Conservation of the Critically Endangered Silky Sifaka (*Propithecus candidus*) in Marojejy National Park, Madagascar

Matthew W. Tolman

Spring 2019

Submitted: May 2019

Two adult silky sifakas (*Propithecus candidus*)

A paper submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Fisheries and Wildlife – Wildlife Concentration at Paul Smith's College.

Executive Summary

The silky sifaka (*Propithecus candidus*) is a critically endangered, large bodied lemur endemic to the eastern montane rainforests of Madagascar. Silky sifakas eat primarily leaves but will also eat seeds, flowers, and fruits, which means they are not true folivores. Silky sifakas reproduce, on average, once every other year and will mate on a single day each year. Like other eastern rainforest sifakas, silky sifakas will not cross non-forested habitat (i.e. clear cuts or farm land) to travel between forest fragments. Thus, deforestation is a primary concern for the species' survival of the species. Additionally, the local villagers hunt lemurs for bush meat. Locals do not specifically target silky sifakas but make no effort to avoid the species while hunting. The goal of this management plan is to increase and maintain the silky sifaka population within Marojejy National Park, in north eastern Madagascar. There are four main objectives to reach and fulfill this goal. First, conduct additional research on silky sifaka population size and natural history, and produce 5 peer reviewed papers to increase what is known about the species. Second, to increase survival rates of each age class to 90% in 20 years. Third, increase education on the importance and uniqueness of the forests and species that live within them, inside Marojejy National Park by 50% in 3 years. And finally, to reduce the illegal harvest of fuel and rosewood within Marojejy National Park, as well as the surrounding forests, by 90% in 3 years. These objectives will be achieved through different actions including education, increased management and monitoring of the park, and implementation of new data collection methods. The completion of each objective and the effective implementation of each action should result in the silky sifaka population stabilizing and increasing in numbers each year.

Acknowledgement

I would like to thank Dr. Ross Conover, and the students of Wildlife Management for their help and support through the development of this project. I would also like to thank my parents for their support through my academic journey.

Table of Contents

Introduction

The silky sifaka (*Propithecus candidus*, henceforth silkies) is a large bodied sifaka that displays reverse sexual dimorphism. Females, on average, weigh more than males (6kg versus 5.03 kg) and have a longer tail and body length (490 mm, 535 mm) than males (462 mm, 508 mm) (Lehman et al. 2005). Silkies have long, silky and white pelage which gives it its common name (Patel 2014). Some individuals can have silver-gray to black tints in their pelage, usually located on the crown, back and limbs, and some yellow tint around the base of the tail (Patel 2014). Silkies faces are bare, as are the tips of the ears that protrude just beyond the fur of their head and cheeks. Infants are born with black skin, but as they age will lose pigmentation to varying degrees depending on the individual (Figure 1). The variation in the degree of pigmentation loss can result in some individuals having all black faces and others having all pink faces (Patel 2014). Silkies were once believed to be an albino subspecies of *P. diadema*, but the lack of red eyes and darker colored fur confirm that silkies are not albino (Patel 2014). Silkies live in montane rainforest habitat and are sensitive to anthropogenic threats (Patel and Andrianandrasana, 2008). These anthropogenic threats include habitat fragmentation and degradation through slash and burn agriculture and illegal harvest of valuable rosewood and fuel wood, as well as hunting of lemurs for bush meat (Styger et al. 2007, Patel 2007a, Patel et al.

2005b). Silkies can be classified as a conservation-reliant species because all factors causing the decline of their population can be controlled, but are hard to eliminate (Mills et al. 2012).

Natural History

Life History

*Figure SEQ Figure * ARABIC 1. Illustrations showing different degrees of pigmentation loss on individual animals faces. (Illustrations: Stephen D. Nash)*

Silkies, like other sifakas, give birth to one infant every 1-3 years (Weir 2014). Silkies will mate on a single day in December or January, with infants being born typically in June or July (Patel 2006). Sifaka infants are very small in relation to the size of the adults (Weir 2014). *P. edwardsi* infants are about 3% of their mother's weight when they are born (Weir 2014). Less than 25% of female silky sifakas survive to reproductive maturity (Pochron et al. 2004). Mortality is highest in infants and juveniles, but if a silky sifaka can reach reproductive maturity at 4 years of age, the mortality rate drops to approximately 10% (Pochron et al. 2004). It is hypothesized that over the parent's life, producing small young and keeping parental investment to a minimum, increases the chance of producing offspring, in a year with favorable environmental conditions, with higher survival rates (Weir 2014). Infant sifakas have all their juvenile teeth by three months of age, by one-year sifakas have all of their adult teeth despite being half the size of adult sifakas (Weir 2014). The teeth allow young sifakas to start to feed on solid foods early on and reduce the food (mother's milk) that the mother must provide to sustain the infant (Weir 2014).

