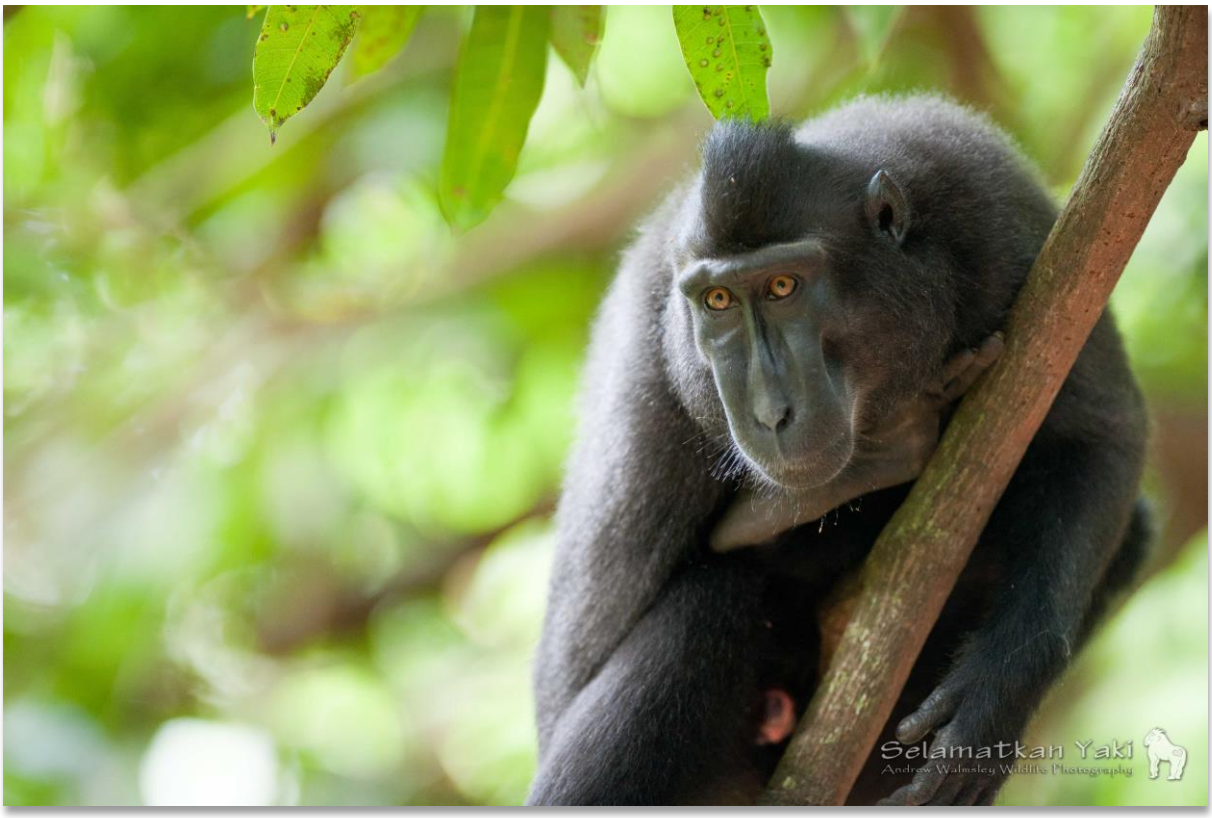


Figure 3. *Macaca nigra* are well recognised for their distinctive crest of hair and all black colouration.

2.2 Behavioural Ecology

M. nigra are considered semi-terrestrial, spending time moving throughout the trees and also on the ground moving quadrapedally (Rowe, 1996). They live in large, philopatric multi-male multi-female groups, with an alpha male at the top of the hierarchy (Kinnaird & O'Brien, 2000). Like other macaques species, *M. nigra* travel in groups of 5-25 animals, but may form large troops of over 100 when troops merge temporarily. *M. nigra* are sexually dimorphic in their vocalisation range and function

(Neumann *et al.,* 2010) and represent one of the few macaque species in which males utter loud calls (Wich & Nunn, 2002). Loud calls serve as a signal of dominance which has been suggested to be used to prevent contests between males for mates (Neumann *et al*. 2010).

2.2.1 Feeding Ecology

M. nigra individuals spend about 59% of their day foraging or eating food, two thirds of which consists of fruit from about 150 tree species (Kinnaird & O'Brien, 1997). During times opf fruit scarcity, they supplement their diet with invertebrates, shoots, young leaves and the stems of flowering plants (Riley, 2007; Supriatna & Andayani, 2008). Additionally, those bordering agricultural areas may opportunistically forage on food crops including maize (*Zea mays*), yams (Dioscorea), cassava (*Manihot esculenta*), papayas (*Carica papaya*), bananas (*Musa*), and cacao (*Theobroma cacao*) (Bynum *et al.,* 1999; Rosenbaum *et al.,* 1998; Riley, 2007). In Tangkoko Duasudara Nature Reserve (henceforth referred to as Tangkoko; see section 4.2) the fruit portion of the diet of *M. nigra* is dominated by the families Anacardiaceae and Moraceae, with *Ficus* spp. being preferable during periods of availability (Rosenbaum, 1998).

Daily movements and home range size is directly related with food availability; in areas where food is scare groups sizes are smaller and travel further, than groups with abundant food availability (O'Brien & Kinnaird, 1997).

2.2.2 Reproductive Biology

The reproductive biology of wild *M. nigra* is a focus of research for the resident research group based in Tangkoko, *Macaca Nigra* Project (Engelhardt & Farajallah, 2008). *M. nigra* are sexual bimaturists; females are recognised to mature at about 4-5 years old, though 3 year old females have successfully conceived in zoos, and males are considered mature at about 7 years (O'Brien and Kinnaird, 1998; Melfi, 2010). Females are philopatric whilst males are obligate dispersers.

M. nigra are promiscuous, or polygynandrous; both male and female have multiple mates. They breed year-round, although periods of high ovarian activity among adult females occur from August to June, and birthing peaks between January and May (Engelhardt & Farajallah, 2008); this peak reflects fluctuations in food availability. As with other macaque species, the anogenital area of female *M. nigra* becomes swollen to indicate ovarian activity and sexual receptivity, roughly every 33-36 days; immature females will often show smaller sexual swellings. Males will further investigate female reproductive status by sniffing female genitalia (Engelhardt & Farajallah, 2008). Sexual swellings have also been observed when females are not ovulating (Thomson *et al.,* 1992), which has been observed at times of high tension in captive *M. nigra* groups (pers. comm. Melfi). Adult males have been observed to copulate at roughly similar frequencies, although adult females approach high-ranking males for sex more often than they do low-ranking males (Reed *et al.,* 1997).

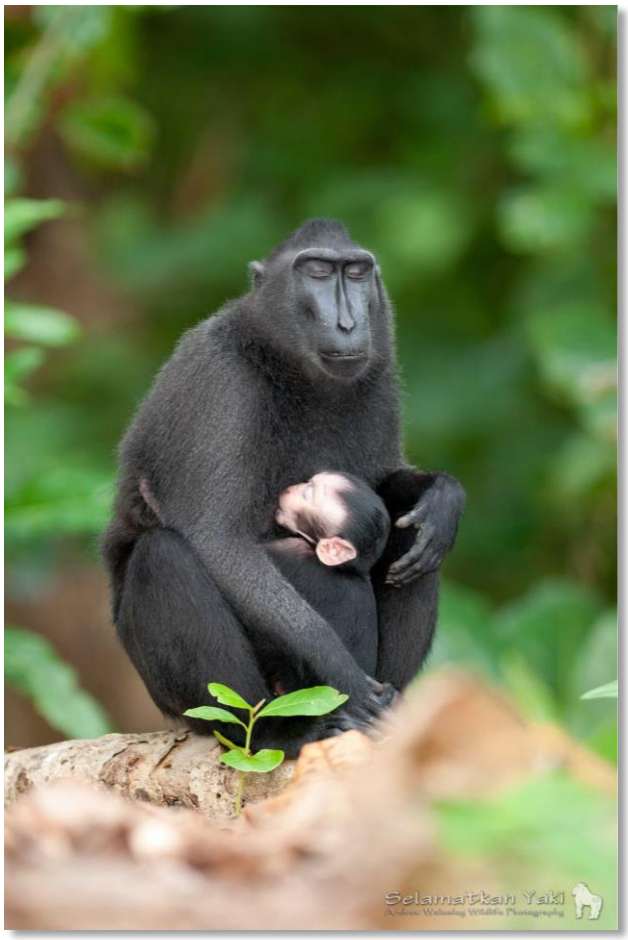


Figure 4. *M. nigra* infants are weaned after about one year of age, having spent the first few months close to their mother.

A single infant is born after a gestation period of 5.5 months, following an interbirth interval of about 18 months (Lang, 2006). At birth, infants have black hair and for about 4-5 months pink skin; this is conspicuous on their face, ears, hands and feet. It is thought that this colouring may act as a warning to other members to take care when interacting with the mother, so as not to injure the baby, which usually clings to her belly. Youngsters spend less time with their mothers once they reach 4 months old and are fully weaned at about a year. Black macaques reach sexual maturity at 4-6 years and may live to be 20-25 years old. Infant mortality is quite high, with around 20% of infants not surviving to weaning age.

2.3 Habitat and Resource Assessment

2.3.1 Physical Geography

Sulawesi is the largest island included in the biogeographically unique region of Wallacea which totals a land mass of 347,000 km^2. Separated from the rest of Indonesia by the Wallace's Line and from Australia-New Guinea by the Lydekkeer's Line, the flora and fauna of Wallacea have evolved to represent a high degree of endemism. As such this area has been designated as one of 34 global biodiversity hotspots by Conservation International (Myers *et al.*, 2000).

The island of Sulawesi covers 174,600 km^2, and is divided into six provinces (Figure 4). North Sulawesi encompasses the regency of Minahasa, recognised as the native range of *M. nigra*.

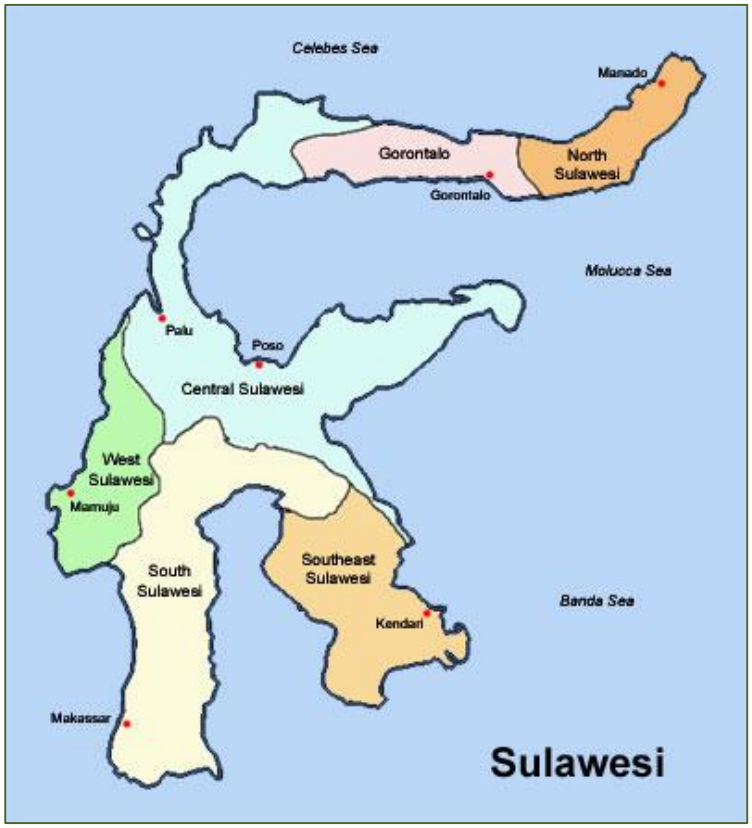


Figure 4. The island of Sulawesi is divided into six provinces.

2.3.2 Climate

North Sulawesi experiences a tropical rainforest climate (Peel *et al.*, 2007). As such the temperature is relatively constant throughout the year at about 30°C. It is noticeably wetter from November to June, but rainfall is always >100mm/month. Climate is closely related to wind direction: from June to September dry winds coming from the direction of Australia bring the dry season, and in December to March, winds from Asia and the Pacific Ocean create the rainy season.

Table 3. Climate data for Manado.

Month (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Record high	33	33	38	38	38	37	37	35	36	39	38	40	40
Average high	28	28	28	29	30	30	30	31	31	30	29	29	29.5
Average low	24	23	24	24	24	24	23	24	23	23	23	24	23.7
Record low	20	20	19	20	17	16	18	18	18	18	15	21	15
Precipitation mm	420	360	300	220	190	180	140	110	110	140	240	350	2,760

2.3.3 Habitat Type and Land Use

M. nigra are generalists and well adapted to inhabiting a wide range of habitats including lowland and montane primary forests, early and mature secondary forests, actively logged forests, mangroves and agricultural areas (Rosenbaum *et al.,* 1998).

Lowland tropical rainforest dominates the majority of Tangkoko (Whitten *et al.,* 2002) with partial sub-montane and cloud forest towards the summit of Mt Tangkoko, one of 3 volcanoes alongside Mt Batuangus and Mt Duasudara (MacKinnon & MacKinnon, 1980).

Several studies in Tangkoko suggest that *M. nigra* prefers intact compared to disturbed forests, with macaque abundance correlating with canopy tree density and mean basal area (O'Brien & Kinnaird, 1997; Rosenbaum *et al.,* 1998; Palacios *et al.,* 2012). As a key species within their habitat, the presence of *M. nigra* populations provide a good indication of the current health of the ecosystem.

Figure 5. A typical forest scene in Minahasa (North Sulawesi), the native habitat of *M. nigra*.

2.3.4 Social Geography

Sulawesi has a population of 16 million people. The 2010 census reports that North Sulawesi is home to about 2,265,937 people, at a density of 163.6 people/ km^2; the second highest population after South Sulawesi, following a population growth rate of 1.35% (BPS, 2010). The majority of people in Indonesia are Muslim (86.9%), though there are regions which are predominantly Christian. This is true of North Sulawesi, where it has been estimated that approximately 85% of people in Minahasa are Christian (KSPSU, 1994 cited by Lee, 2000).

As is the case throughout the Indonesian archipelago, Bahasa Indonesian, the official language of the Republic of Indonesia is spoken as standard across North Sulawesi. Bahasa is a standardized register of Malay, an Austronesian language which has been used as a 'lingua franca' in the Indonesian archipelago for centuries.

2.4 M. nigra Population Status, Current Distribution and Demography

Figure 6. Locations of census surveys undertaken to estimate *M. nigra* population density within their native range, Minahasa.

M. nigra occur in Minahasa, North Sulawesi, Indonesia. Surveys of villagers suggest that few macaques exist outside the protected areas (Feistner, 2001; See 3.4.6.1 Recreational activities (IUCN-CMP 6.1). Although the location of current contact zones with adjacent populations of *M. nigrescens* are uncertain, individuals with intermediate characteristics, presumably hybrids, have historically been seen where the ranges of the two species meet (Sugardjito *et al*., 1989; Watanabe & Matsumura 1991).

There has been an undisputed decline in *M. nigra* populations in their native range since the first population surveys conducted in the 1970s. Since this time various surveys have been conducted, with a bias towards those estimating population densities in Tangkoko (see Table 4); limitations of extrapolating these data to make population estimates have been described by Melfi (2010). Population declines may be as dramatic as 90% within 30 years, according to results of research between 1980 and 1998 (Melfi 2010). *M. nigra* were once estimated to number about 300 individuals/km^2 (MacKinnon & MacKinnon, 1980). However, over the following years, repeat surveys revealed dramatic drops in densities to 76 individuals/km^2 (Sugardjito *et al.,* 1989); a further 10 years later population estimates reached 66.7 individuals/km^2 in Tangkoko, with estimates as low as 23.5 individuals/km^2 for Duasudara (Rosenbaum *et al*., 1998). Recent surveys estimated the *M. nigra* population at 44.9 individuals/km^2 (Palacios *et al.,* 2012), although one long-term assessment of a single transect in Tangkoko revealed an increase in population density to 61.5 individuals/km^2; however the estimations are limited to the core of the reserve where the transect is located (Keyes *et al.* 2013).

Most survey data have been collected in and around Tangkoko, which has been suggested to be the last viable *M. nigra* population in their native range (Rosenbaum *et al.,* 1998; Melfi, 2010; Palacios *et al.,* 2012; Keyes *et al.,* 2012).

Table 4. Summary of census surveys undertaken to estimate *M. nigra* population density within their native range.

Authors	Year	Pop^{n*}	# Transects	Distance (km)	Locations
MacKinnon & MacKinnon	1980	300			Tangkoko
Sugardjito	1989	76	7	193.5	7
Rosenbaum	1998	66.7	13	1,449	Tangkoko; Bacan
WCS (Lee)	2000	40	11	173.5	3
Melfi	2007	/	52	150.14	22
Palacios	2011	44.9	13	40.4	Tangkoko
Keyes	2012	61.5	1	3.6	Tangkoko

* Population = individuals/km^2

There are anecdotal sightings of *M. nigra* on nearby islands, but with one exception these are largely unsubstantiated. Since the mid-1800s *M. nigra* has been reported on Bacan Island; approximately 300km Southeast of North Sulawesi. In 1998, Rosenbaum *et al.* surveyed *M. nigra* on Bacan and estimated a population around 100,000 animals. The large population density estimate of 170 individuals/km^2 on Bacan is however not included within the IUCN threat assessments due to being outside of the native range (Supriatna & Andayani, 2008).

