# Restoring a top predator in Indonesia and Malaysia, the Sunda Clouded Leopard (*Neofelis diardi*)

FWS 470 Spring 2019
Robert Kahlstrom



Andrew Hearn and Joanna Ross

A paper submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Fisheries and Wildlife Science-Wildlife Concentration at Paul Smiths College

## Executive Summary

The Sunda clouded leopard (*Neofelis diardi*) is a semi-arboreal species of feline that is found in Indonesia and Malaysia. Sunda clouded leopard populations are in decline because of increasing deforestation. This specie's diet consists of bearded pig (*Sus barbatus*), sumbar deer (*Rusa unicolor*), mouse deer (*Tragulus spp.*), porcupine (*Hystrix sumatrae*), and muntjacs (*Muntiacus spp.*) among others. Deforestation is having a large effect on the habitat available for the Sunda clouded leopard. Along with the habitat decline, there have been declines in the numbers of prey species due to poaching, creating a low food abundance for this species. These both are creating major conservation concerns for the Sunda clouded leopard in Sumatra, Indonesia and Borneo, Malaysia. The goal of this management plan will be to increase the population of the Sunda clouded leopard to a sustainable level and decrease habitat loss by 10% across Indonesia and Malaysia. For success, three objectives are needed, including: 1) publish 3 peer reviewed papers for the Sunda clouded leopard over the next 20 years, 2) increase the population size by 10% over the next 35 years, and 3) increase the suitable dipterocarp habitat by 10% over the next 25 years. Actions will include conducting scientific studies to gain knowledge of the Sunda clouded leopard. There will also be law enforcement and regulations added for the habitat along with many species that are found in this region. There will be an expected increase in the population of Sunda clouded leopard in order to reach a sustainable level in Sumatra, Indonesia and Borneo, Malaysia.

# Table of Contents

## Introduction

The Sunda clouded leopard (*Neofelis diardi*) is shown to have lineage to the Saber-toothed Tiger (Chiang and Allen 2017). The Sunda clouded leopard has been recently identified as a separate species from the clouded leopard of Southern Asia (Wilting et al. 2007). Both species are listed under the International Union for Conservation of Nature's Red List of Threatened Species (IUCN Red List) because of poaching and habitat degradation. This species is listed under the IUCN Red List as a vulnerable species (IUCN 2015). The Sunda clouded leopard is an apex predator on the islands of Sumatra, Indonesia and Borneo, Malaysia and is an ecologically important species to the conservation of the habitat (Macdonald et al. 2018). This species is found in a range of forested habitats, elevations, and disturbance classes allowing for great adaptability (IUCN 2015). The Sunda clouded leopard is a forest dependent species and with the growing oil and rubber plantations, there is limited forested habitat remaining in Indonesia and Malaysia. These leopards are primarily nocturnal with some crepuscular activity making it difficult to conduct studies (Ross et al. 2013). Along with being nocturnal, they are also a semi-arboreal species that is effective at climbing trees and branches throughout the forest while also being able to stalk on the ground (Brodie and Giordano 2012). With the limited studies conducted, there is still some uncertainty in the population, life history, and ecology of this species. Due to the nature of this species and the decline in population, it is necessary to implement conservation efforts. It has been shown that the young adult (ages 2-5 years) and sub adult (ages 5-10 years) classes for this species are the most important (0.41) according to table 2 (Appendix B).

## Natural History

Sunda clouded leopards are medium sized felids with a weight around 11-23 kg and a tail that is approximately the same length as its head to body, which can be up to 80-90 cm long (Chiang and Allen, 2017). This species has distinctive large dark markings that are clouded in shape along the body



Figure 1: Sunda clouded leopard sleeping on a tree branch

allowing for identifiability of specific individuals in a population. They also possess a relatively long canine compared to skull size of 3.8-4.5 cm in length, the longest of all living felids (Chiang and Allen, 2017).