Diet

Silky sifakas (*Propithecus candidus*) are not true folivores due to their consumption of plant parts other than leaves. Like other eastern sifakas, silkies are only folivores during the dry season when other plant parts are less available (Irwin 2006). Silkies are found in moist montane forests where the effects of the dry season such as a reduction of food and water availability are reduced (Patel and Andrianandrasana 2008). Their diets include leaves, young leaves, flowers, fruit/seeds, and bark (Kelley et al. 2002). Sifakas have gastrointestinal tract specializations, including a long gastrointestinal tract and a large cecum (Cambell et al. 2000). Additionally, sifakas also have a long transit time through the gastrointestinal tract to aid in the digestion of plant parts (Cambell et al. 2000). The diets of male and female silkies differ slightly on the proportion of plant parts being consumed (Figure 2). Unlike males, females have not been observed consuming bark or soil (Kelley et al. 2002). Silkies spend on average 22% of the day foraging for food and nearly half the day is spent resting (49.4%) (Patel 2006). The composition of their diets will vary, with less of their diet being made up of leaves during parts of the year (Kelley et al. 2002, Irwin 2006). Infants cease suckling by 6-7 months and have as much as 50% of their caloric intake from solid foods by 6 months (Weir 2014).

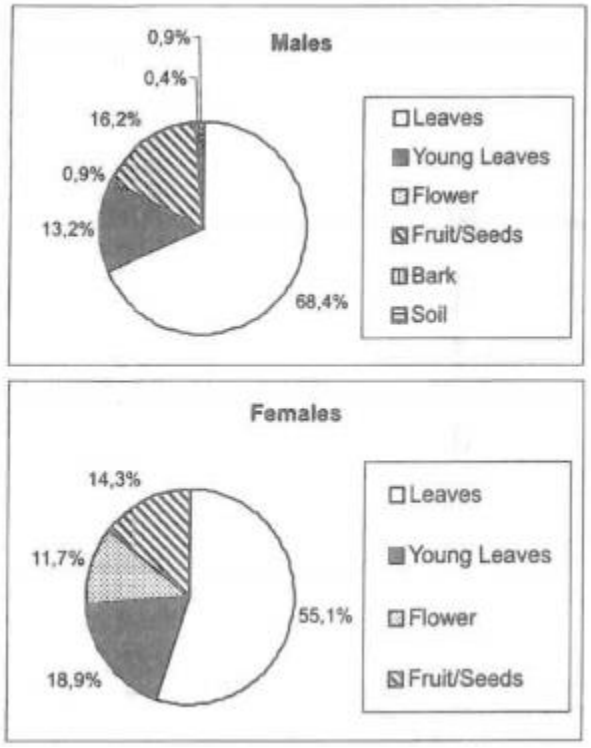

Figure 2 "Mean dietary consumption of food kinds of a) 3 male silky sifakas b) female silky sifakas (n=516 five-minute instantaneous samples)" (Kelley et al.

Habitat

Silkies inhabit the montane rain forests of north eastern Madagascar (Patel and Andrianandrasana 2008). Unlike western sifakas, silkies and other eastern rainforest sifakas rarely cross unforested regions to reach other habitat patches (Irwin 2006). Other than a few groups, silkies are found within Marojejy National Park, Anjanaharibe-Sud Special Reserve, and the Comatsa Protected Area (Patel 2016, Figure 3). Within Marojejy National Park and the Anjanaharibe-Sud Special Reserve, silkies are found from 700-1875 meters above sea level (Irwin 2006). More recently, they have been found as low as 289-558m above sea level, but only in a few locations (Patel and Andrianandrasana 2008). Silkies have a 95% Kernel home range of ~33ha in continuous forest. However, the home range size may be drastically reduced, up to 80% in some cases, for individuals living in fragmented forests (Patel and Andrianandrasana 2008). Sifakas with smaller home ranges, in fragmented forests, feed primarily on abundant mistletoe, compared to those with larger home ranges, in continuous forests, who feed on fruit trees (Irwin 2008). Fitness gains from the higher quality food outweigh the costs of increased travel and intergroup encounters (Irwin 2008).