The current status of this population is largely unknown, although a reconnaissance trip to Bacan Island in 2013 reported high abundance and large areas of intact primary forest and likely suitable habitat to support this large population (Hilser *et al.,* 2013).

2.5 Conservation Status

M. nigra appear to have been extirpated in areas of their native range, along with other sympatric species (e.g. anoa, Burton *et al.,* 2005; babirusa, Clayton & Milner-Gulland 2000) and without immediate intervention face an uncertain future.

Table 5. Species nomenclature, distribution and threat status (as per Fooden, 1980).

Species *name*	Common name	Distribution	IUCN red list category
Macaca nigra	Crested black	North East	Critically Endangered
Macaca nigrescens	Gorontalo	North	Vulnerable
Macaca hecki	Heck's	North West	Vulnerable
Macaca tonkeana	Tonkean	Central	Vulnerable
Macaca Maura	Moor	South West	Endangered
Macaca ochreata	Booted	South East	Vulnerable
Macaca brunnescens	Buton	Islands Buton and Muna (SE)	Vulnerable

M. nigra is currently listed as Critically Endangered on the IUCN Red List following an assessment in 2008 (Supriatna & Andayani, 2008). The classification of A2cd concludes that the species has declined by more than 50% in the last 10 years or three generations and that the decline in mature individuals has been caused by a decline in the quality of habitat as well as actual levels of exploitation. Prior to this classification, the species was designated as Endangered in 1996 and 2000 assessments.

There is a managed captive population of *M. nigra*, particularly predominantly held in European zoos (see 4.5 Ex-situ Population Management).

M. nigra are recognised as an important umbrella species, representing the unique biodiversity of North Sulawesi (Roberge & Angelstam, 2004; Melfi, 2010; Riley, 2010).

Primates have been shown to augment conservation efforts as representative flagship species, facilitating support of projects aimed at protecting their habitat and its biodiversity (Dietz *et al*. 1974; Mittermeier, 1988). Additionally, as the species is highly frugivorous (see 2.2.1 Feeding Ecology) they are also efficient seed-dispersers, especially for species of *Dracomelon* and *Ficus* (Rosenbaum *et al.,* 1998b) and therefore represent a key element in maintenance and regeneration of forest habitat (Corlett, 1998; McConkey, 2009) thus sustaining the network of health throughout the ecosystem.

Figure 7. With dramatic population declines in recent years, *M. nigra* is now Critically Endangered and in need of conservation measures.

CHAPTER 3. Threats

3.1 Background

It is clear from many other threat assessments of endangered species that primate population declines are being driven at an unprecedented rate by human activities such as forest conversion and hunting (Cowlishaw, 1999; Sodhi et al., 2004; Marshall et al., 2006; see 3.4.5.1 Hunting and Collecting of Terrestrial Animals (IUCN-CMP 5.1)).

M. nigra faces a range of threats, but it is commonly recognised that the majority of population declines are likely to be due to overharvesting (Lee, 2000). Other pertinent threats include human induced habitat loss or disturbance and persecution at the human-wildlife interface, largely through raiding of agricultural crops (Rosenbaum *et al.,* 1998; Bynum *et al.,* 1999). This SAP includes a comprehensive and inclusive analysis of all potential threats to both the species and their habitat, the results of which are presented in Table 6 and in Appendix II. *Complete Outcome of Macaca nigra Threat Analysis Using IUCN-CMP Criteria (IUCN-CMP, 2008)*.

A threat is defined as a factor which causes either a substantial, population decline, or contraction of the species' geographic range (Salafsky *et al.,* 2003, 2008). The Conservation Measures Partnership (IUCN-CMP, 2008) published a list of threats which are often referred to when identifying factors which are compromising the survival of species and habitats (see Appendix IV: Criteria for Direct Threat Ratings Using a Simple Method (WWF, 2007).

Threats are often referred to as direct threats or contributing factors (Salafsky, 2008):

1. Direct threats: The proximate human activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity targets, e.g. hunting macaques, logging.

2. Contributing factors: The ultimate factors, usually social, economic, political, institutional, or cultural, that enable or otherwise add to the occurrence or persistence of proximate direct threats, e.g. increased human populations increase disturbance in forests, which negatively impact on macaque breeding success.

3.2 Initial threat rating

Effective conservation needs to identify which threats are of greatest risk to the continued survival of a species or habitat. Harry Hilser, Helen Sampson and Vicky Melfi (current and past Selamatkan Yaki programme managers and founder, respectively) conducted two preliminary threat assessment exercises, to determine which IUCN-CMP threats posed the greatest risk to *M. nigra* and their habitats.

Each IUCN-CMP threats are scored on three different components, scope, severity and irreversibility (1 = low, 2 = medium, 3 = high, 4 = very high; see Appendix IV: Criteria for Direct Threat Ratings Using a Simple Method (WWF, 2007).).

Scope: proportion of the target (*M. nigra* population or their habitat occurrence) that can reasonably be expected to be affected by the threat within 10yrs given the continuation of current circumstances and trends.

Severity: level of damage to the target (degree of *M. nigra* population decline or habitat destruction or degradation) from the threat that can reasonably be expected given the continuation of current circumstances and trends.

Irreversibility: degree to which the effects of a threat can be reversed and the target affected by the threat restored.

Where possible threat ratings were made on the basis of evidence (presented in 3.4 3.4 Evidence), however in some instances little or no evidence was found. As such a a confidence level was ascribed to threat ratings to ensure transparency; a subjective subjective rank from 0 - 5 (0 = educated guess, 5 = good quality data available). Further data required are listed in

.

Table 6. Summary of IUCN-CMP threats rated as high risk according to their impact on a) *M. nigra*, b) their habitats, or c) both of these factors. Threats were scored 1 – 4, where1 = low and 4 = very high, therefore the maximum summary threat rating was 12 for a and b, and 24 for c.

A.

Threat		*M. nigra* Population Rating			Summary Threat Rating
		Scope	Severity	Irreversibility	
5.1	Hunting & collecting of terrestrial animals	Very High (4)	Very High (4)	Medium (2)	**10**
2.1	Annual & perennial non-timber crops	High (3)	High (3)	High (3)	**9**
1.1	Housing & urban	Medium (2)	Medium (2)	Very High (4)	**8**
5.3	Logging & wood harvesting	High (3)	High (3)	Medium (2)	**8**
1.3	Tourism & recreation	Medium (2)	High (3)	Medium (2)	**7**

B.

Threat		*M. nigra* Habitat Rating			Summary Threat Rating
		Scope	Severity	Irreversibility	
2.1	Annual & perennial non-timber crops	High (3)	High (3)	Very High (4)	**10**
1.1	Housing & urban	Medium (2)	High (3)	Very High (4)	**9**
2.3	Livestock farming	High (3)	High (3)	High (3)	**9**
3.2	Mining	Medium (2)	Very High (4)	High (3)	**9**
5.3	Logging & wood harvesting	High (3)	High (3)	High (3)	**9**
7.1	Fire & fire suppression	High (3)	High (3)	Medium (2)	**8**
4.1	Roads & Railroads	Medium (2)	High (3)	High (3)	**8**

1.3	Tourism & recreation	Medium (2)	High (3)	Medium (2)	**7**

C.

Threat		Overall Summary Threat Rating	Confidence Level	Direct/ Contributing
2.1	Annual & perennial non-timber crops	**19**	5	Direct
1.1	Housing & urban	**17**	4	Contributing
5.1	Hunting & collecting of terrestrial animals	**16**	5	Direct
2.3	Livestock farming	**15**	3	Contributing
5.3	Logging & wood harvesting	**15**	4	Direct
3.2	Mining	**15**	5	Contributing

3.3 Threat rating exercise outcome

Of the 40 IUCN-CMP threats considered, the greatest risk to *M. nigra* populations was '5.1 Hunting and collecting terrestrial animals' and the largest risk to their habitats was '2.1 Annual and perennial non-timber crops'; both were assigned a score of 10, out of a possible 12.

Threats scored 7 or above represented high risk to the future survival of *M. nigra* and/or their habitats. Five threats were scored 7 or above for *M. nigra*, whereas eight threats were scored 7 or above for their habitats (see Tables 6 a, b, c).

Scores were combined to determine which threats pose most risk overall. Threat '2.1 Annual and perennial non-timber crops' was found to be the greatest risk, followed by a further five threats which scored 15 or above out of a potential score of 24 (Table 7c). Half of these threats (3) were considered direct threats, the others (3) contributing factors.

3.4 Evidence

Every effort has been made to collate sufficient evidence to adequately score the each threat. A summary of the extent of the data collated, in terms of its relevance to rating the scope and severity of IUCN-CMP threats (Table 8). No experimental or comparative evidence were collected which described the extent to which threats maybe considered irreversible, or for the following threats: 1.2; 2.2; 2.4; 3.1; 3.3; 4.2; 4.3; 4.4; 5.2; 5.4; 6.2; 6.3; 7.1); Natural system modifications (7.1-7.3); Invasive and other problematic species and genes (8.1-8.3); Pollution (9.1-9.6); Geological events (10.1-10.3); Climate change and severe weather (11.1-11.4).

Table 8. Summary of evidence collated, presented and used in the initial threat rating assessment (2013).

Threat	Scope	Severity	GAP
1.1	*** large popn growth	*** if indirect measure of human disturbance	
1.2	* map of planned development		
1.3	**	*	
2.1	*	**	
2.3	*	*	
2.4			
3.2	*		
4.1	* map of planned roads	*	
5.1	***	***	
5.3	*		
6.1	**	*	

Where evidence is lacking, the background knowledge of stakeholders has been used to make initial threat ratings; these will be updated with the input from a larger group of stakeholders after the 'Species Action Plan' workshop (16th-18th April 2013). Further evidence is also being sought to fill gaps in knowledge or to provide a more accurate representation of the situation (Table 8).

3.4.1 Residential and Commercial Development (IUCN-CMP 1)

3.4.1.1 Housing and Urban (IUCN-CMP 1.1)

Human encroachment into habitat via expansion into both urban and rural areas is a significant global threat endangering many primate species (Cowlishaw & Dunbar, 2000). Aside from loss of suitable habitat, as human-dominated ecosystems become increasingly common, crop-raiding by NHPs and other animals becomes an integral aspect of their behavioural ecology consequently growing in significance as a human-wildlife concern (Naughton-Treves *et al.,* 1998; Priston, 2005; Strum, 2010). The antagonistic relationship may include detriment to local community resources and economy and reduction in primate numbers as a result of pest control and the greater accessibility for hunting and acquisition of pets.

The economy of the six provinces of Sulawesi grew by 24 % from 2000 to 2008; compared to 16.7 % recorded nationally for Indonesian (BPS, 2010).

In North Sulawesi, there has been an almost fourfold rise in population of 385% over a 90 year period from 1920 to 2010, from over 587,000 people to 2,226,000 people respectively, representing a significant rise (BPS, 2010). Much of this increase in population has been centralised within the cities, with Manado maintaining a population density of 2,659 people per km^2 in 2009 (BPS, 2010).

The socio-economic and religious demographic of Minahasa is unusual within Indonesia, and Sulawesi, as 85-90% of the population are Christian and are considered relatively wealthy; though the distribution of this wealth has been noted to be extremely unbalanced (O'Brien & Kinnaird, 2000). The human population in Minahasa

has increased substantially in the past few years, which is due to both 'natural' population growth and also transmigration within Indonesia.

Bitung City, which is situated directly below Tangkoko, is an industrial area of the Special Economic Zones (KEK) in North Sulawesi Province. The population of Bitung City amounted to 205,146 inhabitants in 2009. Compared to the results of the last population census of 140,270 individuals in 2000, there has been a yearly average population growth of 3%. If associated with an area of 313 km^2 population density in Bitung City in 2009 reached about 654 inhabitants per square kilometer (BPS, 2010).

Rises in human population necessitates increased infrastructure; Appendix VI. Urban infrastructure planned for North Sulawesi over two decades, 2010 – 2030 illustrates planned urban developments in Northern Sulawesi.

3.4.1.2 Tourism and Recreation (IUCN-CMP 1.3)

Tourism in regions of high ecological value has risen dramatically over the past few decades and now represents a fast growing global industry; in 2007 it was estimated to represent $77 billion of the global tourism market, but estimates suggest this has grown to approximately $473 billion and occupying 25% of the tourism industry (Kipling Newsletter, 2007; LOHAS, 2010). Various different definitions are given to describe tourism to wild places, see below (TIES, 2006; Chafe, 2006; CREST, 2010), but they can all have both negative and positive impacts on the areas that are visited, and indeed the species that tourists come to see.

Figure 8. Tourism surrounding macaque habitat may increase some threats to the species, but has the potential to bring multiple benefits if managed well.

The number of domestic tourists to North Sulawesi increased from 1,798 persons in 2007 to 2,130 people in 2008 (BPS, 2010). Currently, the City of Bitung has 20 attractions, including a zoo. The zoo houses a variety of native Sulawesi animals, including various macaques. The providence of these animals is unknown, as is the contribution the zoo makes to conservation, education and tourism. North Sulawesi has included the development of ecotourism infrastructure as a top priority in its development strategy for 2010-2015 (pers. comm. Noldy Tuereh). *M. nigra* are marketed as a key attraction but only at Tangkoko. Visitor numbers to Tangkoko have remained relatively stable over the past 10 years and include local visitors using the recreation park and more often foreign visitors who spend more time visiting the nature reserve than local visitors (Paulus, 2008).

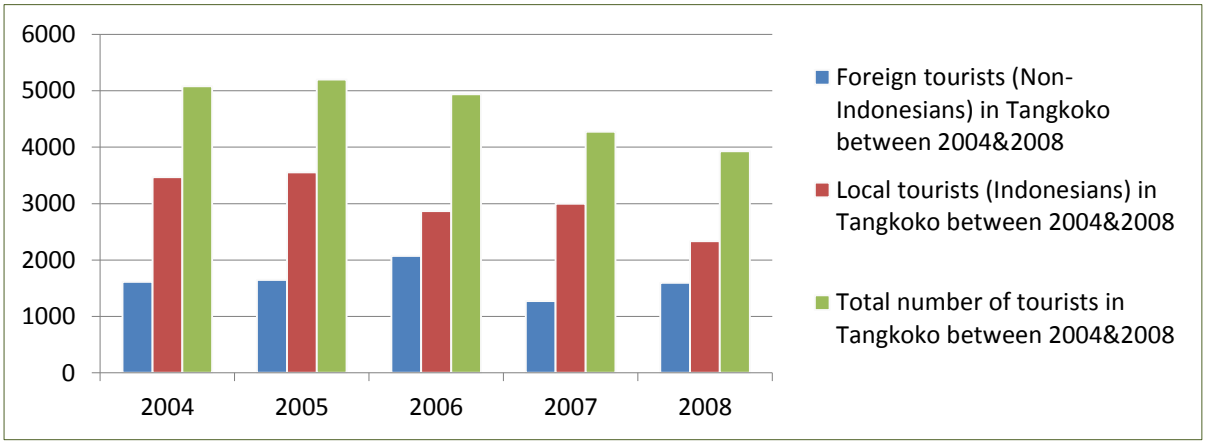


Figure 9. Total number of visitors registered as entering Tangkoko, from 2004-2008 (Paulus and Melfi, in prep.).

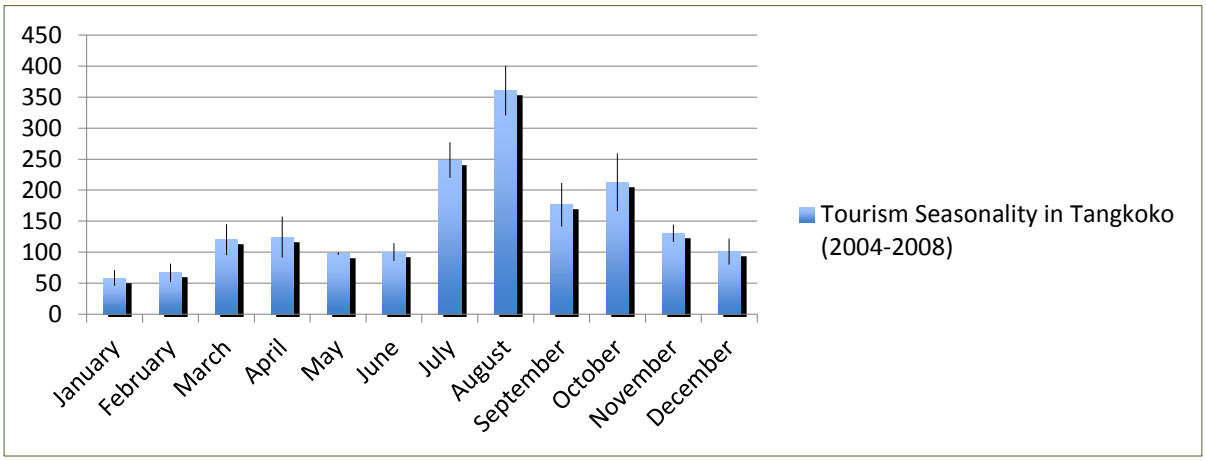


Figure 10. Seasonality of visitors registered as entering Tangkoko, from 2004-2008 (Paulus and Melfi, in prep.).

It has been recognised that tourism has the potential to bring benefits to conservation programmes if managed properly (see 4.2.1 Tourism in protected areas), however it can also be responsible for negative impacts which can reduce the effects of potential benefits. Potential tourism can negatively impact species and habitats by increasing the ease with which people can gain access to wild spaces, facilitating hunting (see3.4.5.1 Hunting and Collecting of Terrestrial Animals (IUCN-CMP 5.1)),

increasing disease risks through direct or indirect transfer (see 3.4.6.1 Recreational activities (IUCN-CMP 6.1)), environmental change and degradation, pollution, and finally contributing to or causing stress and behaviour change in the target species (e.g. Macfie & Williamson 2010).