## Reproductive Success

The Sunda clouded leopard reproduces during any month throughout the year with a higher percentage of kittens being born during March, a result of a greater frequency of mating during December (Yamada and Durrant, 1989). The estrous cycle in this species lasts for approximately 15-40 days and an estrus cycle of 3-6 days (Brown, 2011). Gestation lasts for around 90 days with 1-5 kittens being sired at birth with an average of 2. The average age of sexual maturity of both males and females is 2 years old. This is important in successful breeding because of high incidences of males killing females if not introduced before puberty (Brown, 2011). The greatest reproductive success has been shown to be in the young adult stage class (0.11) according to table 1 (Appendix B). This shows that the young adult age class is the most important to protect for reproduction.

**Distribution**

Distribution is spread across the islands of Sumatra, Indonesia and Borneo, Malaysia. They are found in many habitat types and elevations with a preference for dense primary dipterocarp forests. They have been observed in semi-logged forests, primary forest, and even through plantations for oil and rubber.

IUCN Red List

Figure 2: Current distribution of Sunda clouded leopards

**Diet**

The Sunda clouded leopard consumes a variety of prey species across their habitat range of Borneo and Sumatra. Sunda clouded leopards may consume prey such as ungulates, primates, birds, rodents, domesticated animals, and sometimes fish and snakes (Chiang and Allen, 2017). Some species that are consumed by the Sunda clouded leopard include sambar deer (*Rusa unicolor*), muntjacs (*Muntiacus spp.*), bearded pig (*Sus barbatus*), mouse deer (*Tragulus spp.*), and porcupines (*Hystrix sumatrae*) (Ross et al. 2013). Being documented as a primarily nocturnal species in Sumatra and diurnal and nocturnal in Borneo, the Sunda clouded leopard will feed from dawn to dusk. It has been shown that this species will hang a kill from a tree branch off the ground and return to it the next day (Chiang and Allen, 2017). This can be common for species that are solitary like the Sunda clouded leopard when the kill is a larger prey and takes multiple days to consume. Sunda clouded leopards are semi-arboreal, however they hunt mostly on the ground in Borneo compared to Sumatra. This may be due to interspecific competition with tigers in Sumatra (IUCN, 2015). It is believed that

Sunda clouded leopards kill prey that are smaller, however when attacking a larger prey, they will bite the nape to sever the spinal cord.

**Cover**

Sunda clouded leopards can be found in a wide range of habitat types and elevations. It was observed that this species preferred dense primary forests. However, in more recent studies, it has been shown that they can occur in grasslands, secondary or selectively logged forests, and mature evergreen rain forests (Chiang and Allen, 2017). Sunda clouded leopards can occur in lowland, upland, and submontane dipterocarp forests (IUCN 2015). Some other forest types Sunda clouded leopards are found to occur in are peat-swamps and mangrove forests (Hearn et al. 2016). The Sunda clouded leopard can occur across their habitat range with oil palm plantations not being used but also not creating a barrier. Habitat use is shown to be heavily influenced by small to medium sized prey species (Mohamed et al. 2015).

## Management Needs

**Ecological Issues**

The Sunda clouded leopard has many ecological issues on the islands of Sumatra and Borneo. The Sunda clouded leopard is an ambassador species for both islands they preside on, meaning they are an important conservation icon for forest conservation (Macdonald et al. 2018). This means that this species is considered a flagship species and will act as an icon for defined habitats, issues, or environmental causes. Two main threats to the Sunda clouded leopard are increasing habitat loss causing fragmentation and degradation and poaching of prey species (Macdonald et al. 2018). There has been a drastic decrease in the habitat in Borneo with 30.2% of the habitat being lost from

1973 to 2010, along with having the highest rate of decreasing forest in Indonesia during this time (Macdonald et al. 2018). Using a prediction model, there was an estimated change in forested habitat showing fragmentation in landscape with a significant increase in the change between 2010 and 2020 compared to 2000 and 2010 (Macdonald et al. 2018). There have been observations of three diseases in this species with single occurrences of two and the third being in most feline species. None of the diseases have been observed to have any significant effects on the Sunda clouded leopard.