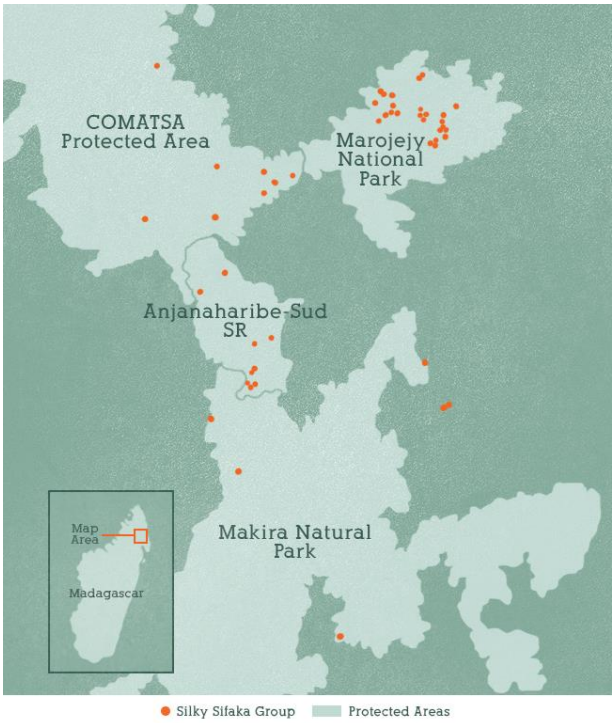

Figure 3. Silky Sifaka group distribution in Madagascar. (https://www.earthtouchnews.com/conservation/endan

Disease

Silkies, like other species of lemurs and primates, are susceptible to several species of parasites that can have varying effects (Bublitz et al. 2015). Silkies living within Marojejy National Park are most commonly affected by ectoparasites and a species of nematode (Patel et al. 2017). Bacteria and other pathogens are found most commonly in lemurs living within disturbed habitat, while lemurs living within intact habitat had greatly reduced rates of enterobacteria presence (Bublitz et al. 2015). *Lemuricola sp.* are a type of pinworm that affect many species of sifakas; approximately 5.5% of silkies are infected by *Lemuricola sp.* while about 33% of sifakas are infected by some other type of parasite (Bublitz et al. 2015, Patel et al. 2017). *Lemuricola sp.* life cycle relies on a fecal-oral route for transmission. Lemurs can either be infected from eating food contaminated with fecal matter or while grooming body parts contaminated with fecal matter. While pinworms are not inherently devastating, severe infections can cause hair loss and pruritic irritation to perianal region of the host (Patel et al. 2014). While *Lemuricola sp.* does not typically affect humans due to its fecal-oral transmission route, other pathogens carried by sifakas can. Lemurs may carry pathogens such as *E. Coli*, *V. cholerae*, and *Salmonella*, which all affect humans (Bublitz et al. 2015).

Need Statement

Background

There are around 103 species of primates,including subspecies, that live in Madagascar (Schwitzer et al. 2013). Of the lemur species found on Madagascar, 94% are threatened with extinction, and less than a dozen species are not classified in one of the IUCN's three threat

categories (Schwitzer et al. 2013). Madagascar has the second highest primate diversity; only Brazil has greater diversity, however all five families of primates found on Madagascar are endemic to the island (Schwitzer et al. 2013). There are nine species of sifaka which are broken into two groups the *P. diademed* and the *P. verreauxi* (Irwin 2006). Sifakas are also split into two additional groups, eastern and western sifakas. Eastern sifakas include all species in the *P. diademed* group as well as *P. tattersalli.* (Irwin 2006). Eastern sifakas, especially the rainforest species which include the silkies, live at much smaller population densities than do the western sifakas (Irwin 2006). Western sifakas can be found in forest patches close to human populations due to their tolerance for trees preferred by humans like *Magifera indica* (Mango) (Irwin 2006). Silkies prefer endemic species that make up the montane rainforest habitat (Patel and Andrianandrasana 2008). Silkies and the other rainforest sifakas are at a disadvantage compared to the dry forest western sifakas, because western sifakas will cross open areas between habitat fragments reducing the effect of habitat fragmentation whereas the eastern sifakas will not (Irwin 2006, Patel and Andrianandrasana 2008).