In 1996, Kinnaird and O'Brien (1996) described the tourist activities at Tangkoko to represent a threat to *M. nigra* conservation (Kinnaird & O'Brien, 1996). *M. nigra* individuals and groups have been observed to flee and vocalise when tourist numbers exceed five people (Kinnaird & O'Brien, 1996). There are also numerous observations where the tourist codes of conduct have not been heeded (pers. comm. Antje Engelhardt). Tourism could be improved through comprehensive guide training, including better education, training in English, certification and clarification of reserve policy and regulations. Furthermore, mass local tourism on the beach would benefit from tighter management and rules of the reserves enforced (pers. comm. Antje Engelhardt). Although tourism does not represent as prominent or direct a threat as hunting or habitat loss, it is a contributing factor which could be minimised through cooperative management with the tourism board, guide association, local communities and NGOs therefore complementing the other conservation activities in the area.

3.4.2 Agriculture and Aquaculture (IUCN-CMP 2)

3.4.2.1 Annual and Perennial Non-timber Crops (IUCN-CMP 2.1)

Sulawesi contributed 4.2 % of national Gross Domestic Product (GDP) of Indonesia in 2008. A third of this contribution (1.4%) was generated from agriculture; historically a non-intensive agricultural systems has been adopted and the production of low value added agricultural products (BPS, 2010).

Since the 1970s large scale commercial agriculture has been supported in North Sulawesi. According to the results of Landsat imagery, 42% of North Sulawesi's total land surface still consists of forested area (BPS, 2010).

To meet the demands of a growing population but still sufficiently meet their nutritional needs, agricultural output needs to increase. Consequently the city of Bitung has increased their agricultural crop production from 6016 tons in 2008 to 15,089 tons in 2009 (BPS, 2010).

Unavoidable impacts of the increase in agriculture are likely to be widespread land conversion and land degradation. In addition, increased commercial agriculture is associated with increased human encroachment into habitat occupied by *M. nigra*, causing fragmentation in the population and reduced contiguous forest available to the species.

Though not normally vulnerable to fires even during drought, tropical forests that are severely logged are at high risk of destruction by wildfires (Siegert *et al.,* 2001). Severe drought have been associated with periods of El Niño, during which time the logged forests can be particularly sensitive to fire activity which can become uncontrollable; in these circumstances fires started by people can lead to significant damage (Siegert *et al.,* 2001).

The use of fire is widely employed as a tool to clear land for commercial and subsistence agriculture as well as hunting in some areas of Indonesia.

Coconut plantations: a special case

Coconut trees are widely distributed throughout Northern Sulawesi, growing in coastal areas from sea level to mountainous areas at elevations more than 600 meters above sea level. The total registered area set aside for coconut plantations was 274,917 hectares in 2009 (Plantation Agency of North Sulawesi, 2009). Around 93 % of these plantations are operated by smallholders, the remainder are owned by private companies. As with many areas, coconut dominates the crop grown in plantations; in the city of Bitung coconut represents the majority of the 10,986 tonnes plantation production.

In the future, it is anticipated that land conversion to coconut may rise significantly, to meet the demands of European and American 'health food' markets; where production does not currently meet demand (Sutherland *et al.,* 2012).

Now dominating much *M. nigra* native habitat, coconut plantations represent a serious threat to the survival of the species and the integrity of it's native habitats.

Figure 11. Coconut palms make up a majority of smallholder crops in Minahasa.

Crop-raiding

An increase in human-dominated ecosystems, fragmentation of primate populations and overlap between human agriculture and primate habitats, leads to a reduction in food availability for NHPs and the subsequent opportunistic raiding of crops. Crop-raiding by NHPs and other animals can become an integral aspect of their behavioural ecology (Naughton-Treves *et al.,* 1998; Priston, 2005; Strum, 2010). The raiding of agricultural crops by non-human primates has become one of the most widespread human-wildlife conflicts (Priston, 2005; Tweheyo *et al.,* 2005; Woodroffe *et al.,* 2005). The antagonistic human-animal relationship is likely to be detrimental to the local community, in terms of economic losses, but also result in increased mortality of primate populations as a consequence of pest control measures.

Though data are not available which have measured the level of crop-raiding behaviour currently expressed by *M. nigra*, anecdotal reports suggest there is little tolerance for this behaviour and villagers often set traps and snares on the borders of their gardens to catch offending *M. nigra* (*pers. comm. Macaca Nigra* Project; see also Rosenbaum *et al.,* 1998; Bynum *et al.,* 1999). Preventing crop-raiding through opportunistic hunting of *M. nigra* is an emerging concern, in Minahasa, though it appears to have been practised for some time on the island of Bacan (*pers. comm.* Harry Hilser).

3.4.2.2 Livestock Production (IUCN-CMP 2.3)

North Sulawesi maintains relatively large numbers of livestock; numbering 106,598 cattle, 42,814 goats, 320,136 pigs and 7,676 horse in 2009 (BPS, 2010). Production of livestock is associated with various potential negative ramifications, for example waste management, habitat conversion for grazing and other contributing factors. Furthermore, livestock farming is land and resource intensive; further contributing to land change and degradation.

Livestock farming may indirectly pose a risk to wild *M. nigra* populations, as domesticated animals such as cats, dogs, birds and livestock animals, may act as potential reservoirs for infectious disease and cause potential population crashes (Contacos, 1970; Sapolsky, 1987; Fayer *et al.,* 2000; Lewis *et al.,* 2002).

3.4.3 Energy Production and Mining (IUCN-CMP 3)

3.4.3.1 Mining (IUCN-CMP 3.2)

Current mining concessions in Northern Sulawesi are illustrated in Figure 12. The provincial government rank the mining and energy sector third in their priority for development in North Sulawesi (including the development of hydro and geothermal plants).

British-based Archipelago Resources and Austindo have invested about US$300 million in Indonesia. The firm controls over 741,000 hectares of mining concessions in Minahasa that is estimated to produce 162,000 ounces of gold every year. In 2012, the North Minahasan Head of Government granted a permit to the Chinese company Mikgro M*et al.,* PerdanaPlc (Aempire Resource Hongkong) to mine iron ore on Bangka Island (Company Exploration Permit No. 162/2010). The "Forum Save Bangka Island", which was launched by islanders, environmental organisations and dive resorts, pressed charges against the Bupati (local council) on grounds of corruption and violation of law and has taken the case to the Indonesian National Commission on Human Rights; they suggest the mining licence granted to the Chinese company violates Indonesian laws (UU No. 27/2007 relating to the management of coastal areas and small islands; UU No. 4/2009 relating to minerals and coal, UU No. 26/2007 relating to regional management; UU No. 32/2009 relating to the conservation and management of the environment; UU No. 10/2009 relating to tourism (Wand & Jackson, 2012).

Extensive illegal open area mining occurs across North Sulawesi, and is particularly detrimental, where mercury is used to find gold; an activity which even takes place in protected areas, causing habitat destruction through direct clear-cutting of forest accompanied by pollution from mercury run off (Aspinall, 2011). Although not directly measured empirically, it is likely that remaining *M. nigra* habitat would be further degraded through environmental impacts as a result of mining operations, especially if more concessions are likely to be established in proximity to populations of *M. nigra*.

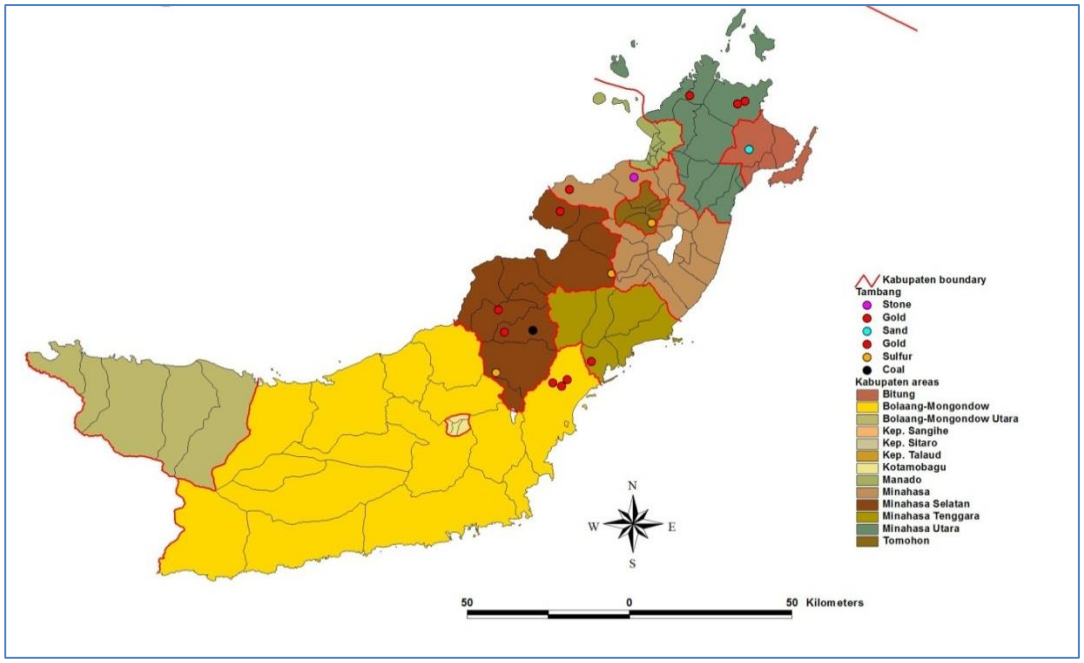


Figure 12. Distribution of registered mines throughout North Sulawesi (Aspinall, 2011).

3.4.4 Transportation and Service Corridors (IUCN-CMP 4)

3.4.4.1 Roads and Railroads (IUCN-CMP 4.1)

Growing human population and expansion of urban areas requires growth of transportation links, exacerbating habitat loss, disturbance and greater exposure to other threats such as hunting through increased accessibility.

The most extensive transport development is a 45km toll road in construction, at the time of writing this document, which will run between the two major cities in Minahasa, between Manado and Bitung. Amongst the benefits the road is anticipated to yield, the development agency also hopes it will facilitate the growth of Bitung as a major dock and hub for tourisM. Several other road developments have been proposed in the North Sulawesi Transportation Systems Development Programme (see Figure 13 below). Plans include construction of two large ring-roads which will encircle the cities of Tondano and Tomohon, both adjacent to known *M. nigra* habitat.

As road networks increase and become more extensive native *M. nigra* forest habitat has to be cleared, and people have easier access to previously wild spaces. Furthermore, the position of the planned road systems will further fragment *M. nigra* habitat.

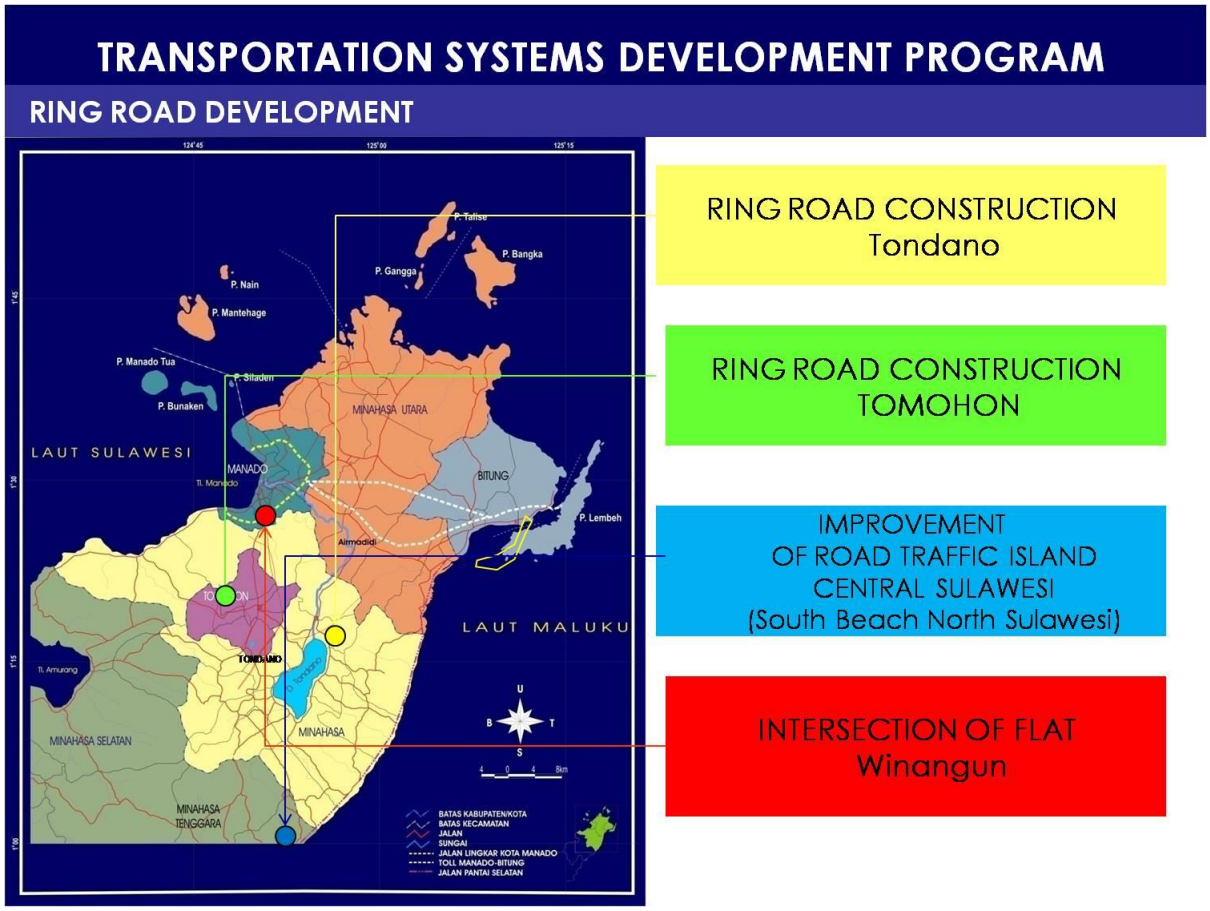


Figure 13. Proposed developments in the transportation system for North Sulawesi (Tuerah, 2010).

3.4.5 Biological Resource Use (IUCN-CMP 5)

3.4.5.1 Hunting and Collecting of Terrestrial Animals (IUCN-CMP 5.1)

Hunting rates of endemic species in Northern Sulawesi have been demonstrated to be unsustainable (O'Brien & Kinnaird, 2000; Lee, 2000), and led to local extirpation of species throughout Minahasa such as anoa and babirusa (Burton *et al.,* 2005; Clayton & Milner-Gulland, 2000).

The predominantly Christian population in Minahasa are not food restricted due to religious doctrine unlike those following other religions. O'Brien and Kinnaird (2000) suggested that *M. nigra* hunting was fuelled by commercial demand, for sale in local bushmeat markets throughout the region. North Sulawesi is a well-developed and relatively affluent province within Indonesia, thus people are rarely dependent on *M. nigra* to satisfy their nutritional requirement; instead they can gain high levels of protein and calories from various 'non-bushmeat' foods which are in abundance. Instead, *M. nigra* is considered a delicacy and to have certain medicinal properties, e.g. enhancing physical strength and curing skin disease. Thus hunting appears to be driven to meet the demands of ceremonial food consumption, rather than for subsistence.

Few prosecutions have ever been made in Minahasa for unlawful hunting or trade in *M. nigra*. One exception was a prosecution facilitated by a local researcher; as such enforcement of law prohibiting hunting of *M. nigra* is considered to be poor (Clayton

& Milner Gulland, 2000). If *M. nigra* are confiscated the is currently only one location where they could be housed; Tasikoki Wildlife Rescue and Education Centre in Bitung currently houses 55 macaques of 6 species, including 26 *M. nigra* individuals (BKSDA/Tasikoki, 2013). Currently they are at capacity and cannot take in any more animals, despite getting reports of *M. nigra* being kept as pets, often in unsuitable conditions. It is common for villagers to voluntarily surrender pet *M. nigra* after they learn ownership illegal, or that the animal might be a source of potential zoonotic transmission to their families.

3.4.5.1.1 Hunting for consumption

Most hunting of *M. nigra*, is considered to be for consumption, either by the hunter or for sale at a locally-based commercial market for consumption.

In 2007, villagers were surveyed in 19 villages throughout Minahasa (Melfi *et al.,* in prep). These data show that eating bushmeat and especially *M. nigra* is widespread throughout the region (see Figure 14). Over 50% of respondents in seven villages reported consuming *M. nigra*, and most other villagers also reported consuming *M. nigra*, while *M. nigra* consumption was varied but often still high in other villages (Figure 14).