**Economic and Sociocultural Issues**

With an increase in immigrant populations, there is an increase in economy, and market-based actions causing an increase in plantations being formed across the forests (Luskin et al. 2013). With this increase, there has been more habitat loss and fragmentation occurring across Sumatra (Luskin et al. 2013). With the plantations, an increase in generalist species and a decrease in area-demanding species has been seen in the Jambi providence of Indonesia (Luskin et al. 2013). Many of the different ethnic groups in the region hunted for meat trade or personal consumption. The main species that was hunted was wild boar (*Sus scrofa*) and deer like the mouse deer (*Tragulus spp.*) which are prey species for the Sunda clouded leopard (Luskin et al. 2013). The result of poaching from prey species and the Sunda clouded leopard is causing a significant threat in Sumatra and Borneo (IUCN 2015).

**Legal, regulatory, and policy**

This species is protected under CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix I (IUCN, 2015).

## Statement of Needs

The main needs for the Sunda clouded leopard include protecting the habitat from future deforestation and degradation, reducing poaching events, and protecting prey species at a sustainable level as well as conducting more research to gain a more thorough knowledge of populations, life expectancy, and reproduction.

## Goals and Objectives

**Goal:** To increase populations of the Sunda clouded leopard to a sustainable level while decreasing habitat loss in Indonesia and Malaysia by 2054.

**Objectives:**

1) Publish 3 peer reviewed papers for the Sunda clouded leopard over the next 20 years.

2) Increase the population by 10% over the next 35 years.

3) Increase the suitable dipterocarp habitat by 10% over the next 25 years.

## Actions

**Objective 1:** Publish 3 peer reviewed papers for the Sunda clouded leopard over the next 20 years.

**Action 1.1:** Research the population using mark-recapture techniques and camera traps to assess the population densities across four 100 km$^2$ plots (Brodie and Giordano, 2012). To increase the visits to camera sites, there would be attractants placed at each site. This can be done using turkey feathers or scent disks (Tanner and Zimmerman 2012). Using this method, there will be information collected about sex ratios of the population.

**Action 1.2:** Use traps and chemical immobilization techniques to increase the current knowledge of size, weight, sex, and disease. This will be done with a baited box trap and immobilizing Sunda clouded leopard using a pole syringe mixed in the field. The chemical agent that will be used is ketamine hydrochloride with xylazine hydrochloride or KH-XH mixed at a 15:1 ratio (Grassman et al. 2004). This will allow for gained knowledge about the different individuals in the population.

**No Action:** If no action is taken, there will be insufficient data on the Sunda clouded leopard for Indonesia and Malaysia. This will result in a continually declining population and higher probability of extinction.

**Final Courses of Action:** Actions 1.1, 1.2. Conducting these actions in order will allow researchers to gain a more thorough knowledge base for the Sunda clouded leopard. This will allow for more thorough management practices and enhance the methods used to manage this species.

**Assessment Protocol:** Objective 1 will be considered completed if both actions 1.1 and 1.2 are successful. Actions 1.1 will be considered successful if the population densities have been assessed and calculated. If research about the sex ratios in the population and the size, weight, and diseases in the population have been assessed, then action 1.2 will be considered successful. With this information, 3 peer-reviewed papers will be published about the Sunda clouded leopard and objective 1 will be successful and allow for further knowledge of the population. If the objective is not met in this time, then more studies will be conducted to

reach the 3 peer reviewed papers. This will be done by continuing research to increase the data set being collected.

**Objective 2:** Increase the population by 10% over the next 35 years.

**Action 2.1:** Increase the prey abundance for the Sunda clouded leopard. Prey of the Sunda clouded leopard are being depleted and are listed on the IUCN Red List as endangered or vulnerable (Wolf and Ripple, 2016). There are about fifty percent of the prey species listed as endangered and vulnerable while the other fifty percent are listed as of least concern. It has also been shown that around eighty-five percent of the prey species are decreasing (Wolf and Ripple, 2016). Adding more protection and enforcement of prey species will create a higher abundance of food availability. This will be done by creating laws and having law enforcement officials to enforce the new laws.

**Action 2.2:** Decrease poaching of Sunda clouded leopard to increase the survival of young adult and subadult population classes. It is important to increase the survival of the young adult class by 11% and subadult class by 8% to increase the population. With some protection and no enforcement within this species, they have been observing an increased disturbance from poaching (Hearn et al. 2018). Create law enforcement positions to enforce poaching and implement protection for the population of this species. Law enforcement officials would be assigned sections to patrol and enforce the regulations that have been implemented into the

area.  By doing this, it will deter residents from poaching and increase the chance of further population increase.