Ecological Issues

Deforestation is the largest threat to flora and fauna in Madagascar (Schwitzer et al. 2013). Madagascar has lost as much as 90% of its original natural vegetation with the remaining habitat being severely fragmented (Schwitzer et al. 2013). Most of the remaining forests providing habitat for the endemic species of Madagascar are within the protected areas including Marojejy National Park (Schwitzer et al. 2013). Since the political collapse in 2009, the protection of these lands has declined, with the invasion of protected areas to illegally harvest rosewood increasing almost immediately (Schwitzer et al. 2013). Places most affected by this sudden increase include Marojejy and Masoala National Parks (Schwitzer et al 2013). In just one

day, from a single port approximately 7200 logs weighing around 989 tons were shipped to China with an estimated value of 11,000,000 dollars U.S. (Schuurman and Lowry 2009). In addition to the illegal harvest of rosewood, the other major driver of deforestation in Madagascar is slash and burn agriculture, or tavy (Styger et al. 2007). Tavy is when either primary forest or secondary vegetation is cut or burned, upland rice is grown for one season, then a root crop like sweet potato is grown, followed by a fallow period (Styger et al. 2007). The current fallow periods used are not long enough to ensure the long-term stability of productivity, which leads to farmers expanding cropland and cutting down additional forests to find new productive soils to produce the same amount of rice (Styger et al. 2007).

Economic Issues

Many ecological issues are driven by economic issues. The poverty level is very high in Madagascar with over 70% of the population living below the national poverty line (World Bank 2019). One of the reasons for the increase in the illegal harvest of rosewood was the drop in value of the cash crop vanilla 230 USD / kg in 2003 to 25 USD / kg in 2005 (Patel 2007). This drop in the price of vanilla, coupled with rosewood being valued at 70-140 USD per tree, led to many impoverished local harvesting trees(Patel 2007). The harvest of these trees is labor intensive, and locals are usually hired to cut down the trees and then drag the 100-200 kg logs to a river where they are paid 1,000 AR, 50 to 100 times less than the retail value of the tree (Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.).

Sociocultural Issues

Harvesting bush meat, while less common in Madagascar than in Africa or Asia, is still a cause of mortality in silkies. In northeastern Madagascar it was believed that there was not a need for bush meat due to the cattle and rice culture, but instead was consumed as a delicacy by

upper middle-class families (Patel et al. 2005). While these upper middle-class families do still consume lemurs as a delicacy, as much as 50 percent of the population actively harvest and consume lemurs (Schwitzer et al. 2013). The upper middle-class families who eat lemurs would often hire the impoverished men who lived near Marojejy National Park, and other protected areas, and provide them with guns and bullets to hunt the lemurs (Patel et al. 2005). The number of lemurs killed in a hunt can range from several individuals to 70, with each animal being worth about 4 U.S. dollars. Most locals are not aware of how rare these primates are and how high the risk of extinction is (Patel et al. 2005).

Legal and Regulatory Issues

In 2003, Décret d'Application No 848-05 was approved by the Council of Ministers in Madagascar to enable the creation of four new categories of protected areas that correspond with the IUCN categories II, III, V, and VI (Durbin 2007). With the addition of these four new categories, Madagascar has protected areas that correspond with all six of IUCN's categories of protected areas (Durbin 2007). In 2006, the President of Madagascar declared an additional 1,000,000 ha of protected area should be created before Madagascar's independence celebrations on June 26, 2006 (Durbin 2007). In 2009, there was an unconstitutional change of government, however the creation of new protected areas continued (Schwitzer et al. 2014). The creation of protected areas has slowed since the breakdown of government presence and control in many regions (Schwitzer et al. 2014). Additionally, the enforcement of the laws protecting these areas have also decreased (Schwitzer et al. 2014).

Population Trends

There are several factors causing the decline of silkie's population size including hunting, and deforestation. Using Propithecus edwardsi (a sifaka of similar size and natural history) as a

surrogate species, a population model was created to predict the current population trend. Life table data from Propithecus edwardsi (Pochron et al. 2004), as well as population size estimates using population density estimates (Patel 2016) and the total area of Marojejy National Park, were used to populate the model. The population projection for silky sifakas, with the current environmental conditions and anthropogenic threats, shows the population will be extinct within 50 years, however the population size will fall below 100 individuals within 20 years (Figure 4). If the survival rate of reproductive adults is increased to 90% the population will start to increase in size (Figure 4.).