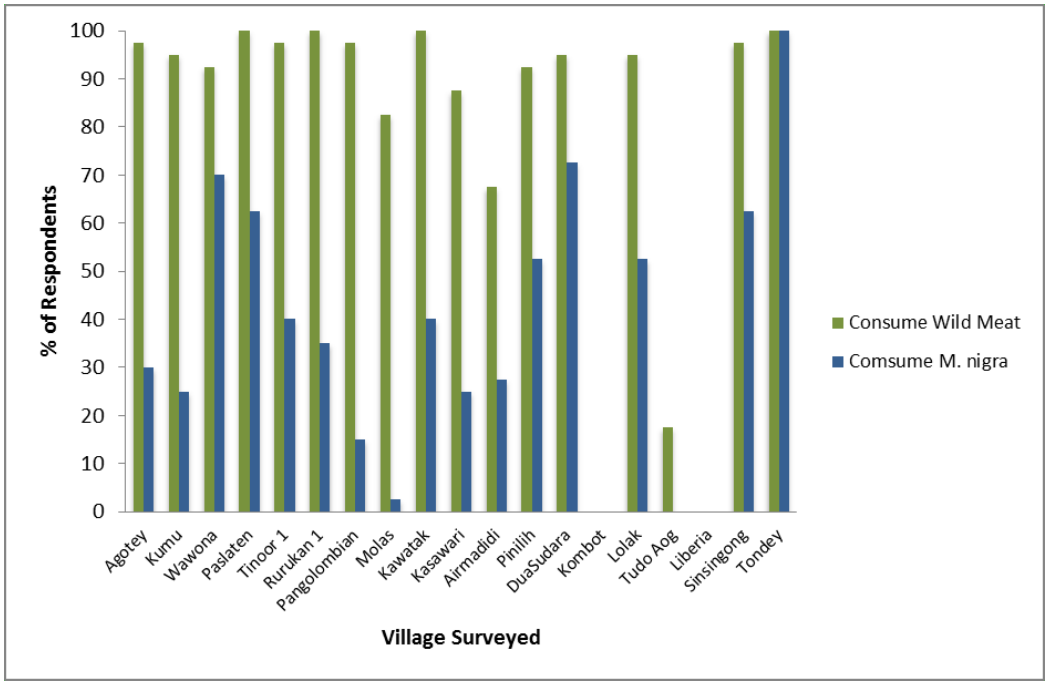
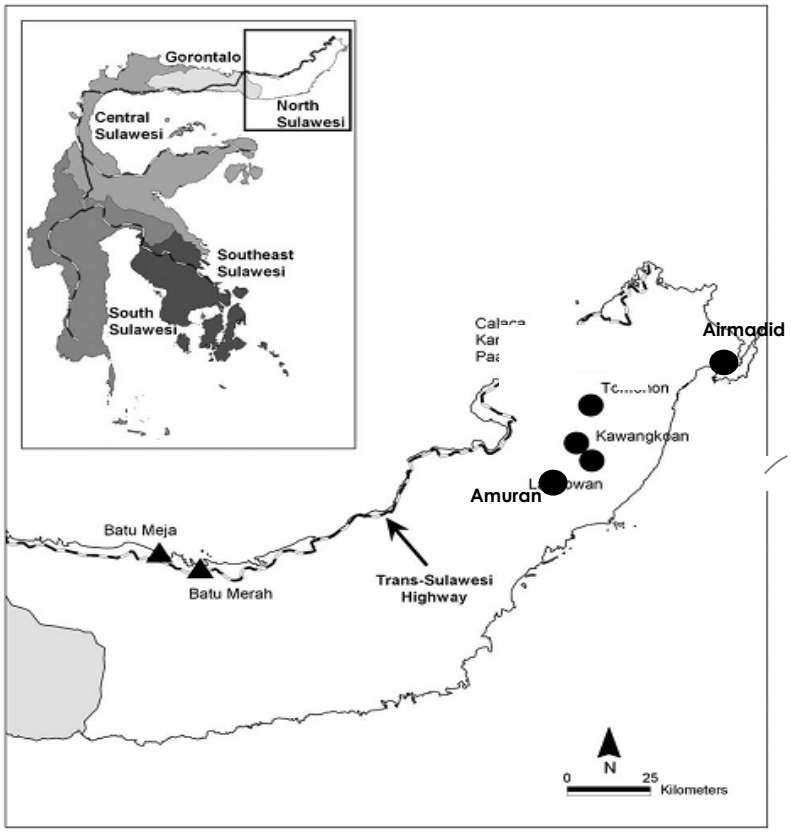


Figure 14. The percentage of villagers (respondents) in Minahasa, who reported that they consume *M. nigra* and/or other bush meat (Melfi *et al.,* in prep).

Local markets supply bushmeat to the growing urban communities without direct access to *M. nigra* habitat sometimes via a large number of traditional restaurants. There is evidence that the trade in *M. nigra* increases around festive periods (Lee, 2005). Selamatkan Yaki conducted surveys of 5 markets over a 3 month period from October to December 2011; using methods similar to the research performed by Wildlife Conservation Society (WCS) between 2001 and 2006 (Sampson *et al*., in prep; Lee, unpublished WCS report). Researchers observed and monitored bushmeat being

sold from 0600 - 0830 on Saturdays. They recorded the total number of whole animals of each species, whether dead or alive, the cost of different species/kg and, when possible, the origin of the bushmeat being sold.



Markets surveyed
Airmadidi
Tomohon
Kawangkoan
Langowan
Amurang

Figure 15. The locations of five markets surveyed in 2011 (Sampson et al., in prep).

Data collected indicate that a large quantity of bushmeat is currently being traded across all markets in Minahasa. Tomohon and Langowan markets trade in the largest quantities across the majority of taxa monitored. These two markets were also the only markets found to trade macaque. It is likely that trade in *M. nigra* is maintained in Minahasa due to a lack of awareness about laws prohibiting the practice and lack of enforcement of these laws.

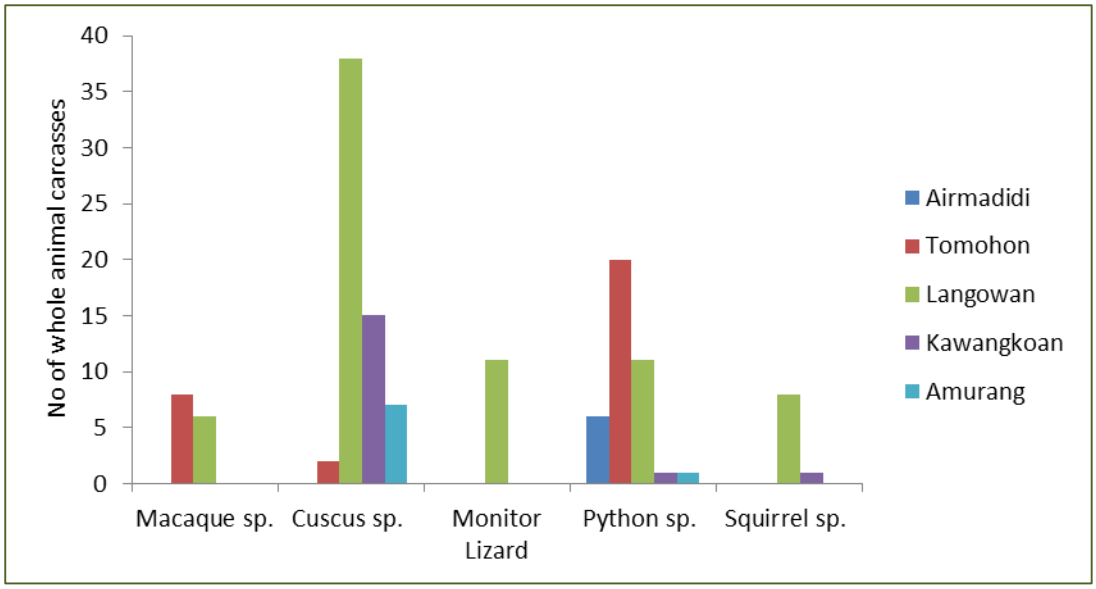


Figure 16. The number of whole animal carcasses, of each taxa identified, found for sale in five markets throughout Minahasa (Sampson *et al.,* in prep).

3.4.5.1.2 Pet and other trade outlets

Few data exist which quantify the extent to which *M. nigra* are used within the pet trade. Anecdotally, there appear to be many situations where *M. nigra* infants are kept as pets either through opportunistic capture or as a result of hunting *M. nigra* and killing the mother. Some of these infants are kept solely as pets, others are maintained for relatively short periods prior to consumption.

M. nigra is listed as Appendix II on the Convention of International Trade in Endangered Species (CITES). Trade is therefore permitted in the species, but is controlled to avoid utilisation incompatible with their survival and an export permit or re-export certificate issued by the Management Authority of export is required.

The international trade in NHPs is widely recognised as a significant obstacle to effective conservation (Pearl, 2004; Rosen & Smith, 2010; Nijman *et al.,* 2011). Indonesia has never published an export quota for *M. nigra*, but in the past 15 years there have been records of substantial exports of samples of the species (see Table 7).

Table 7. All recorded exports of *Macaca nigra* sample specimens (blood, hair or tissue) from Indonesia, 1997-2008. (UNEP-WCMC, 2009).

Importer	Term	Purpose	Source	Reported by	2003	2005	2006	2007	Total
Germany	specimens	S	W	Germany	Importer			1034	1034
					Exporter		15	2554	2569
United States	specimens	S	W	United States	Importer	128			128
					Exporter	175		100	275
Subtotals					**Importer**	**128**		**1034**	**1162**
					Exporter	**175**	**15**	**100**	**2554**

3.4.5.2 Logging and Wood Harvesting (IUCN-CMP 5.3)

The fundamental drivers of tropical forest destruction have changed in recent years, with commercial-scale developments including logging and plantations a leading role in the causal determinants (Rudel, 2005; Butler & Laurance, 2008). Sulawesi has 14 different types of forest; one reason accounting for the high level of biodiversity and endemicity found in this area (Whitten *et al.,* 2002).

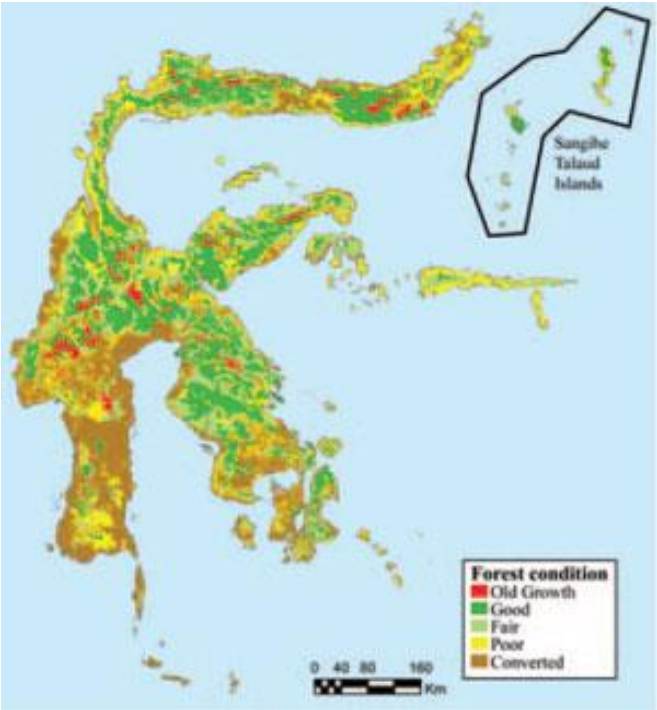


Figure 17. Sulawesi forest condition as scored by Cannon *et al.,* (2007).Forest condition is defined as: 'Old-growth' areas exhibited an unbroken and even canopy layer with no obvious human-mediated disturbance patterns; 'Good' condition areas exhibited a forest canopy unbroken by large clearings with only scattered signs of human activity; 'Fair' condition areas possessed a mostly intact canopy with obvious signs of human activity; 'Poor' condition areas were highly fragmented, largely dominated by human activity but with scattered forest remnants present; and 'Converted' areas were dominated completely by human land-use patterns, including urban and agricultural landscapes. These areas could normally be easily distinguished by the sharp angularity of margins and textures in the images

Cannon *et al.,* (2007) undertook a comprehensive review of forests throughout Sulawesi, noting that across the region about 30% of the forest was in good condition (including old growth), whereas over 50% was considered to be in poor condition (including converted forest). They note that there is a significant positive correlation between altitude and forest condition, as most of the forest in good condition occupies the highlands above 1500 meters (see Figure 17).

Forest loss in Sulawesi is due primarily to logging and land conversion. Beginning in the 1970s the government began supporting large-scale logging and large agricultural projects. Since then migrants from urban areas to the countryside have converted large tracks of forest into cash crops such as coffee and cacao; (BPS 2010).

North Sulawesi encompasses 168,902 ha of protected forest, 66,449 ha of production forest, 6,735 ha of nature reserves and 178,123 ha of national parks; the total land protected in Minahasa is smaller (see 4.2 Protected Area Management/ Table 8. *Protected areas in Minahasa. (BKSDA, 2006).*). Average annual deforestation rate in North Sulawesi was approximately 34,428 ha/year across the period 1985-1998 (BPS, 2010). These levels of deforestation are lower than those reported in other areas of Indonesia, due to accessibility issues at altitude with the many volcanic slopes within the region; however the majority of areas where *M. nigra* should be found are being destroyed at a fast rate (Bynum *et al.,* 1999).

Consequences of selective logging on the survival of frugivore species may also be severe (Johns, 1988), and deforestation has clear negative implications for endangered mammal species (Kinnaird *et al.,* 2003).

3.4.6 Human Intrusions and Disturbance (IUCN-CMP 6)

3.4.6.1 Recreational activities (IUCN-CMP 6.1)

There are a variety of activities undertaken by people, which bring them into close proximity to *M. nigra* or their habitats; some have already been discussed in this section e.g. hunting IUCN-CMP 5.1 and logging IUCN-CMP 5.3. The majority of people living in 19 villages surveyed throughout Minahasa, did not visit the forest (Figure 18). However, for those that did visit the forest many visited at least weekly. Extraction of wood from the forest was the most commonly undertaken activity followed by hunting of animals for consumption (Figure 19).

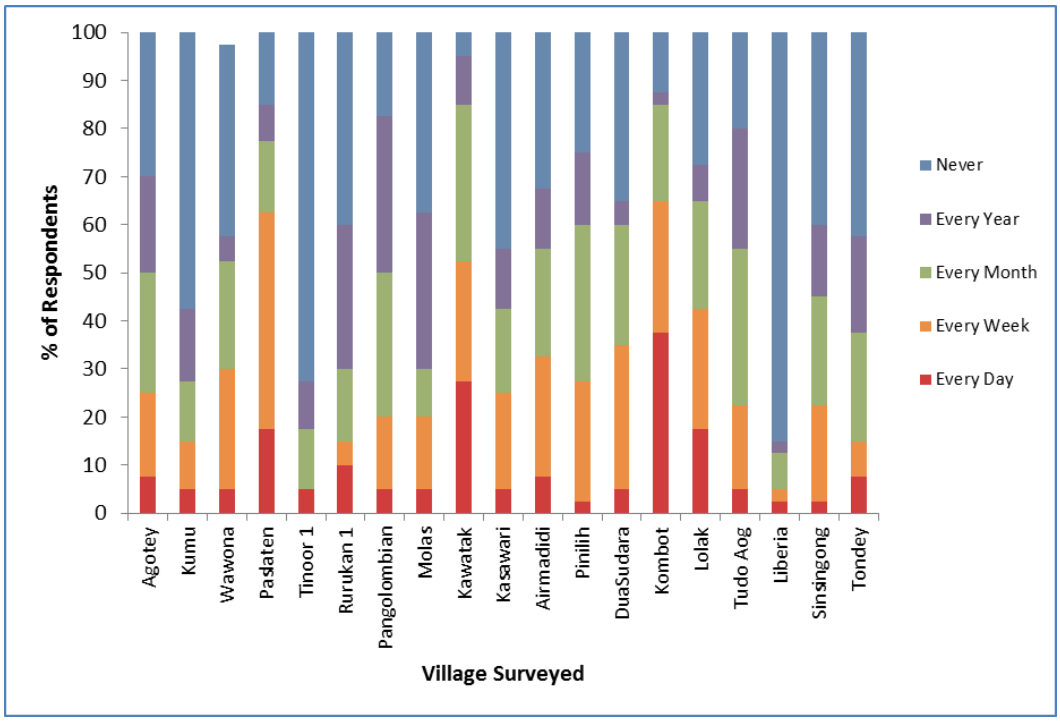


Figure 18. The percentage of villagers (respondents) throughout North Sulawesi who report visiting the forest, regularly, or not at all.

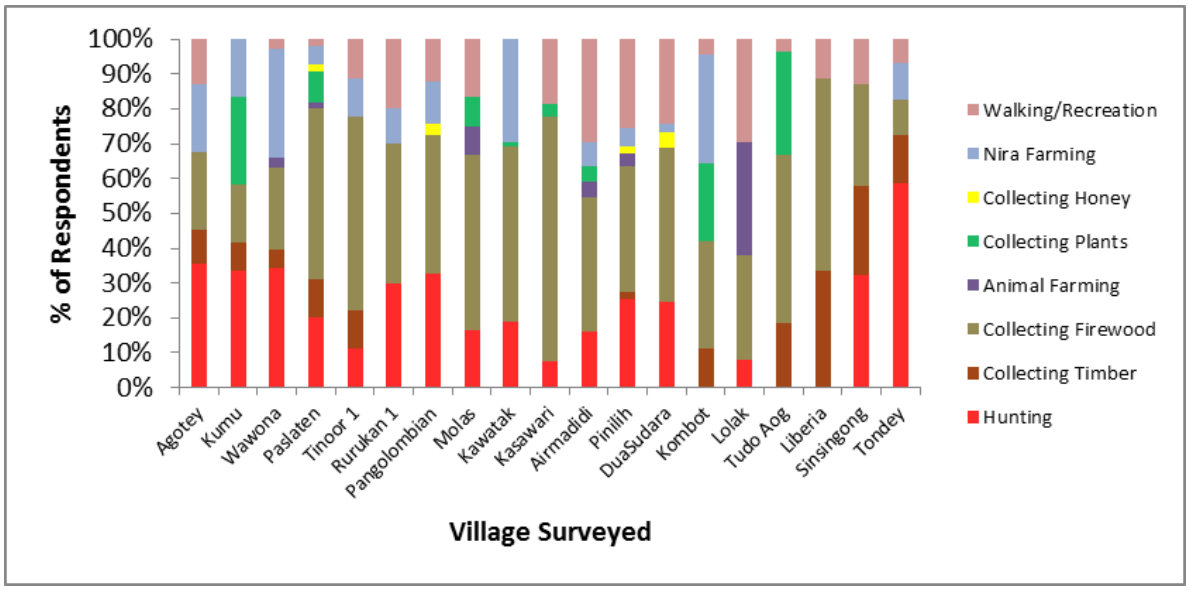


Figure 19. The percentage of villagers (respondents) throughout North Sulawesi who report undertaking 'various' tasks when they visit the forest.