**Action 2.3:** Implement captive breeding to increase the fecundity of the population. This is challenging due to mating incompatibility of clouded leopards (Tipkantha et al. 2017). Mating incompatibility is caused by teratospermia in males and having inconsistent ovulation patterns in females. Another problem with captive breeding is caused by males and females needing to be introduced before puberty to become a successful breeding pair (Brown, 2010). With these challenges, there has been one case in Thailand of successful breeding of two cubs after artificial insemination (Tipkantha et al. 2017). This would be the method used for breeding this species in captivity.

**No Action:** If no action is taken, the population will continue to decrease at a significant rate due to a reduction in survival from limited prey abundance and poaching. This will eventually lead to extinction of the Sunda clouded leopard.

**Final Courses of Action:** Actions 2.1 and 2.2. First adding the law enforcement agency and incorporate laws to decrease poaching in action 2.2. This will allow for a starting recovery of the population numbers and then following it up with action 2.1 will influence the growth of the population and eventual stabilization of the species population numbers. Action 2.3 is difficult to accomplish and does not have the influence on the

population as the other actions because of this it is not plausible to continue with action 2.3.

**Assessment Protocol:** Objective 2 will be considered complete if actions 2.1 and 2.2 are successful and the population is shown to have an increase. Action 2.1 will be considered successful if the prey abundance has been documented to have an increase in population size. Action 2.2 will be considered successful if it has been documented that poaching of the Sunda clouded leopard has decreased. If objective 2 is not completed in the time frame then further protection will be implemented. Action 1.3 will be implemented after the first 25 years if there has been no documented increase in population size.

**Objective 3:** Increase the suitable dipterocarp habitat by 10% over the next 25 years.

**Action 3.1:** It is important to talk with the local people and logging companies to incorporate a sustainable and suitable forest reserve. By doing this, the forest can have a chance of regrowth creating more habitat for many species in Indonesia and Malaysia. There have been observations of a major decline in the suitable habitat for Sunda clouded leopards (Macdonald et al. 2018). To do this, a survey will be used to understand the need and importance of the forest to the public and logging companies (Appendix C).

**Action 3.2:** Assess the habitat using GIS (geographic information systems). This will be done using GIS based tools and satellite imagery with limited cloud cover at the time of images taken (Osborne et al. 2001). After collection of this data, it will be imputed into the GIS software and using a GIS based tool, the cover types will be assessed (Adeel and Pomeroy, 2002). To do this, the digitized maps of the cover types will be layered to distinguish the importance of the different habitat used (Osborne et al. 2001).

**Action 3.3:** Decrease deforestation by using selective logging for ten years. Deforestation is causing a major decline in Sunda clouded leopard habitat (Hearn et al. 2018). By incorporating selective logging, it would allow for different sections of the forest to be utilized for logging for the resident's economic growth along with keeping suitable habitat for the Sunda clouded leopard to survive in.

**Action 3.4:** During this time, incorporate protection for 50% of the habitat range. Implement forest reserves on a selected area of the habitat range. It is important to have protection for the forest due to having most of the habitat being lost causing declines in predator and prey abundance throughout the landscape. It is critical to have protection for degradation of forested habitats (McCarthy et al. 2015). Along with implementing forest reserves, adding law officials to enforce protection for the reserves would be implemented.

**No Action:** If no action is taken, there is going to be an increasingly rapid loss of forest habitat for the species in Indonesia and Malaysia. This will create a decline in the biodiversity and eventually lead to the extirpation or extinction of many species that would otherwise be able to survive.

**Final Courses of Action:** Actions 3.1, 3.2, 3.3 and 3.4. Incorporating action 3.1 will give a gained understanding of the thoughts of the pubic and logging companies. Action 3.2 will allow for gained knowledge about the habitat that is still available. Both actions 3.3 and 3.4 will allow for increased habitat with eventual stabilizing. All of these actions are feasible and achievable using protection agencies along with discussing the importance to the landowners and logging companies.