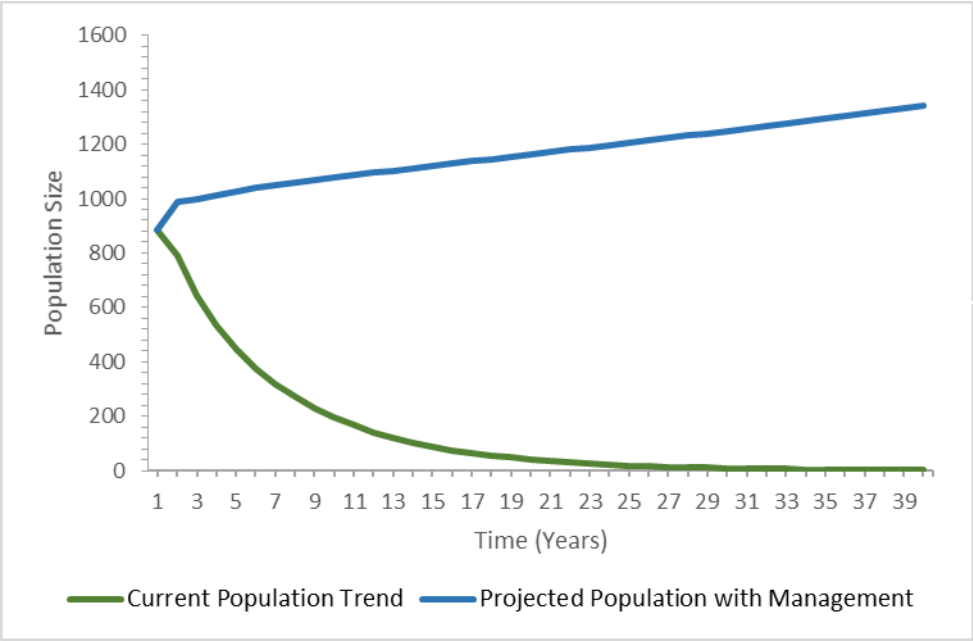

Figure 4. Current population model and population model after management actions are implemented for silky sifakas (Propithecus candidus)

Goals and Objectives

Goal: Increase and maintain the population of silky sifakas (*Propithecus candidus*) within Marojejy National Park in Madagascar.

Objectives:

1. Increase the information known about population size and natural history of silky sifakas by producing five peer reviewed papers over the course of 15 years to better the management of the species.
2. Increase survival rates of each age class to 90% in 20 years.
3. Increase education on the importance and uniqueness of the forests and the species that live within Marojejy National Park by 50% in 3 years.
4. Reduce the illegal harvest of fuel/rosewood within Marojejy National Park, as well as the surrounding forest, by 90% in 3 years.

Management Actions

Objective 1: Increase the information known about population size and natural history of silky sifakas by producing five peer reviewed papers over the course of 15 years to better the management of the species.

Action 1.1: Use camera traps to study silky sifaka population size and spatial distribution.

Camera traps have been used as an effective tool for documenting primate ecology and distribution (Pebsworth and LaFleur 2014). When using camera traps there are multiple factors that influence their effectiveness including flash type and intensity, trigger speed and sensitivity, the detection zone, memory, security, effects of climate, trap days,

camera placement, assessing biases, and how to correct these biases (Pebsworth and LaFleur 2014). Place camera traps, strategically where silkies have been frequently observed, to monitor groups and identify whether any individuals are emigrating or immigrating into or out of the groups. Secondly, use camera traps to monitor if and how silkies use habitat corridors to travel between Marojejy National Park, COMATSA Protected Area, Anjanaharibe-Sud Special Reserve, and Makira National Park (Patel 2016). A systematic layout of camera traps can be used to more accurately estimate the population size of silkies as well as their spatial distribution and space use.

Action 1.2: Continue the support of forest monitoring by park rangers and Comité Locale du Parc (CLP).

The support of park rangers and the local villagers (CLP's) was started by Schwitzer et al. (2014) and should be continued to protect silkies. The park rangers and CLP's will continue to be provided with equipment such as boots, raincoats, and GPS units with cameras to conduct population surveys on silkies to help more accurately determine the population size and status of silkies.

Action 1.3: Conduct day-long animal follows and focal animal sampling to collect behavioral data.