Close proximity between humans and non-human primates can have indirect negative consequences. For example, Jonas and Melfi (in prep) found a significant positive correlation between proximity to humans and helminth parasite burden (see Figure 20). Assessments of parasites in wild and captive *M. nigra* individuals have revealed *Balantidium* sp., *Entamoeba* sp., *Ascaris* sp. and Trichostrongylus sp., all of which are found in both humans and NHPs (Jonas & Melfi, in prep.; Jones-Engel *et al.,* 2004; Paulsen *et al.,* 2006). While parasite transfer is expected to increase with higher rates of human-animal interaction (Sleeman *et al.,* 2000; Gillespie et al. 2005; Nunn & Altizer, 2006) parasite infection may also be linked to habitat characteristics associated with forest disturbance as found in red colobus *Piliocolo bustephrosceles* (Gillespie *et al*., (2006). Recreation areas in Tangkoko and other areas of *M. nigra* habitat may also increase the risk of pathogen transfer due to greater contact with humans and other parasite hosts (Sleeman *et al.,* 2000; Gillespie et al. 2005; Nunn & Altizer, 2006), exacerbating the risks to small, fragmented populations. In particular, agricultural areas tend to have higher quantities of associated animals, including domesticated animals such as cats, dogs, birds and livestock animals, all of which may act as potential reservoirs for infectious disease and cause potential population crashes (Contacos, 1970; Sapolsky, 1987; Fayer *et al.*, 2000; Lewis *et al*., 2002).

Parasites are important determinants of host-health and significantly influence survival and reproduction rates in populations (Scott, 1988; Lewis et al., 2002; Roberts & Janovy, 2008). The role that parasitism plays in the behavioural ecology and evolution of primates is often overlooked (Nunn & Altizer, 2006; Huffman & Chapman, 2009).

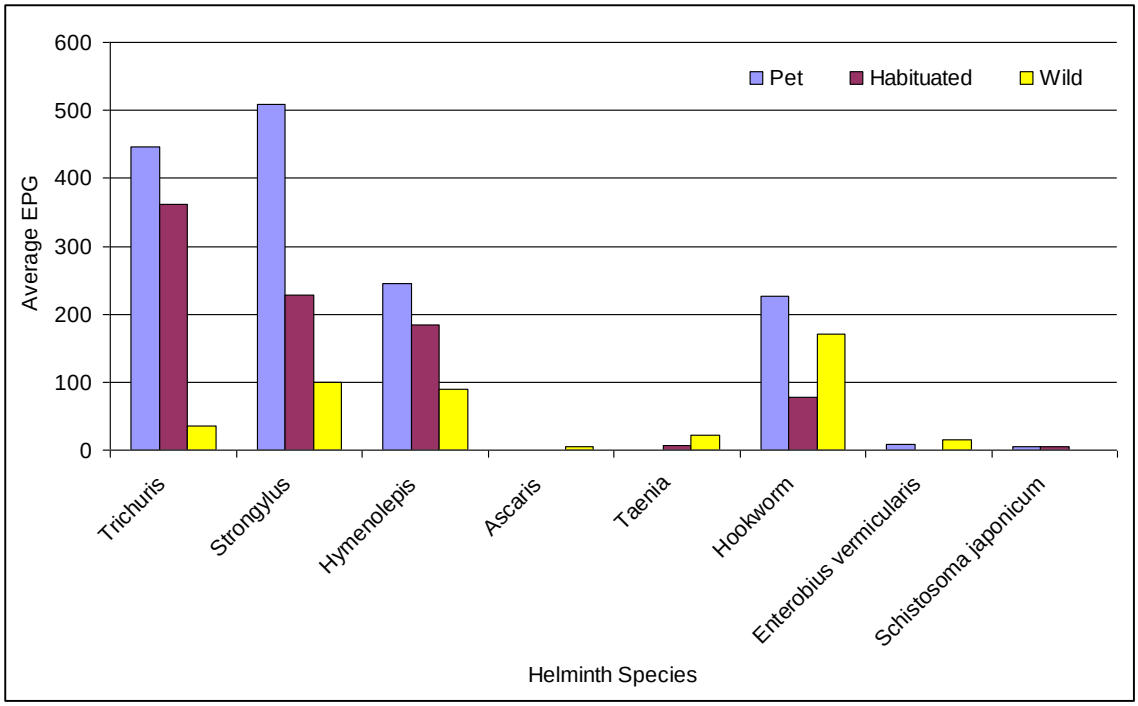


Figure 20. The average eggs per gram of faeces estimated, for several helminth species, in *M. nigra* living in Sulawesi, relative to their proximity to humans (Jonas and Melfi, in prep); Pets were confined to human residences; habituated animals were those regularly studied at Tangkoko; and wild animals were neither pet nor habituated.

CHAPTER 4. Conservation and Management of Protected Areas

This Chapter provides an overview of some conservation and research activities that have been implemented to conserve *M. nigra* and its habitats.

In terms of conservation management, it is useful to approach the ultimate threats on a regional, or broad-scale level, whilst proximate threats may be tackled on a local scale often on a short-term basis, with conservation practitioners working to design projects that will reduce a combination of proximate factors that will eventually result in effective cessation of the ultimate cause of population declines. For the current analysis, the proximate human activities that are causing population declines or habitat degradation of *M. nigra* are referred to as *direct threats*. Contributing factors refer to the ultimate factors which represent a combination of social, economic, political, institutional and cultural factors that maintain the persistence of the direct threats (Salafsky *et al.,* 2008).

The objective of formal protected areas is biodiversity conservation, whereas traditional conservation is often practiced for livelihood and cultural reasons. As discussed earlier, one major threat to the survival of *M. nigra* in North Sulawesi is the use of destructive agricultural practises which lead to land conversion, habitat loss and fragmentation of populations. In many conservation programmes the needs of threatened animals and their habitats are counter to those of local people; the latter are often poor, without resources or the knowledge necessary to utilise innovations in agriculture which can provide high crop yields with low tech resources.

It is worth bearing in mind that nature protection actions operate at different spatial and temporal scales. Biodiversity preservation in North Sulawesi, including the recognition and mitigation of endangerment of *M. nigra,* can be viewed on either micro-scale: endangered species and habitat preservation; meso-scale: regional conservation efforts, including international wildlife trade regulation covering trans-boundary conservation agreements, and macro-scale: international cooperative efforts on a global level (Sodhi *et al.,* 2011). The past and current conservation management of wildlife in the region is described here, considering local, provincial and international involvement and what is being conducted on these scales.

4.1 Regional, National and International Legislation

Indonesian wildlife based on the law is divided into two, the protected and the unprotected. According to the Law number 5 year 1990 concerning the Conservation of the Natural Resources and the Ecosystem, the trade of the protected wildlife is illegal and liable to a maximum of five year prison term and a 100 millions Indonesia Rupiah fine.

List of the protected animals and plants according to the Government Regulation (Peraturan Pemerintah) number 7 year 1999 concerning the Preservation of Wild Plants and Animals is in the following link: [List of the Protected Animals and Plants in Indonesia]

M. nigra has been protected by Indonesian Law Since 1977 (Republik Indonesia, 1990) making it illegal to hunt, kill, or trade in the species. The species is listed under Appendix II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) of which Indonesia is a signatory by Presidential Decree No. 43/1978 and the Convention on Biological Diversity by Law No. 5/1994. This affords the species protection against unregulated international trade.
.
New decentralisation laws (No. 22 and No. 25, both passed in 2001) and other recent changes in government policies have had major impacts on nature protection and conservation in Indonesia. Indonesia has more than 150 national laws and regulations to protect its wildlife species and natural areas.

Forest governance and management in Indonesia, which is governed by Law No. 41/1999, explicitly includes provisions for decentralisation and local people empowerment. Protection of natural resources in Indonesia is now implemented through a participation between local governments, non-governmental organisations and local communities. This consequently requires careful coordination between government and non-government sectors, and between national and local government agencies, to enforce laws.

4.2 Protected Area Management

About 10% of the total land mass of Indonesia has been allocated Protected Area (PA) status. This includes a network of 495 terrestrial PAs covering 22.7 million hectares and 40 marine PAs covering 11.6 million hectares. Indonesia's 1999 Forestry Law divides forested areas into three broad categories, based on function: Hutan Konservasi (Conservation Forests), Hutan Lindung (Protected Forests) and Hutan Produksi (Production Forests). The main purpose of Conservation Forest is to conserve the ecosystem and diversity of plants and animals within it (Article 1 (9) of the Forestry Law). Conservation Forests are Forest Areas with special features, and consist of Nature Reserve Areas (kawasan suaka alam), being: (i)Wild Life Conservatories (cagar alam); and (ii)Fauna Conservatories (suaka margasatwa); and Nature Conservation Areas, being: (i)National Parks (taman nasional); (ii)Natural Tourism Parks (taman wisata alam); (iii)Grand Forest Parks (taman hutan raya); and (iv)Hunting Parks (taman buru). A Protected Forest is a Forest Area which needs to be maintained in order to promote good water management, prevent floods, control erosion, stop sea water intrusion and/or maintain land fertility (Article 1(8) of the Forestry Law). A Production Forest is a natural Forest Area with established and non-man induced plant growth, the main function of which is to produce Forest products (Article 1(7) of the Forestry Law). These classifications are important, as *M. nigra* is found across all of these forest types across its native range, and as such receives varied degrees of protection within these different forest types.

The government agency responsible for protected area management is the Directorate General of Protection and Nature Conservation (PHKA) in the Ministry of Forestry. Within the Ministry of Forestry, the Natural Resources Agency (BKSDA -Balai Konservasi Sumber Daya Alam) is responsible for management of all nature reserves and national parks.

[Note: map as example only – still in production]

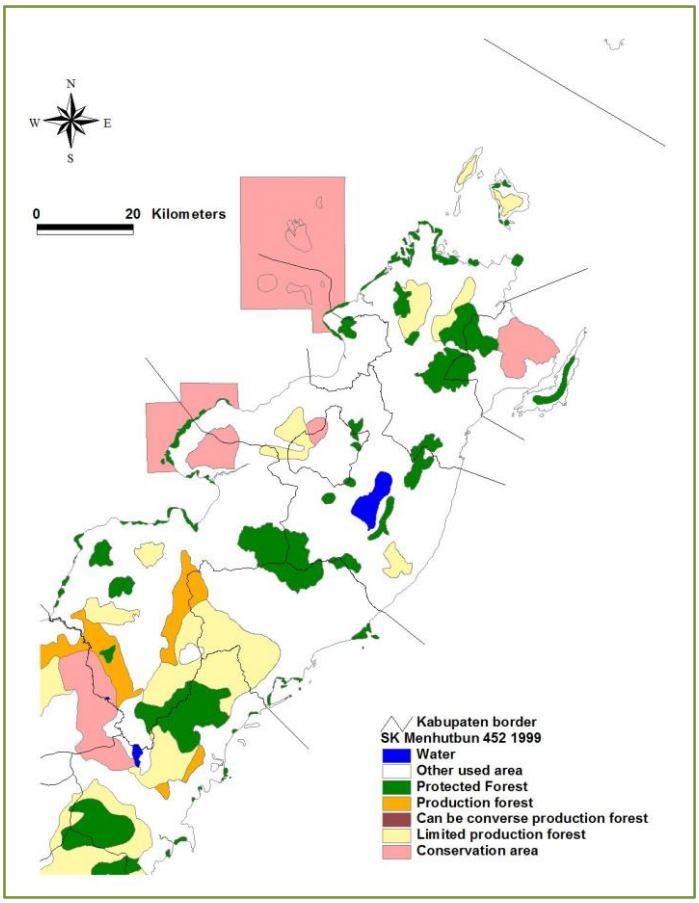


Figure 21. Protected areas in Minahasa under control and management of the BKSDA (BKSDA, 2006)

North Sulawesi has several protected areas, though there are only four much smaller protected areas in Minahasa (Table 8), including Tangkoko Duasudara, Gunung Manembo-nembo and Gunung Ambang. These are managed by BKSDA. From the previous surveys, it would seem that the largest population of *M. nigra* occurs at Tangkoko (Rosembaum *et al.*, 1998; Palacios *et al.*, 2010) and while they are found in other protected areas, densities are much lower (See Table 4. *Summary of census surveys undertaken to estimate M. nigra population density within their native range*.).

Table 8. Protected areas in Minahasa. (BKSDA, 2006).

Protected area name	Protected area status	Area (ha)	Location
Tangkoko Duasudara	**Nature Reserve**	**8,800**	**Bitung**
Gunung Tangkoko	*Nature Reserve*	*3,196*	*Bitung*
Gunung Duasudara	*Nature Reserve*	*4,299*	*Bitung*
Batuangus	*Nature Recreation*	*635*	*Bitung*
Batu Putih	*Nature Recreation*	*615*	*Bitung*
Gunung Lokon	Nature Reserve	720	Tomohon

Manembo-nembo	Nature Reserve	6,500	Minahasa
Gunung Ambang	Nature Reserve	18,765	Minahasa/Bolaang Mongondow

Tangkoko Duasudara Nature Reserve covers an area of 88.67km^2 of lowland tropical rainforest, ranging from sea level to 1350m. The reserve was established in 1919 by the Dutch colonial government under Decree No. GB 21/2/1919 stbl. 90 and remained as a nature reserve by the newly independent Indonesian government in 1945. Tangkoko (part of Tangkoko Duasudara complex) is a 4,450 ha Nature Reserve which includes a 615 ha area recently given the status of Nature Recreation Park (TWA: Taman Wisata Alam), a category that was introduced in original Indonesian Forestry Act (No. 5, 1967) with actual intention for tourism development (Departemen Kehutanan 1986, pg. III-18). Tangkoko was extended by the addition of the Duasudara Nature Reserve (4,299ha) in 1978 under Sk. Mentan No. 700/kpts/Um/11/78, to create a nature reserve complex comprising the reserves of Gunung Tangkoko and Gunung Duasudara in addition to the Nature Recreation Parks of Batuangus and Batuputih, commonly referred to collectively as Tangkoko.

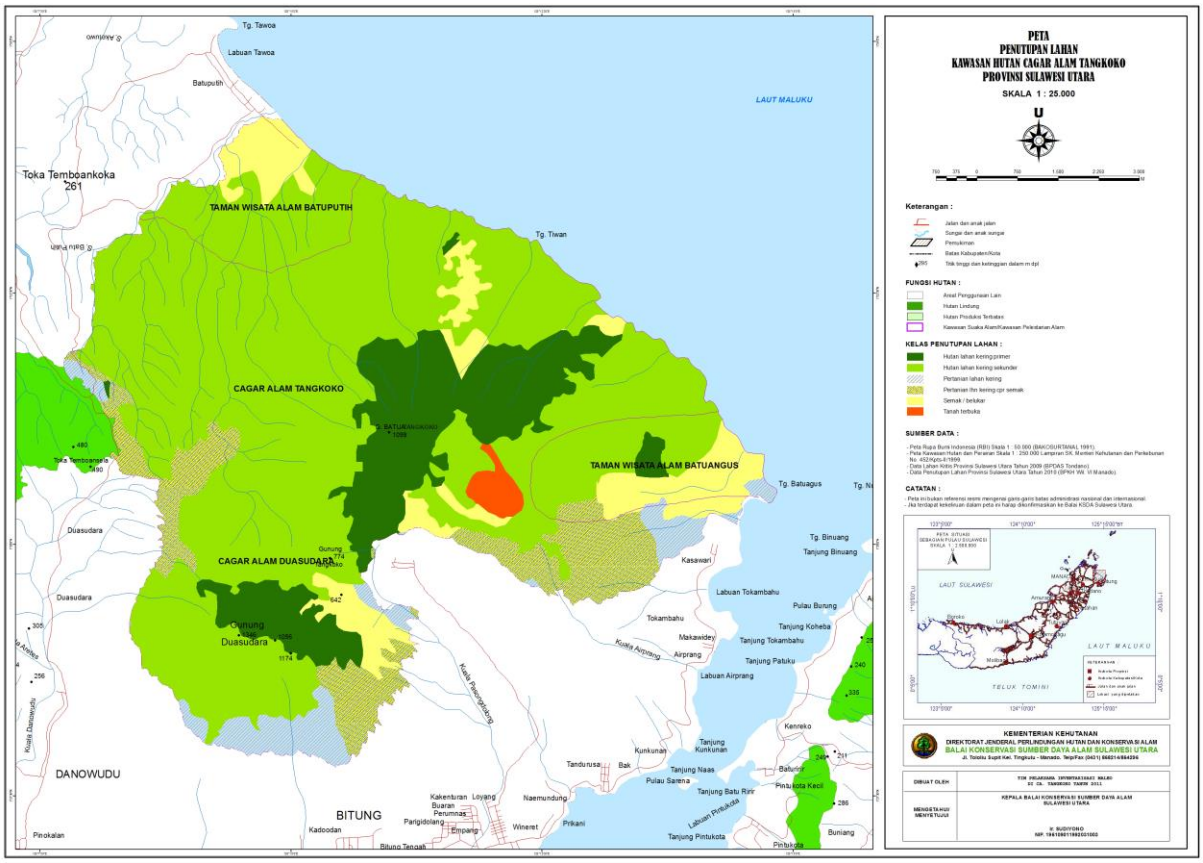


Figure 22. Tangkoko Duasudara Nature Reserve Complex (BKSDA, 2013)

According to the Law on Forestry (No. 41, 1999)a Nature Reserve (*IUCN Category Ia*) falls in the category of Sanctuary Reserve Area (little/almost no management intervention). Along with several other categories and sub-categories, they are strictly protected as a type of Conservation Forest, devoted for scientific and educational

purposes.Nature Recreation Park (*IUCN Category V*) is a Nature Conservation Area (some management intervention) mainly for the benefit of ecotourism and recreational activities.