**Assessment Protocol:** Objective 3 will be considered completed if actions 3.1, 3.2, 3.3 and 3.4 are successful. Action 3.1 will be successful if the survey receives a positive response and thorough knowledge is gained. Action 3.2 will be successful if the habitat is assessed and documented to determine the important habitat types. Action 3.3 will be successful if there is documentation of decreased habitat loss. Action 3.4 will be successful if there has been documentation of protection to the habitat needed. If objective 3 is not met in the time frame then there will be further outreach to the public and research will be continued. There will be continual protection enforced for the habitat along with outreach to the logging companies to assess another forest practice to decrease deforestation.

## Conclusion

The goal of this management plan will be to increase the Sunda clouded leopard population and habitat to sustainable levels in Indonesia and Malaysia for future generations. With the help of researchers, the public, and law enforcement agencies, it will be possible to bring this species back to the predator it should be. The research and public opinion may change throughout the course of this 35-year management plan. With little knowledge of this species, the research to be conducted will provide added knowledge about the biology and ecology. With this added knowledge, it is going to provide better management practices and longer survival of this species. With the support of the people of Indonesia and Malaysia and the knowledge now gained, the Sunda clouded leopard will be an example of successful conservation to be used for other similar species of the region.

## Acknowledgements

## Literature Cited

Adeel, Z. and R. Pomeroy. 2002. Assessment and management of mangrove ecosystems in developing countries. Trees 16:235-238.

Allen, M.L., H. U. Wittmer., E. Setiawan., S. Jaffe., and A.J. Marshall. 2016. Scent marking in Sunda clouded leopards (*Neofelis diardi*): novel observations close a key gap in understanding felid communication behaviors. Science Reports.

Brodie, J. and A. J. Giordano. 2012. Density of the Vulnerable Sunda clouded leopard *Neofelis diardi* in a protected area in Sabah, Malaysian Borneo. Fauna and Flora International 46:427-430.

Brown, J.L. 2011. Female reproductive cycles of wild female felids. Animal Reproductive Science 124:155-162.

Cerveny, N.S.S., M.E. Thompson., S.M. Corner., A.K. Swinford., and R.L. Coke. 2013. Cutaneous atypical mycobacteriosis in a clouded leopard (*Neofelis nebulosa*). Journal of Zoo and Wildlife Medicine 44:756-760.

Chiang, P. and M.L. Allen. 2017. A review of our current knowledge of Clouded Leopards (*Neofelis nebulosa*). International Journal of Avian and Wildlife Biology 2.

Grassman, Jr.L.I., S.C. Austin., M.E. Tewes., N.J. Silvy. 2004. Comparative immobilization of wild felids in Thailand. Journal of Wildlife Diseases 40:575-578.

Hearn, A. 2015. *Neofelis diardi*. The IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/136603/97212874#conservation actions. Accessed 11 February 2019.

Hearn, A.J., J. Ross., D.W. MacDonald., G. Bolongon., S.M. Cheyne., A. Mohamed., H. Samejima., J.F. Brodie., A. Giordano., R. Alfred., R. Boonratana., H. Bernard., B. Loken., D.M. Augeri., M. Heydon., J. Hon., J. Mathai., A.J. Marshall., J.D. Pilgrim., J. Hall., C. Breitenmoser-Wursten., S. Kramer-Schadt., and A. Wilting. 2016. Predicted distribution of the Sunda clouded leopard *Neofelis diardi* (Mammalia: Carnivora: Felidae) on Borneo. Raffles Bulletin of Zoology 33:149-156.

Luskin, M.S., E.D. Christina., L.C. Kelley., and M.D. Potts. 2013. Modern Hunting Practices and Wild Meat Trade in the Oil Palm Plantation-Dominated Landscapes of Sumatra, Indonesia. Human Ecology 42:35-45.

Macdonald, D. W., H. M. Bothwell., A.J. Hearn., S.M. Cheyne., I. Haidir., L.T.B. Hunter., Z. Kaszta., M. Linkie., E.A. MacDonald., J. Ross., and S.A. Cushman. 2018. Multi-scale habitat selection modeling identifies threats and conservation

opportunities for the Sunda clouded leopard (*Neofelis diardi*). Biological Conservation 227:92-103.