Focal animal follows have been used to study the behavior and movements of sifakas in Madagascar (Patel 2007, Irwin 2008). Groups of silkies will be followed throughout the day while focal animal sampling is being conducted on a single individual from the group (Irwin 2008). When possible, individuals will be located while they are in their morning sleep trees before they become active for the day (Irwin 2008). More information on the

behavioral ecology as well as food source and habitat preferences can be gained through day-long follows and focal animal sampling (Irwin 2008). This information would greatly increase the ability to make informed management decisions for the protection of silkies.

No Action: If no action is taken and the information known about the life history and population size of silkies is not increased it will be difficult to manage the species and will result in species extinction.

Final Course of Action: 1.1, 1.2, and 1.3 will be used to collect the data required to produce five peer reviewed papers.

Assessment Protocol: Objective 1 will be considered complete if five papers are published in scientific journals within 15 years. The creation of these papers based on research and field work on silkies population size and natural history is critical to the management of this species. The population size is currently estimated between 100 and 2000 mature individuals (Irwin 2006, Patel 2014). Effective management of this species will be difficult without having a better estimate of the current population size. If five papers are not published in 15 years, field work and research will continue until the five paper goal is reached.

Objective 2: Increase survival rates of each age class to 90% in 20 years.

Action 2.1: Limit the hunting of silky sifakas in Marojejy National Park through education and active monitoring of the park for illegal activity.

Lemurs are hunted using several active methods including spears, dogs, and guns (Golden 2009). Lemurs are most commonly hunted using passive traps and snares that also use an artificial bridge to connect man made forest fragments to funnel the lemurs

into the snares (Golden 2009). It can be difficult to determine the hunting and consumption of sifakas and other protected species because people may be hesitant to admit to hunting these species. The monitoring of the park for snares is of utmost importance because it is the most common way to hunt sifakas and has the greatest impact on the population compared to active hunting methods.

Action 2.2: Decrease the population size of silky sifaka predators.

Silkies like other large bodied lemurs have a single natural predator, the fossa. The fossa (*Cryptoprocta ferox*) is the largest extant terrestrial mammal endemic to Madagascar (Patel 2005a). Smaller species of lemurs are hunted by raptors and snakes in addition to fossas, however no raptors or snakes have been observed to attempt predation of a silkie (Patel 2005a). Lemurs compose over 50% of a fossa's diet with 6 different species of lemur being consumed (Hawkins and Racey 2008). When managing to increase birth rates, the survival of adult tends to have the highest proportionate effect on population growth (Mills et al. 2012). Reducing the effects of predators on a population can reduce the loss of reproductive adults and improve the survival rate of offspring, increasing recruitment (Mills et al. 2012).

No Action: If no action is taken then the silky sifakas will go extinct within the next 30 years.

Final Course of Action: Action 2.2 will not be used due to the status of fossa as a species vulnerable to extinction. Reducing their population would improve the survival rates of silkies however fossas are a protected species who require their own protection and management. Action 2.1 as well as the completion of objective 4 will increase surivival.

Assessment Protocol: Objective 2 will be considered complete if the survival rates of each age class are increased to 90% in 20 years. Based on the population model (Figure 4) an average survival rate of 90% for each age class is required for the population to stop declining and start increasing. To determine the survival rate of silkies, they should be followed five simultaneous days per month using full-day, focal-animal follows (Pochron et al. 2004). Birth and death dates can be accurate within one week on average (Pochron et al. 2004). With the long-term capability of monitoring survival rates over 20 years, a high confidence can be obtained in the ability to distinguish between dead animals and those who migrated from their group or range (Pochron et al. 2004). If this is not achieved, then the silkies population will be in a critical situation with extremely low population numbers (Figure 4).

Objective 3: Increase education on the importance and uniqueness of the forests and the species that live within Marojejy National Park by 50% in three years.

Action 3.1: Give presentations at primary and secondary schools adjacent to Marojejy National Park.

The participation of local teachers and school officials to help facilitate the effectiveness of school presentations has been found to be important in the region around Marojejy (Patel et al. 2005). Groups should be kept below 75 individuals to maximize the learning that is taking place as well as given in the local dialect of the Malagasy language (Patel et al. 2005). These presentations should include information on the rarity, location and behavior of silkies as well as the threats to silkies. There should be a chance for students

and teachers to ask questions as well as be asked questions about personal interactions with silkies (Patel et al. 2005).

Action 3.2: Take school children on trips into Marojejy National Park to learn about and observe silkies.