Despite the management intervention proposed for Nature Recreation Parks it is questioned whether sub-classifications such as these simply act as another development and production strategy rather than truly in line with the ideas of nature protection discourse (Arnsheidt, 2009). The strengthening of the management and enforcement of Protected Areas in Indonesia is an endeavour that involves pro-active, responsive evaluation (Hockings *et al*., 2006) and the cooperation between multiple stakeholders (Contreras & Fay, 2005).

The remaining protected forests are under heavy resource pressures and although surveys from previous years have identified small populations throughout various areas (Melfi, 2007; Appendix III. Summary of transects followed and the number of sightings and consequent estimation of Macaca nigra populations in these areas), the viability of populations outside of reserves has been questioned (Bynum *et al.*, 1999) thus highlighting the requirement for a comprehensive census effort and PVA to ascertain a full species population overview (see
).

4.2.1 Tourism in protected areas

Tourism is promoted by provincial and district governments throughout Indonesia. In spite of this, according to federal law (Nature Protection Ordinance of 1941) tourism in Indonesian nature reserves is prohibited. The Nature Protection Ordinance states that any activity, such as tourism, which 'changes the character of the soil, flora or fauna in any way or affects its pristine condition' is prohibited in strict nature reserves (Kinnaird & O'Brien, 1996). This identifies potential challenge at the management interface: In Tangkoko, tourism is not officially managed by the BKSDA, but activities that concern tourists, including the distribution of guides and entrance fee collection to the nature recreation area is controlled by BKSDA staff. The potential for loss of revenues and negative impacts for both the environment and communities is great.

Table 9. Domestic and international tourists visiting North Sulawesi between 2008 – 2010 (BPS, 2010).

Month	2008		2009		2010	
	Local Tourist	Foreigner	Local Tourist	Foreigner	Local Tourist	Foreigner
Jan	777	11678	1690	13844	1666	17122
Feb	1179	11756	1728	14330	2308	20872
March	1508	15368	2013	18508	1602	22098
April	1515	20194	2275	20686	1445	24072
May	1534	22512	2216	21386	1602	20118
June	1440	21804	2062	22504	1590	25148
July	1790	22608	2615	22712	1776	21518
August	1886	25642	3223	17462	1689	20632
Sept	2002	18204	2331	17852	1561	20632
Oct	2164	15864	2380	22258	1847	20024
Nov	1782	17008	1661	22060	1477	20334
Dec	2002	19660	1934	235948	1482	

Total	**19579**	**222298**	**26128**	**449550**	**20045**	**232570**

The financial benefit of tourism is currently limited to a few families in Batu Putih, and local government. Currently, all visitors to Tangkoko pay an entrance fee (15,000 standard base fee) which provides them with entry to the reserve, and a guided tour (price depends on duration of tour, but as standard brings total price to 85,000); unaccompanied visitors are not permitted in the reserve. Visitor numbers to Tangkoko have remained relatively stable over the past 10 years (Table 9) and include local visitors using the recreation park and more often foreign visitors who spend more time in the nature reserve (Paulus, 2008). It has been recognised that tourism has the potential to bring benefits to the situation facing the macaques in Tangkoko, although if managed improperly the negative impacts can these potential benefits. If tourism is to be considered sustainable, it should recognise both the environmental influence it may have and the long-term economic viability by protecting the area.

4.3 Research

As a foundation for informing conservation priorities, long-term research including monitoring of indicators of change at the species and ecosystem level, is essential for enabling evidence-based approaches for conservation practitioners, particularly with priority setting for endangered species (Salafsky *et al.,* 2002; Srivastava *et al.,* 2005).

Tangkoko has been the centre for a plethora of research projects spanning the past 3 decades. John and Kathleen MacKinnon conducted the first detailed research in the late 1970s (MacKinnon and MacKinnon, 1980; MacKinnon, 1983). Margaret Kinnaird and Timothy O'Brien from Wildlife Conservation Society studied the reserve's ecology more intensively between 1990-1996 (O'Brien &Kinnaird,1998; Kinnaird & O'Brien, 1996, 2000; Reed *et al.,* 1997). At the beginning of 1999, WCS-Sulawesi Program carried out baseline surveys as a basis for long-term biodiversity monitoring work (Lee *et al.,* 1999).

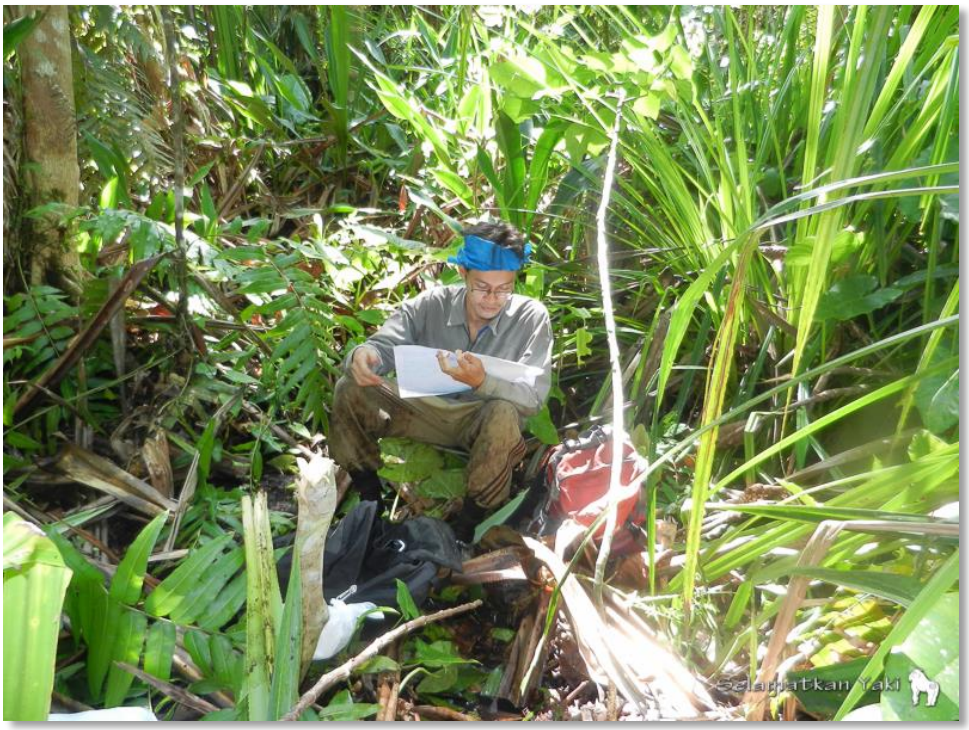


Figure 23. Research such as that conducted by the Macaca Nigra Project is essential for our understanding of the species, whilst informing future priority setting for conservation action.

In 1996, an institutional partnership called Yayasan Tangkoko Lestari (Tangkoko Conservation Foundation) involving Sam Ratulangi University, the University of Washington and the Primate Research Center of Bogor Agricultural University was established to promote field research, training and community outreach. This has enabled 15 years of annual repeat surveys of *M. nigra* populations along a transect within the core of Tangkoko, identifying potential stabilisation of macaque populations (Kyes *et al.,* 2012).

Macaca Nigra Project (MNP) is a research programme initiated in 2006. MNP have performed various studies on the ecology and reproductive biology of wild *M. nigra*, with particular focus on primate sexual selection. A research base situated within the reserve allows both Indonesian and international students and scientists to study two groups of macaques living in mixed habitat. Investigations have included the adaptive significance of male and female sexual signals, their physiological correlates and their effect on male reproductive success (e.g. Neumann *et al.,* 2010, 2011; Engelhardt *et al.,* 2008; Duboscq *et al.,* 2009).

The majority of research has been conducted within Tangkoko and subsequently outside of the reserve the species has received little study. This is particularly true of Bacan island, which has received relatively little research at all (Hamada *et al.,* 1996; Rosenbaum *et al.,* 1998; Hilser *et al.,* in prep).

4.4 Past, Current and Projected Conservation Action

Despite Sulawesi's remarkable biodiversity and the extinction risks of numerous species, it receives relatively little conservation attention, with efforts and resources

often centralised in regions containing megafauna with greater recognition and popularity (Wilson *et al.,* 2006).

Tangkoko has long been recognised as an area of high conservation value for *M. nigra* as well as many other endemic species of biodiversity. The long-term goal of this document and SCS is to preserve a self-sustaining *M. nigra* population in their native range; thus conserving sympatric biodiversity. This can only be achieved by reducing the current threats which endanger the species, namely illegal hunting and habitat encroachment and fragmentation. As Tangkoko represents the last stronghold for this species and may currently receive inadequate protection, it is recognised that finding solutions to an enhanced system of management and protection are to be of critical importance to the survival of *M. nigra*.

Following the establishment in 2006, MNP have also been actively involved in promoting conservation of *M. nigra* and other biodiversity, by supporting other projects and assisting BKSDA staff with collection and monitoring of data regarding illegal activities.

The tarsier species residing in North Sulawesi (*Tarsius spectrum*) has become a widely recognised icon, representing the region's diverse flora and fauna and demonstrating the effectiveness of using flagship and umbrella species. Dr Myron Shekelle spent 14 years travelling Sulawesi researching tarsiers and has been instrumental in promoting conservation of biodiversity through research of tarsier species.

Since 2011 researchers have established strong connections within the Minahasan region and developed a conservation programme named Selamatkan Yaki ("Save the Macaques"). Selamatkan Yaki is an integrated conservation programme focussed on protecting the last remaining populations of macaques and mitigating the threats they face. Working partnerships both in-situ and ex-situ have combined to identify the anthropogenic threats posed to the current population of *M. nigra* within their native range. A multitude of approaches addressing the conservation objectives comprise research, education, the improvement of ecotourism infrastructure and sustainable development. Long-term cooperative efforts hope to facilitate investment of resources into improving agriculture techniques and sustainability and developing alternative livelihood strategies.

Figure 24. Education is essential for fostering positive attitudes towards the species and other biodiversity.

Tangkoko Conservation Education is an education programme dedicated to help the next generation of local communities preserve the flora and fauna of Sulawesi, especially in Tangkoko. The project aims to increase the environmental and conservation awareness of local youth and community members throughout the important district.

PPS Tasikoki is a wildlife education and animal rehabilitation centre in North Sulawesi which specialises in the housing and reintroduction of native animal species (including *M. nigra*), the birds from Wallacea and Papua, as well as a variety of other endemic animals such as Babirusa. Tasikoki is a unit of the Masarang Foundation which works directly with local communities to protect the forests of North Sulawesi for the benefit of the people, the flora and the fauna. Masarang Foundation, which was founded in 2001, is run entirely by volunteers and addresses a wide range of conservation issues, from biodiversity loss to climate change, striving for positive development in local communities whilst fostering positive attitudes towards nature protection.

In addition to the conservation projects currently being undertaken in the region, the Wildlife Conservation Society (WCS) and other NGOs have collaborated with the BKSDA with several initiatives to help preserve the flora and fauna of North Sulawesi. A wide variety of programmes have been initiated through both the short to long-term, from community alternative livelihood approaches to environmental education, all of which are proposed to bring about positive developments in nature protection, including the conservation of *M. nigra.* A collaborative team has been established which represent the main stakeholders working in this area. By strategically evaluating current protection activities, working directly with patrols, providing education and both national and international recognition of the species, facilitating local and

regional dialogue, monitoring illegal activities and working towards sustainable ecotourism, it is proposed that the management of *M. nigra* habitat can be brought to a higher standard.

4.5 Ex-situ Population Management

A managed captive population can be an important part of an integrated conservation programme. The significant influence that zoos have for promoting conservation is rarely considered, yet zoos may play a substantial role in raising public and political awareness and providing support, infrastructure and funds for *in-situ* conservation research and programs (Higginbottom *et al.,* 2003; Leader-Williams *et al.,* 2007). Zoos worldwide get 600 million visitors annually with a large proportion from tourists, emphasising the scope for engaging a mass audience. Furthermore, many zoos operate breeding programs of endangered species in order to maintain supportive captive populations, often with the ultimate goal of restocking or reintroduction into the wild (Cowlishaw & Dunbar, 2000).

Table 10. lists the number of *M. nigra* in zoos globally according to the International Species Information System (ISIS, 2013).

Table 10. Number of *M. nigra* maintained globally in zoos as recorded in the Information Species Information Systems (ISIS) database, plus additional members not signed up to EAZA (data downloaded April, 2013).

Global Region	No. of Zoos	Male	Female	Unknown	Total Population
Asia	5	13	19	0	**32**
Europe	27	83	124	8	**215**
North America	6	11	19	0	**30**
Total Global Population	**38**	**107**	**162**	**8**	**277**

These figures may be an underestimate the total population, as they represent data from ISIS members, which includes zoos from the major zoo associations (e.g. Association of Zoos and Aquaria, AZA; European Association of Zoos and Aquaria, EAZA; Zoo and Aquariums Association, ZAA) but does not include all zoos/captive institutions. The *ex-situ* population is of most value to conservation efforts when maintained in self-sustaining collaborative management programme. Though *M. nigra* are found in captivity globally, there are only three managed ex-situ populations, in Europe (European Endangered Species Programme, EEP; N = 64.95.3, coordinated by Dr Holly Farmer, WWCT), North American (Species Survival Programme, SSP; N = 11.19.0 coordinated by Christie Eddie) and Asia (N = 13.19). There are various challenges to managing these populations which are common to many *ex-situ* programmes. These include a small founding population, limited spaces to maintain the necessary population to ensure genetic diversity and reduce inbreeding, as well as missing and inaccurate information in the dataset used to manage the population (Lees and Wilckin, 2009).

The ex-situ management of *M. nigra* populations is also hindered by many zoos no longer wanting to include the species within their living collection; M. nigra are now being 'phased out' of collection plans in AZA and ZAA region zoos. Reasons given for

not wanting this species within zoos are the health risks the animals might pose, the difficulties with managing their complex social systems, the large amount of space required to maintain an appropriately sized group, and more recently the need for heated accommodation (pers comm. Vicky Melfi).

Currently, only the EEP represents a viable *ex-situ* programme, though it needs to grow to ensure its long term sustainability and fitness (e.g. Melfi, 2011). To remedy these issues and bring conservation value to the animals maintained in other regions, a Global Species Management Programme (GSMP) could be established to manage the *ex-situ M. nigra* population, under the auspices of the World Association of Zoos and Aquaria (WAZA).

Section II: Conservation Action

CHAPTER 5. Framework for Action

As described in the Species Conservation Action Plan from the IUCN/SSC group focussed on Asian primates (Eudey, 1987), the results of developing action plans are a mitigation of the threats to the species, as outlined here in Section I. According to the Primate Specialist Group the most effective mitigation by:
1. setting aside protected areas for endangered and vulnerable species;
2. creating large national parks and reserves in areas of high primate diversity and/or abundance;
3. maintaining or increasing the effectiveness of parks and reserves that already exist; and
4. creating or increasing public awareness of the need for primate conservation and the importance of primates both as part of the natural heritage of the countries in which they occur, and as important components in the environmental systems whose proper functioning is vital for human well-being.

Eudey (1987) highlighted the requirement for surveys of the species in order to establish priority populations and contribute to range-wide threat status, and the improvement of protected area management for threat mitigation. Within these protected areas, highest priority was recommended for the largest areas, and those containing several threatened species, therefore preserving sympatric biodiversity. The 1987 Action Plan had brought together four central recommended projects for the Sulawesi-Molocca region, which included surveys of *M. ochreata* and *M. brunescens,* implementation of a management plan for Dumoga-Bone (Bolaang-Mongondow) National Park; increasing habitat availability and protection of *M. Maura* through expansion of protected areas; and protected area management assessments for *M. hecki*. Following the reassessment of *M. nigra* from Endangered to Critically Endangered in 2008 (Supriatna & Andayani, 2008) and following previous research, these priority recommendations would be more inclined towards conservation focus for *M. nigra* and protected area management within the remaining habitat strongholds for the species, namely Tangkoko.

The central outcome of the workshop was the collective development of a series of recommended actions formulated with the aim of mitigating the threats to successful protection of Tangkoko and *M. nigra*. These combined activities, although conducted at a comprehensive level and time consuming, proved to be highly valuable as it brought wide recognition to what action is needed, who should be either responsible or involved at a supportive level in the implementation of these actions, and over what time period.

It should be kept in mind that these actions have been derived from a broad participatory process and are generally all-encompassing. Several of the suggested actions are beyond current operating and resource capacity of the involved parties; this encourages the imperative point to ensure that the procurement of financial longevity is sought as part of an action plan formation. It is further suggested that priorities are made for these suggested actions.