Macdonald, E. A., S. A. Cushman., E.L. Landguth., A.J. Hearn., Y. Malhi., and D.W. MacDonald. 2018. Simulating impacts of rapid forest loss on population size, connectivity and genetic diversity of Sunda clouded leopards (*Neofelis diardi*) in Borneo. PLOS ONE 13.

McCarthy, J.L., H.T. Wibisono., K.P. McCarthy., T.K. Fuller., and N. Andayani. Assessing the distribution and habitat use of four felid species in Bukit Barisan Selatan National Park, Sumatra, Indonesia. Global Ecology and Conservation 3:210-221.

Mohamed, S.W., D.M. Rayan., W.C.T. Christopher., M. Hamirul., A. Mohamed., C.F. Lau., E.S. Siwan. 2015. The first description of population density and habitat use of the mainland clouded leopard *Neofelis nebulosa* within a logged-primary forest in South East Asia. The Society of Population Ecology 57:495-503.

Osborne, P.E., J.C. Alonso., and R.G. Bryant. 2001. Modelling landscape scale habitat use using GIS and remote sensing: a case study with great bustards. Journal of Applied Ecology 38:458-471.

Pukazhenthi, B., D. Laroe., A. Crosier., L.M. Bush., R. Spindler., K.M. Pelican., M. Bush., J.G. Howard., and D.E. Wildt. 2006. Challenges in cryopreservation of clouded leopard (*Neofelis nubulosa*) spermatozoa. Theriogenology 66:1790-1796.

Ross, J., A. J. Hearn., P.J. Johnson., and D.W. MacDonald. 2013. Activity patterns and temporal avoidance by prey in response to Sunda clouded leopard predation risk. Journal of Zoology 290:96-106.

Sollmann, R., M. Linkie., I.A. Haidir., and D.W. MacDonald. 2014. Bringing clarity to the clouded leopard *Neofelis diardi*: first density estimates from Sumatra. Fauna and Flora International 48:536-539.

Steinel, A., C.R. Parrish., M.E. Bloom., and U. Truyen. 2001. Parvovirus infections in wild carnivores. Journal of Wildlife Diseases 37:594-607.

Tanner, D. and P. Zimmerman. 2012. Optimal attractants to increase visits by Clouded leopards to remote-camera sets. Wildlife Society Bulletin 36:594-599.

Tipkantha, W., P. Thuwanut., U. Maikeaw., A. Thongphakdee., S. Yapila., S. Kamolnorranath., B. Siriaroonrat., P. Comizzoli., and K. Chatdarong. 2017. Successful laparoscopic    oviductal artificial insemination in the Clouded leopard (*Neofelis nebulosa*) in Thailand. Journal of Zoo and Wildlife Medicine 48:804-812.

Wada, Y., H. Kondo., G. Bando., M. Kosuge., Y. Ishikawa., and K. Kadota. 1996. Intestinal adenocarcinoma with neuroendocrine cells in a clouded leopard (*Neofelis nebulosa*). J. Comp. Path 115:305-310.

Wolf, C. and W.J. Ripple. 2016. Prey depletion as a threat to the world's large carnivores. Royal Society Open Science 3.

Wilting, A., A. Mohamed., L.N. Ambu., P. Lagan., S. Mannan., H. Hofer., and R. Sollmann. 2012. Density of the Vulnerable Sunda clouded leopard *Neofelis diardi* in two commercial forest reserves in Sabah, Malaysian Borneo. Fauna and Flora International 46:423-426.

Wildt, D.E., J.G. Howard., L.L. Hall., and M. Bush. 1986. Reproductive Physiology of the Clouded Leopard: I. Electroejaculates Contain High Proportions of Pleiomorphic Spermatozoa throughout the Year. Biology of Reproduction 34:937-947.