Many children who live in the villages adjacent to Marojejy National Park have never been into the park, taking them to see silkies and the other species of plants and animals has a significant impact on them (Patel et al. 2005). Almost all the observers, but particularly the children, were visibly stunned at their first site of a live silky. There were 55 children brought into the park in four groups (average 14 kids) between June and August 2004 (Patel et al. 2005). This plan would use similar approach to bring school children into the park to view live silkies in their natural habitat.

Action 3.3: Distribute informational flyers about threats to silky sifakas and information about their natural history in villages surrounding Marojejy National Park.

Flyers providing general information on the life history of silky sifakas as well as the threats to their survival will be laminated, have a large image of a silky sifaka, and concise information in an easy to read font.

No Action: If no action is taken, school children will learn less about silkies and be less likely to actively support their conservation and protection.

Final Action: 3.1, 3.2, and 3.3 are necessary to educate the public on the importance of silky sifakas and the habitat they require to live. This education will help to decrease anthropogenic threats to silky sifakas.

Assessment Protocol: Objective 3 will be considered complete based on survey results. A user-friendly, multiple choice survey will be administered to households in the villages adjacent to Marojejy National Park (Appendix A). Each round of surveys will be passed out and collected over the course of a year, both before and after the management actions have been implemented. These surveys will identify the local knowledge level regarding silkies. The surveys will include questions about the natural history of silkies and questions to assess how many locals have seen a silkies and whether it was a wild living specimen or one who had been hunted. Questions will also seek to determine what locals know about the threats silkies face and if they know which ones pose the greatest threat. In addition, questions about how the locals learned this information will be asked to determine the most effective way to increase local knowledge. Objective 3 will be completed if the knowledge about silkies is increased by 50% between the baseline before education actions are completed and after. If the objective is not met, then using the questions about how locals came to understand what they know about silkies can be used to determine which methods are most effective for increasing local knowledge.

Objective 4: Reduce the illegal harvest of fuel and rosewood with in Marojejy National Park as well as the surrounding forests by 90% in three years.

Action 4.1: Introduce local villages to fuel efficient rocket stoves and constructing 50 units in villages surrounding Marojejy National Park.

Through the introduction of fuel-efficient rocket stoves, the locals' need for fuel wood will be decreased. The use of rocket stoves compared to the use of open fire to cook food can reduce the fuel required by up to 40% (Chastonay et al. 2012). With the use of fuel-

efficient stoves, local villagers will not have to penetrate Marojejy National Park to cut down and collect additional fuel wood.

Action 4.2: Increase park ranger presence in Marojejy National Park by 50%.

The laws are in place in Madagascar to protect Marojejy National Park and the other categories of parks in Madagascar (Durbin 2007). However, since the former president was forced to resign and flee the country in 2009, the government has been focused on stabilizing itself, and less focused on the protection of the national parks (Schwitzer et al. 2014). The creation of new protected areas has slowed since the change in power, however, new protected areas have been created, but none of the parks are being effectively protected by park rangers and people are able to harvest rosewood and fuel wood without repercussions (Durbin 2007, Schwitzer et al. 2014).

Action 4.3 Introduce local villagers to alternative food sources.

Slash and burn agriculture for the cultivation of upland rice is a major cause of degradation and deforestation in Madagascar (Styger et al. 2007). This upland rice and the manioc or sweet potato that follows are some of the main forms of food for local villagers. Due to the reliance on rice, other alternative sources of food that do not require the destruction of forests need to be introduced. One alternative source is the introduction of aquaculture (fish farming) to locals living around Marojejy National Park. The development and adoption of aquaculture has been a significant basis for improving the food security in households of developing countries (Ahmed and Lorica 2002). The adoption of aquaculture helps low income families two-fold; It helps the farmers who raise the fish through on farm consumption and an increase in small aquaculture

operations leads to the reduction of the price of fish in markets, allowing more families to have access to fish (Ahmed and Lorica 2002).

No Action: If no action is taken then villagers will continue to enter Marojejy National Park for slash and burn agriculture and the harvest of rosewood and fuel wood leading to further habitat destruction and fragmentation. The continued destruction of silkies habitat will lead to their extinction.

Final Course of Action: 4.1, 4.2, and 4.3 will help to reduce the destruction of silky sifaka habitat.