Many actions are relevant to two or more threats, and are thus repeated, so should not be viewed as exclusive to reducing one threat only. Additionally, if implemented together, many of these actions, such as raising awareness of community members about laws whilst

effectively enforcing laws and following up on prosecutions, will act synergistically to reduce the threat at a greater speed.

To include short explanation that these are barriers to effective conservation, based on the threats from section 3.

Summary of Recommendations from Framework:

5.1 Lack of effective law enforcement

Enforcement of law is considered high on the agenda for means to reduce the threats to *M. nigra* (with reference to the discussions at the stakeholder workshop April 2013). As a priority, improved coordination between authorities, agencies and communities was recommended as the basis for improving likelihood of enhancing the regulations and the enforcement of them. Raids of establishments keeping or trading in the species, including restaurants would complement an official notification of the protected status of *M. nigra* alongside the campaign of new local regulations. Finally, an external evaluation of the current status of management for protected areas and forest habitat would help to prioritise efforts whilst identifying strengths and challenges to focus on.

5.2 Lack of land stewardship

Identifying key viable habitat for the species through a satellite and ground survey research project would be a first step in understanding where problems are most prevalent and where opportunities for habitat stewardship may be maximised. Again as with the land conversion and agricultural threats for Tangkoko, necessary changes in agricultural methods, demarcation of boundaries, reforestation projects for suitable land and investigation into habitat connectivity schemes were put forwards. It was suggested that communities have greater communication and empowerment to amend land rights issues, and have greater input such as providing patrols conducted by local community members.

5.3 Lack of environmentally sensitive and sustainable project development

It was suggested that governmental development plans include close dialogue with other stakeholders to ensure minimum impact on *M. nigra* habitat or populations. Dissemination of results from research of flora and fauna to appropriate agencies will aid in this, in addition to the adoption of sustainable policies for companies effecting plants and animals in particular *M. nigra*. Finally, it was advised that the Bitung Zoo is investigated for its future viability for nature preservation, including *M. nigra*.

5.4 Lack of awareness of *M. nigra* locally, regionally, nationally and internationally

Raising the species' profile will be key to fostering greater support and creating advocates of sustainable development plans, policies or conservation efforts. Adoption of stringent

ecotourism principles to lower tourism impacts whilst maximising benefits was identified as important to reduce threats to the species. The official declaration of *M. nigra* as a key species in N. Sulawesi that needs protecting, in line with a pride campaign would enhance local recognition, complemented by the use of all available media channels from local through to international recognition of the species. Further to this, it was suggested that local leaders or inspiring individuals such as religious, societal or traditional leaders are approached to raise support.

- Monitoring;
- Human-wildlife conflict;
- Ex-situ management plan and implementation (to include EEP) "continue to manage ex-situ *M. nigra* populations, and identify role of such populations in the wider conservation of the species."

5.5 Lack of capacity of resources and implementation

It is clear that all of these recommendations will only be attainable through greater capacity and management of available resources. Teacher training and incorporation of environmental education into local curriculum to schools and informal education would bring farther reaching scope of impact beyond singular school visits, as would empowering protected area management for more frequent and more efficient, better equipped patrols of *M. nigra* habitat. Revenue generation systems could bring economic benefits through marketing areas as tourism attractions and creating village cooperatives. Finally, it is reiterated that improvements in communication at all stakeholder levels would enhance the efforts of all for implementation of any threat reduction activity aimed at protecting *M. nigra*.

Table 11. Full Framework for Action for *Macaca nigra*.

Activities	Organisations Responsible (R) or Partners (P)	Years													Notes
		1	2	3	4	5	6	8	10	12	14	16	18	20	
1. Lack of effective law enforcement															
1.1 Improved coordination between authorities, agencies and communities	BAPPEDA (R); BKSDA (P); Kepolisian (P); Kelurahan (P); NGOs (P)														To incorporate protection of *M. nigra* and other biodiversity into future priorities; forum group formation
1.2 Upgrading capacity of Patrol team	BKSDA-Polhut (R); Kepolisian/TNI (P); Kejaksaan (P); Kelurahan (P); Satpol PP (P); DPRD (P); SY (P)														Equipment, training, techniques, data storage and dissemination, number of patrol staff
1.3 Implement integrated patrols periodically	BKSDA (R); DISHUT (P); POLDA (P); Masyarakat local (P); Manggala agni														Including community patrol members; also including fire response team
1.4 Intelligence	BKSDA-Polhut (R); Kepolisian/TNI (P); Kejaksaan (P); Kelurahan (P); Satpol PP (P); DPRD (P); SY (P)														Establish an independent, outside intelligence team to monitor and track illegal activities and mitigation programmes' performance
1.5 Training to enforcers of the laws regarding protected animals	BKSDA (R); NGO (P); Instansi Penegak Hukum lain (P)														Including the identification of all protected species by police staff
1.6 Making PERDA for protection of *M. nigra*	Pemprov/Pemda (R)														PERDA: peraturan daereh, meaning local regulations and policies; law against consumption, trade, hunting of *M. nigra*
1.7 Firm direct action against anyone selling, trading or consuming *Macaca nigra*	POLDA (R); PD Pasar (P); Pol PP (P)														Ensure prosecutions are followed up by police, especially in line with PERDA (1.5)
1.8 Evaluation of the effectiveness of the PA management to identify any challenges and requirements for long-term progress (METT)	SY(R); BKSDA (P); UNDP (P)														Includes METT (Management Effectiveness Tracking Tool) surveys of appropriate stakeholders, in addition to village community surveys about *M. nigra*
1.9 Unannounced inspections	POLDA (R); BKSDA (P); PPST (P)														Inspections of properties or individuals suspected of trading, hunting or keeping *M. nigra* as pets
1.10 Official notification of the protected status of *Macaca nigra*	BKSDA (R); Dispar (P); Asita (P); SY (P) Pemprov (P); Kepolisian (P)														Of both national law and local PERDA (1.5) through community campaigns via multiple media channels,
1.11 Provide awards to informants of cases of illegal activities	BKSDA-Polhut (R); Kepolisian/TNI (P); Kejaksaan (P); Kelurahan (P); Satpol PP (P); DPRD (P)														Also for protection of informants; positive incentives for supporting law enforcement
1.12 Training to enforcers of the laws regarding protected animals	BKSDA (R); NGOs (P); Instansi Penegak Hukum lain (P)														Including the identification of all protected species by police staff
1.13 Action hotline created to deal with cases of illegal activities related to *M. nigra*	PPST (R); SY (P); POLDA (P); BKSDA (P) Polhut (P)														Mobile, sms, BBM and internet contacts directed to central site to alert fast response team of cases
2. Lack of land stewardship															
2.1 Development of sustainable local community economies	Pemda/Pemprov (R); BKSDA (P); NGOs (P)														Creation of trials and pilots of souvenir, crafts, sustainable products etc and creation of cooperatives
2.2 Clear area boundaries (creating buffer zones)	Pemda/Pemprov (R); BKSDA (P)														Informing local communities and farmers of correct land status and tenure availability; creation of buffer zones for limited resources extraction; coordination of stakeholders about the clarity of the boundaries

2.3 Provide training techniques and technology practices in sustainable agriculture	Distan-Pemda (R); BP4K (P); SY (P); UNSRAT (P); Perguruan Tinggi (P)														Investigations into aquaponics and other potential agricultural developments
2.4 Development of community based conservation initiatives for related threats	BKSDA (R); Pemda/Pemprov (P); NGOs (P)														Requires further coordination of threats and the related activities; related to forum groups
2.5 Patrols conducted by local communities	Kelurahan(R); BKSDA (P)														Coordination with BKSDA patrols to cover greater area and more frequently
2.6 Reforestation projects on suitable land	PHKA (P); Yayasan Masarang (P); PKT (P); PPST (P)														Planting of trees and maintenance and restoration of key areas in Minahasa
2.7 Increase the protected area available	BKSDA (R); Pemda (P); Pemprov (P); Bappeda (P)														Assess potential to expand PA total area after initially identifying *M. nigra* habitat in need of protection
2.8 Investigations into viability of habitat connectivity, especially for viability of *Macaca nigra* habitat	SY (R); PKT (P); BKSDA (P); PPST (P); MNP (P); PPST (P); Yayasan Masarang (P)														Assess potential for connecting suitable habitat for *M. nigra* to increase genetic flow and future viability of species
2.9 Instigate corridor programme to connect *M. nigra* populations	BKSDA (R); Pemda (P); Pemprov (P) Bappeda (P)														Following assessments of habitat connectivity (2.8), to include development blocks and environmental assessments; integrated into survey and PVA research
3. Lack of environmental sensitivity and sustainability within project development															
3.1 Environmental pride campaign	SY (R); BKSDA (P); Pemprov-Dishut (P) Pemda-Dishut (P); Pemda-Dispar (P) NGOs (P); local communities (P)														To create awareness to all people about the importance of *M. nigra* and their threats and decline in numbers
3.2 Increase *M. nigra* populations through collaborative programmes with government and other stakeholders	SY (R); BKSDA (P); Pemprov-Dishut (P) Pemda-Dishut (P); Pemda-Dispar (P) NGOs (P)														Through greater communication, formulate strategy to reduce threats and increase populations of *M. nigra*
3.3 Regular monitoring and evaluation	BKSDA (R); MNP (P); Pemda (P); WCS (P); SY (P)														Of harvesting amounts and change in harvesting behaviour/attitudes/population declines etc; including any hunting related deaths or injuries of *M. nigra*; also surveys of households regarding *M. nigra*
3.4 Dissemination of results from research of flora and fauna	BKSDA (R); SY (P); Perguruan Tinggi (P); MNP (P); BPK (P); NGOs (P)														Also all other institutions that may conduct research in Tangkoko
3.5 Development of an "essential ecosystems programme"	BKSDA (R); Pemprov-Dishut (P); Pemda-Dishut (P); NGOs (P)														BKSDA led initiative to prioritise with areas of great ecosystem services value and high ecological function
3.6 Create greater capacity for stakeholder communication	SY (R); BKSDA (P); Pemprov-Dishut (P) Pemda-Dishut (P); Pemda-Dispar (P) Other NGOs (P)														Contact networks, media and resource sharing, forum groups
3.7 Ex-situ management – assessment of validity of Bitung Zoo	PPST (R); BKSDA (P); Kepolisian (P)														Investigation into whether Bitung Zoo may be acting irresponsibly and below minimal husbandry and welfare standards for housing animals
3.8 Creation of sustainable policies for companies effecting plants and animals (in particular *M. nigra*)	SY (R); BKSDA (P); Pemprov-Dishut (P) Pemda-Dishut (P); Other NGOs (P)														Initially provide outreach to local companies, and collaboratively formulate policies to enhance sustainability
4. Lack of recognition of value for *Macaca nigra* locally, regionally, nationally and internationally															

4.1 Official declaration of *M. nigra* as a key species in N. Sulawesi that needs protecting via change in Status classification	SY (R); BKSDA (P); Pemprov-Dishut (P) Pemda-Dishut (P); Pemda-Dispar (P) ASITA (P); HPI (P); PHRI (P); GAHAWISRI (P); PKT (P); NSTB (P)														Currently 14 priority endangered species recognised throughout Indonesia by Ministry of Forestry (PHKSA); to include M. nigra would increase capacity for priority setting of funding and resources for protection
4.2 Development of ecotourism principles	SY (R); ASITA (P); HPI (P); PHRI (P) MNP (P); BIMP-EAGA (P); NSTB (P)														Triple bottom line principles: net overall positive social, economic and environmental impact; to reduce any threats to M. nigra from tourism and increase benefits provided; begin with strategy and assessment, follow with improvements in tourist experience and potential for revenue spread to increase from tourism
4.3 Socialisations for logging companies and SKPD (related government offices)	BP4K (R); Dishut (P); BLH (P); Kecamatan/Kelurahan (P); BKSDA (P); SY (P); MNP (P)														Meetings, presentations and events in order to ensure clear limitations and impacts of commercial logging in surrounding areas
4.4 Research continuation to understand the species	MNP (R); SY (P); UNSRAT (P); BKSDA (P); Other NGOs (P)														To expand research to other areas of Minahasa, including population surveys and monitoring
4.5 Recognition and appreciation of *M. nigra* as an important tourist attraction	SY (R); HPI (P); PHRI (P); MNP (P); BIMP-EAGA (P); ASITA (P); NSTB (P)														By all stakeholders, whilst respecting the environment and lowering impacts; ecotourism principles (4.2)
4.6 Environmental pride campaign	SY (R); BKSDA (P); Pemprov-Dishut (P); Pemda-Dishut (P); Pemda-Dispar (P); NGOs (P)														Specifically locally based activities, including youth camps, church services, local ambassadors to represent environmental protection around Tangkoko
4.7 Creation of educational materials (leaflets, bulletin, magazine, cartoon/comic etc)	SY (R); NGOs (P); BKSDA (P); Dispar (P); BAPPEDA (P); Dis Kominfo (P)														Specially printed materials and their dissemination
4.8 Conservation campaign using printed and electronic materials both local, nationally and internationally	SY(R); BKSDA (P); other NGOs (P); Kelurahan (P); Dinaskominfo (P)														For greater scope about Tangkoko nationally - online media, i.e FB, Twitter etc; additionally raising ecotourism revenue from greater tourism numbers
4.9 Approach to religious / society leaders / traditional leaders of conservation concern	SY (R); NGOs (P); BKSDA (P); BAPPEDA (P); Dis Kominfo (P)														Integrated into part of pride campaign
4.10 Identify the areas and causes of any conflict between *M. nigra* and people	SY (R); MNP (P); Kelurahan (P)														Work towards conflict mitigation strategy
4.11 Conduct a comprehensive population survey of *M. nigra* across their native range	SY (R); Other NGOs (P); UNSRAT (P)														Including genetic analyses; to better understand population status and monitoring of any declines; priority setting
4.12 Conduct research into primate health and any associated health issues with humans	MNP (R); Other NGOs (P)														Zoonotic and anthroponotic emerging infectious diseases that may threaten *M. nigra* population
4.13 Investigate alternative livelihood strategies	SY (R); Other NGOs; Kelurahan (P); Pemda (P)														Create strategy for community development programme including alternatives to hunting or trading in *M. nigra*
5. Lack of capacity of resources and implementation															
5.1 Dissemination to the public about the impact of forest destruction	PKT (R); SY(P); KeKelurahanan (P)														Through presentations, group forums, showing of BBC film and other materials; with aim to build capacity to mitigate forest destruction and hunting
5.2 Addition of extra officers (security personnel)	BKSDA (R); Polhut (P)														More patrol staff recommended during workshop; to increase effectiveness of patrols
5.3 Teacher training and incorporation into local curriculum to schools and informal education	PKT (R); SY(P); PPST (P); KeKelurahanan (P); Dinas Pendidikan (P)														Core aim of educational activities; empowering future generations of teachers to provide environmental education

5.4 Procurement of long-term funding for rejuvenation project in Tangkoko and other habitat critical to *M. nigra*	BKSDA (R); Pemda (P); Pemprov (P); Bappeda (P)														Essential for continuity of conservation activities; using lessons learnt and survey/ METT/ workshop results to guide short to long term conservation strategy
5.5 Creation of revenue and economic benefits through marketing area as tourism attraction	Dispar (R); Asita (P); HPI (P); Tour operators (P); NGOs (P)														Linked to 4.4 to increase the appreciation of *M. nigra* as an important tourist attraction; also to ensure revenue generation is fairly and widely disseminated; intelligence and watchdog to monitor tourism revenue benefits
5.6 Communication between policy makers	BKSDA (R); Pemda (P); Pemprov (P); Bappeda (P)														To incorporate protection of *M. nigra* and other biodiversity into environmental and developmental priorities; important for drafting and campaigning for PERDA (1.10, 1.6, 1.7)
5.7 Official declaration of *M. nigra* as a key species in N. Sulawesi that needs protecting via change in Status classification	PHKA (P); BKSDA (P); Pemprov-Dishut (P); Pemda-Dishut (P); Pemda-Dispar (P); ASITA (P); HPI (P); PHRI (P); SY (P); GAHAWISRI (P); PKT (P); NSTB (P)														Currently 14 priority endangered species recognised throughout Indonesia by Ministry of Forestry (PHKSA); to include M. nigra would increase capacity for priority setting of funding and resources for protection; also other channels for declaration as key species

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Appendices

Appendix I. Conceptual Model of Threat Reduction Approach (Miradi)

Appendix II. Complete Outcome of *Macaca nigra* Threat Analysis Using IUCN-CMP Criteria (IUCN-CMP, 2008)