Yamada, J.K. and B.S. Durrant. 1989. Reproductive parameters of Clouded Leopards (*Neofelis nebulosa*). Zoo Biology 8:223-231.
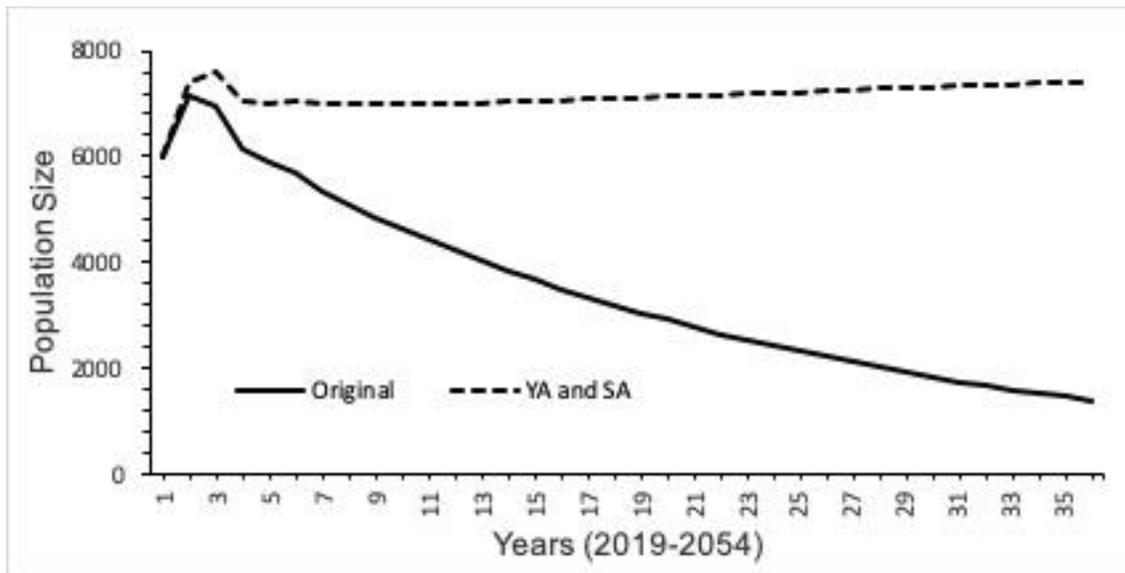
## Appendix A



Figure 3: Current vs. projected population of the Sunda clouded leopard (*Neofelis diardi*) over a 35-year time span. This population model was created using five age classes. (YA = young adult, SA = Subadult)

## Appendix B

Table 1: Elasticity matrix created using Microsoft Excel based on five life stage classes. This matrix shows the young adult class is most important to manage for (0.41).

| | Elasticity matrix | | | | |
|---|---|---|---|---|---|
| | F(k) | F(c) | F(ya) | F(sa) | F(a) |
| Kittens | 0 | 0 | 0.1103016 | 0.0559036 | 0.0121898 |
| Cubs | 0.1783951 | 0 | 0 | 0 | 0 |
| Young Adults | 0 | 0.1783951 | 0.2321777 | 0 | 0 |
| Subadults | 0 | 0 | 0.0680935 | 0.1149922 | 0 |
| Adults | 0 | 0 | 0 | 0.0121898 | 0.0373616 |

Table 2: Sensitivity matrix created using Microsoft Excel based on five life stage classes. This matrix shows that fecundity is more important than survival for management of this species.

| | Sensitivity matrix | | | | |
|---|---|---|---|---|---|
| | | F(c) | F(ya) | F(sa) | F(a) |
| Kittens | 0.1988 | 0.1065 | 0.1463 | 0.0741 | 0.0377 |
| Cubs | 0.2989 | 0.1784 | 0.2451 | 0.1242 | 0.0632 |
| Young Adults | 0.5007 | 0.2989 | 0.4106 | 0.2081 | 0.1059 |
| Subadults | 0.4405 | 0.2630 | 0.3612 | 0.1831 | 0.0932 |
| Adults | 0.2343 | 0.1399 | 0.1922 | 0.0974 | 0.0496 |

## Appendix C

Sample Survey: Forest and Logging

1. How important do you feel the logging industry is?

   1 2 3 4 5 6 7 8 9 10

2. How important is the forest to you?

   1 2 3 4 5 6 7 8 9 10

3. What do you feel is the most important about the forest? Please be specific.


4. Have you had any negative interactions with the Sunda clouded leopard?

   Yes                    Not Sure                    No

5. If yes, please explain and be specific.


6. What is your knowledge of the needs of the forest for the Sunda clouded leopard?

   Good                    Intermediate                    Bad


Thank you for taking the time to take this survey. We value the feedback and will keep it in mind for the final management plan.