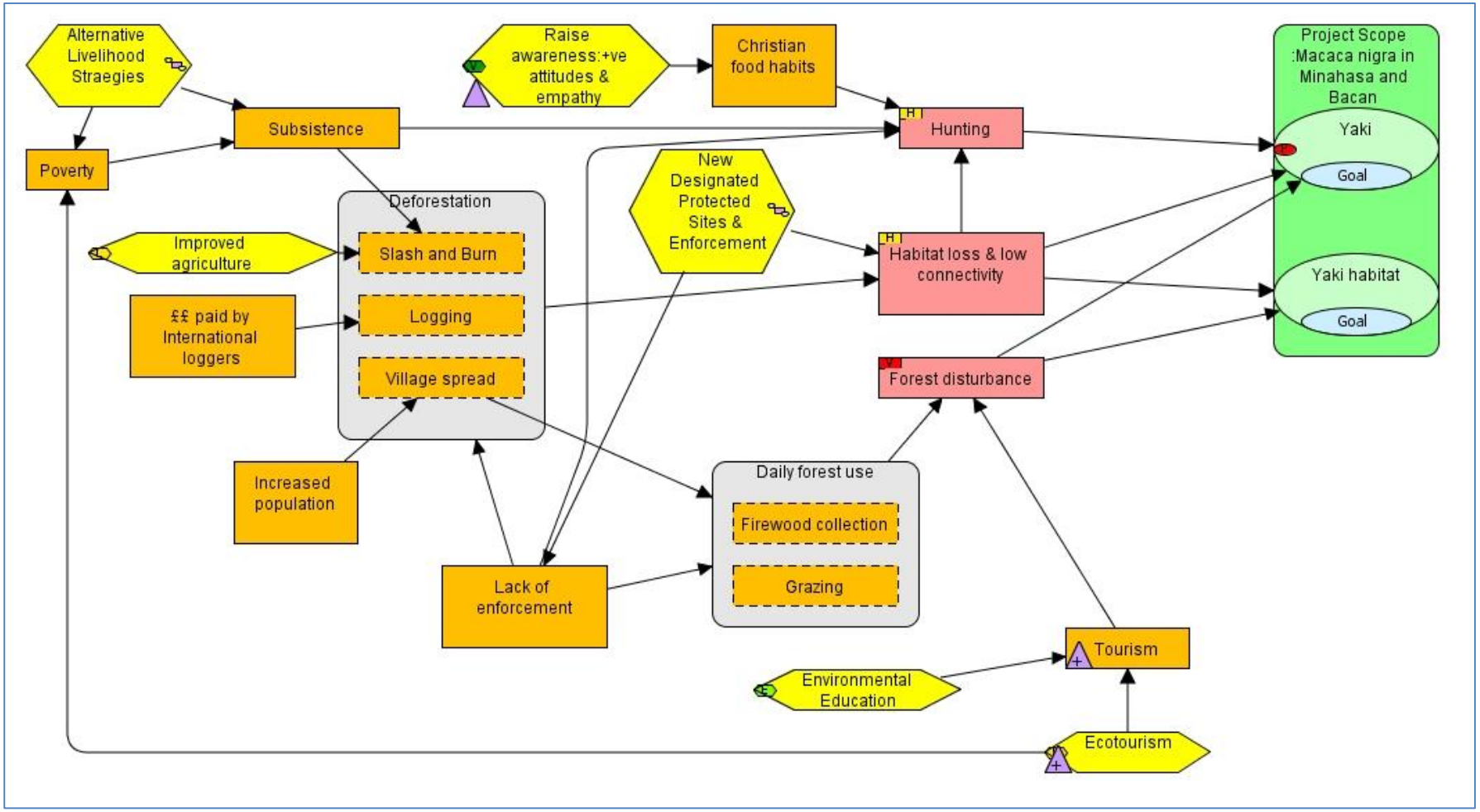
Appendix III. Summary of transects followed and the number of sightings and consequent estimation of *Macaca nigra* populations in these areas

Appendix IV. Criteria for Direct Threat Ratings Using a Simple Method (WWF, 2007)

Appendix V. List of Species Conservation Action Plan contributors (including details)

Appendix VI. Urban infrastructure planned for North Sulawesi over two decades, 2010 – 2030

Appendix I. Conceptual Model of Threat Reduction Approach (Miradi)



Appendix II. Complete Outcome of Macaca nigra Threat Analysis Using IUCN-CMP Criteria (IUCN-CMP, 2008).

Threat		*Macaca nigra* Population Rating			*M. nigra* Summary Threat Rating	*M. nigra* Habitat Rating			Habitat Summary Threat Rating	Overall Summary Threat Rating	Confidence Level	Direct/ Contributing
		Scope	Severity	Irreversibility		Scope	Severity	Irreversibility				
1. Residential & Commercial Development												
1.1	Housing & urban	Medium (2)	Medium (2)	Very High (4)	**8**	Medium (2)	High (3)	Very High (4)	**9**	**17**	4	Contributing
1.2	Commercial & Industrial Areas	Low (1)	Medium (2)	High (3)	**6**	Low (1)	Medium (2)	High (3)	**6**	**12**	3	Contributing
1.3	Tourism & recreation	Medium (2)	High (3)	Medium (2)	**7**	Medium (2)	High (3)	Medium (2)	**7**	**14**	4	Contributing
2. Agriculture & Aquaculture												
2.1	Annual & perrenial non-timber crops	High (3)	High (3)	High (3)	**9**	High (3)	High (3)	Very High (4)	**10**	**19**	5	Direct
2.2	Wood and pulp plantations	Low (1)	Medium (2)	Medium (2)	**5**	Low (2)	Low (1)	Medium (2)	**5**	**10**	3	Contributing
2.3	Livestock farming	Low (1)	High (3)	Medium (2)	**6**	High (3)	High (3)	High (3)	**9**	**15**	3	Contributing
2.4	Marine & Freshwater Aquaculture	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	Contributing
3. Energy Production & Mining												
3.1	Oil & Gas Drilling	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	5	none
3.2	Mining	Medium (2)	Medium (2)	Medium (2)	**6**	Medium (2)	Very High (4)	High (3)	**9**	**15**	5	Contributing
3.3	Renewable Energy	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	2	Contributing
4. Transportation & Service Corridors												
4.1	Roads and Railroads	Medium (2)	Medium (2)	Medium (2)	**6**	Medium (2)	High (3)	High (3)	**8**	**14**	5	Contributing
4.2	Utility & Service Lines	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	2	Contributing
4.3	Shipping Lanes	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
4.4	Flight Paths	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
5. Biological Resource Use												
5.1	Hunting and collecting of terrestrial animals	Very High (4)	Very High (4)	Medium (2)	**10**	Medium (2)	Medium (2)	Medium (2)	**6**	**16**	5	Direct
5.2	Gathering terrestrial plants	Medium (2)	Medium (2)	Medium (2)	**6**	Medium (2)	Medium (2)	Medium (2)	**6**	**6**	2	contributing
5.3	Logging and wood harvesting	High (3)	High (3)	Medium (2)	**8**	High (3)	High (3)	High (3)	**9**	**15**	4	Direct
5.4	Fishing & Harvesting Aquatic Resources	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
6. Human Intrusions & Disturbance												
6.1	Recreational Activities	Low (1)	Low (1)	Low (1)	**3**	Medium (2)	Medium (2)	Low (1)	**5**	**8**	2	Contributing
6.2	War, Civil Unrest & Military Exercises	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
6.3	Work & Other Activities	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
7. Natural System Modifications												
7.1	Fire & fire suppression	Medium (2)	Medium (2)	Medium (2)	**6**	High (3)	High (3)	Medium (2)	**8**	**14**	4	contributing
7.2	Dams & Water Management/Use	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Medium (2)	Medium (2)	**5**	**8**	3	contributing
7.3	Other Ecosystem Modifications	Low (1)	Low (1)	Medium (2)	**4**	Low (1)	Medium (2)	Medium (2)	**5**	**9**	2	contributing
8. Invasive & Other Problematic Species & Genes												
8.1	Invasive Non-Native/Alien Species	Low (1)	Medium (2)	Low (1)	**4**	Low (1)	Medium (2)	Low (1)	**4**	**8**	2	contributing
8.2	Problematic Native Species	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	2	contributing
8.3	Introduced Genetic Material	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	3	contributing
9. Pollution												
9.1	Household Sewage & Urban Waste Water	Medium (2)	Low (1)	Low (1)	**4**	Medium (2)	Medium (2)	Medium (2)	**6**	**10**	3	Contributing
9.2	Industrial & Military Effluents	Low (1)	Medium (2)	Low (1)	**4**	Medium (2)	Medium (2)	Medium (2)	**6**	**10**	4	Contributing
9.3	Agricultural & Forestry Effluents	Low (1)	Medium (2)	Low (1)	**4**	Medium (2)	Medium (2)	Medium (2)	**6**	**10**	4	Contributing
9.4	Garbage & Solid Waste	Medium (2)	Medium (2)	Low (1)	**5**	Medium (2)	Medium (2)	Medium (2)	**6**	**11**	4	Contributing
9.5	Air-Borne Pollutants	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
9.6	Excess Energy	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
10. Geological Events												
10.1	Volcanoes	Low (1)	Low (1)	Low (1)	**3**	Low (1)	High (3)	Low (1)	**5**	**8**	4	none
10.2	Earthquakes,tsunamis	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
10.3	Avalanches,landslides	Low (1)	Low (1)	Low (1)	**3**	Medium (2)	Medium (2)	Medium (2)	**6**	**9**	4	none
11. Climate Change & Severe Weather												
11.1	Habitat Shifting & Alteration	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
11.2	Droughts	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
11.3	Temperature Excess	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none
11.4	Storms & Flooding	Low (1)	Low (1)	Low (1)	**3**	Low (1)	Low (1)	Low (1)	**3**	**6**	4	none

Appendix III. Summary of transects followed and the number of sightings and consequent estimation of Macaca nigra populations in these areas

Area	**Location**	**Transect (T: # & total length) &*M. NIGRA*obs (*M. NIGRA*: # &popn est.)**				
		#	**days**	**WCS '99-2000**	**Sugardito '89**	**Melfi '07**
Northern tip	Tangkoko Duasudara	15	5	T: 5x @ 5km (99.5km)*; *M. NIGRA*: # 21 (++)	T: 124.5km; *M. NIGRA*: (+++/++)	T: 4 x 3.9km (total 15.3km); *M. NIGRA*: # 6 (++)
Northern tip	Mt. Wiau	2	1			T: 3x 1.5km (total, 4.5km); *M. NIGRA*: (ø)
Northern tip	Mt. Klabat	2	1		T: 19.5km; *M. NIGRA*: (ø)	T: 3x 2.6km (total, 7.8km); *M. NIGRA*: (ø)
Northern tip	Likupang-Wori	2	1			☒
Northern tip	Mt. Tumpa	2	1			T: 3x 1.1km (total, 3.3km); *M. NIGRA*: (ø)
Tatawiran complex	Mahawu	2	1			T: 3x 1.3km (total, 3.9km); *M. NIGRA*: (ø)
Tatawiran complex	Lokon (Tinno instead)	2	1			T: 1x 1km; *M. NIGRA*: (ø)
Tatawiran complex	Tatawiran	2	1			T: 1x 4.32km; *M. NIGRA*: (ø)
Tatawiran complex	Manembo-nembo	5	5	T: 2x 1.8km (10.8km); *M. NIGRA*: # 3 (++)	T: 6.5km; *M. NIGRA*: (++)	
	(Senduk)					☒
	(Wawona)	1				T: 1x 10.7km; *M. NIGRA*: (ø)
	(Kumu)					**T: 3x 1.9km (total, 5.7km); *M. NIGRA*: #1 (+)**
Lembean Range	Minawerot	1	1			☒
Lembean Range	Kombi	1	1			T: 1x 2.2km; *M. NIGRA*: (ø)
Lembean Range	Eris	1	1			☒
Lembean Range	Kakas	1	1			T: 3x 2.8km (total 8.4km); *M. NIGRA*: (ø)
Inland Minahasa	Mt. Tampusu	1	1			T: 3x 1.3km; (total 3.9km); *M. NIGRA*: (ø)
Inland Minahasa	Mt. Kawatak	2	1			T: 3x 2.2km (total 6.6km); *M. NIGRA*: (ø)
Inland Minahasa	Mt. Manimporok	1	1			⊗
Inland Minahasa	Mt. Kalilondey	1	1			☒
Inland Minahasa	Mt. Rindengan	1	1			☒
Motoling Landscape	Liandok	2	2			⊗
*Motoling Landscape	Eluson				T: 20km; *M. NIGRA*: (ø/+) (Eluson/ Pondus)	☒
Motoling Landscape	Motoling†	2	1			☒
Motoling Landscape	Mt. Lolombulan†	2	2			⊗

Ambang Range	Mt. Ambang (Sinsingon)	5	5	T: 4x @5km (63.15km)*; *M. NIGRA*: # 5 (+)	T: 22.5km; *M. NIGRA*: (ø)	T: 5x 2.1km (total 14.52km); *M. NIGRA*: (ø)
Ambang Range	Mt. Sinonsayang	2	2			T: 1x 6.6km; *M. NIGRA*: (ø)
Ambang Range	**Mt. Ambang (Liberia)**					**T: 3x 2.2km (total 6.6km); *M. NIGRA*: # 1 (+)**
Ambang Range	**Mt. Bumbungan/ *TDA**	**2**	**3**		***M. NIGRA*: (ø)**	**T: 1x 4.1km; *M. NIGRA*: # 1 (+)**
Pasaan Landscape	Belang	2	2			☒
Pasaan Landscape	Ratatotok	2	2			T: 2x 1.2km (total 2.4km); *M. NIGRA*: (ø)
Pasaan Landscape	Kotabunan	2	2			T: 2x 6km (total 12km); *M. NIGRA*: (ø)
Crossing S borders	**Pinolosian**	**2**	**3**		***M. NIGRA*: (ø)**	**T: 2x 5.9km (total 11.8km); *M. NIGRA*: # 1 (+)**
Crossing S borders	Lolak	2	3			T: 3x 3km (total 9km); *M. NIGRA*: (ø)
Islands	Manado tua					T: 1x 5.5km; *M. NIGRA*: (ø)
Total		69	53	11 (3 locations) (total 173.5km)	7 locations (total 193.5km)	52 (22 locations) (total 150.14 km)

Transect locations:
***** transect location known (repeated in Melfi '07)
☒visual inspection of area from surrounding roads showed that the location was >85% farmland, so no transect was attempted OR
⊗ currently inaccessible (bad roads or military activity).
† location changed to Eluson

***M. NIGRA* observations:**
Ø no sightings
Number of animals estimated:
+++, > 50/km²; ++, 10-40/km²; + <10/km²;

RED: what do we know?
GREEN: farmland ~ so not visited
BLUE: new area
GREY: not accessible, bad roads or military area
BOLD: animals found

Appendix IV: Criteria for Direct Threat Ratings Using a Simple Method (WWF, 2007).

Scope - Most commonly defined spatially as the proportion of the target that can reasonably be expected to be affected by the threat within ten years given the continuation of current circumstances and trends. For ecosystems and ecological communities, measured as the proportion of the target's occurrence. For species, measured as the proportion of the target's population.

- **Very High:** The threat is likely to be pervasive in its scope, affecting the target across all or most (71-100%) of its occurrence/population.
- **High:** The threat is likely to be widespread in its scope, affecting the target across much (31-70%) of its occurrence/population.
- **Medium:** The threat is likely to be restricted in its scope, affecting the target across some (11-30%) of its occurrence/population.
- **Low:** The threat is likely to be very narrow in its scope, affecting the target across a small proportion (1-10%) of its occurrence/population.

Severity - Within the scope, the level of damage to the target from the threat that can reasonably be expected given the continuation of current circumstances and trends. For ecosystems and ecological communities, typically measured as the degree of destruction or degradation of the target within the scope. For species, usually measured as the degree of reduction of the target population within the scope.

- **Very High:** Within the scope, the threat is likely to destroy or eliminate the target, or reduce its population by 71-100% within ten years or three generations.
- **High:** Within the scope, the threat is likely to seriously degrade/reduce the target or reduce its population by 31-70% within ten years or three generations.
- **Medium:** Within the scope, the threat is likely to moderately degrade/reduce the target or reduce its population by 11-30% within ten years or three generations.
- **Low:** Within the scope, the threat is likely to only slightly degrade/reduce the target or reduce its population by 1-10% within ten years or three generations.

Irreversibility (Permanence) - The degree to which the effects of a threat can be reversed and the target affected by the threat restored.

- **Very High:** The effects of the threat cannot be reversed and it is very unlikely the target can be restored, and/or it would take more than 100 years to achieve this (e.g., wetlands converted to a shopping center).
- **High:** The effects of the threat can technically be reversed and the target restored, but it is not practically affordable and/or it would take 21-100 years to achieve this (e.g., wetland converted to agriculture).
- **Medium:** The effects of the threat can be reversed and the target restored with a reasonable commitment of resources and/or within 6-20 years (e.g., ditching and draining of wetland).
- **Low:** The effects of the threat are easily reversible and the target can be easily restored at a relatively low cost and/or within 0-5 years (e.g., off-road vehicles trespassing in wetland).

Appendix V: Summary of Survey Data Depicting Specifics of Methods Used and Constituent Results Per Location

Data	Z MacKinnon and MacKinnon (1980)	Sugardjito *et al.*, (1989)	Rosenbaum *et al.*, (1998)	Melfi, (2010)	Palacios *et al.*, (2012)	Kyes *et al.*, (2012)
Location 1.		Tangkoko NR	Tangkoko / TBDS		Tangkoko NR	Tangkoko NR
Methods			5 transects (2T+2B+1D)		13 transects walked 12 times each	1 transect walked twice a day for 2 weeks/year
Density I/km²		76.2	68.7 / 47.2		44.9	61.5
Density G/km²	9.0	5.1	3.9 / 2.7		2.6	4.3
Group size		15.0	20.0 / 18.7		16.7	14.3
Total G seen		42.0	88.0 / 160.0			22.0
Total I seen			2,447.0 (TBDS)			
Esti I in TBDS		3,655.0			1,951 (CI 1,113–3,421)	
Location 2.		Tangkoko, ,Duasudara ,Manembo nembo, Gn. Ambang& Modayaq, Pondos&Elu san	GunungSibel a + Wayamiga			
Methods		Line transects in 25 locations	6 transects (3GS+3W)			
Density I/km²		28.86	152.1			
Density G/km²		2.38	3.9			
Group size		/	26.15			
Total I		11.4	11,812.0			
Total G seen		51.0	451.0			

Appendix VI. Urban infrastructure planned for North Sulawesi over two decades, 2010 – 2030