Assessment Protocol: Objective 4 will be met if the amount of fuel and rosewood illegally harvested in Marojejy National Park is reduced by 90% in three years. However, there is no recent data to quantify the illegally harvested wood within Marojejy National Park per year. There is evidence within the park of the illegal harvesting of wood such as cut stumps and small stacks of cut rosewood (Patel 2007). Reducing the frequency of illegal wood harvest to as close to zero as possible is the desired outcome. Anonymous surveys will be distributed to determine what portion of the local villagers are involved, or know someone who is involved, in the illegal harvest of rose and fuel wood (Appendix B). These surveys will be distributed before and after the management actions are implemented to determine the effectiveness of the actions.

Conclusion

Habitat protection and restoration are crucial factors in the survival of this species. Educating local villagers on the importance of forests for the survival of silky sifakas is vital for reducing and stopping deforestation and habitat degradation. Through the actions listed above and the commitment of local villagers to adopting more environmentally friendly practices, silky sifakas can be saved.

Literature Cited

Ahmed, M., M. H. Lorica. 2002. Improving developing country food security through aquaculture development – lessons from Asia. Food Policy 27:125-141.

Bublitz, D. C., P. C. Wright, F. T. Rasambainarivo, S. J. Arrigo-Nelson, J. R. Bodager, and T. R. Gillespie. 2015. Pathogenic Enterobacteria in Lemurs Associated with Anthropogenic Disturbance. Am J Primaatol 77:330-337. doi:10.1002/ajp.22348.

Campbell, J. L., J. H. Eisemann, C. V. Williams, and K. M. Glenn 2000. Description of the gastrointestinal tract of five lemur species: Propithecus tattersalli, Propithecus verreauxi coquereli, Varecia variegata, Hapalemur griseus, and Lemur catta. American Journal of Primatology 52:133–142.

Duckworth, J. W., M. I. Evans, A. F. Hawkins, R. J. Safford, and R. J. Wilkinson. 1995. The lemurs of Marojejy Strict Nature Reserve, Madagascar: A status overview with notes on ecology and threats. International Journal of Primatology 16:545-559.

Durbin, J. 2007. Madagascar's new system of protected areas-implementing the "Durbin Vison". Available from: https://conservation-development.net/Projekte/Nachhaltigkeit/CD2/Madagaskar/Links/PDF/01DurbanVision.pdf

Hawkins, C. E., and P. A. Racey. 2008. Food habits of an endangered Carnivore, *Cryptoprocta Ferox,* in the dry deciduous forests of western Madagascar. Journal of Mammalogy 89: 64-74. doi:10.1644/06-mamm-a-366.1

Irwin, M. T. 2006. Ecologically enigmatic: The sifakas of the eastern forests (*Propithecus candidus, P. diadema, P. edwardsi, P. perrieri,* and *P. tattersalli*). Pages 305-326 in L. Gould, M.L Sauther, editors. Lemurs. Developments in Primatology: Progress and Prospect. Springer, Boston, MA.

Irwin, M. T. 2008. Diademed Sifaka (*Propithecus diadema*) Ranging and Habitat Use in Continuous and Fragmented Forest: Higher Density but Lower Viability in Fragments? Biotropica 40:231-240.

Kelley, E. and M. I. Mayor. 2002. Preliminary study of the silky sifaka (*Propithecus diadema candidus*) in north-east Madagascar. Lemur News 7:16-18.

Mills, L. S., J. M. Scott, K. M. Strickler, and S. A. Temple. 2012. Ecology and Management of Small Populations. Pages 270-292 in N. J. Silvy, editor. The Wildlife Techniques Manual – Management. The Johns Hopkins University Press, Baltimore, USA.

Patel, E. R. 2016. Synthesis of the silky sifaka's distribution (*Propithecus candidus*). In Press.

Patel, E. R. 2014. *Propithecus candidus* Grandidier, 1871 Madagascar. Pages 38-43 in C.

Schwitzer, R. A. Mittermeier, A. B. Rylands, L. A. Taylor, F. Chiozza, E. A. Williamson, J. Wallis, and F. E. Clark, editors. Primates in Peril: The World's 25 Most Endangered Primates 2012-2014. IUCN/SSC PSG, International Primatological Society, Conservation International, and Bristol Conservation and Science Foundation.

Patel, E. R., and L. H. Andrianandrasana. 2008. Low elevation silky sifakas (*Propithecus candidus*) in the Makira conservation site at Andaparaty-Rabeson: Ranging, demography, and possible sympatry with red ruffed lemurs (*Varecia rubra*). Lemur News 13:18-22.

Patel, E. R. 2007a. Logging of rare rosewood and palisandre (*Dalbergia spp.*) within Marojejy National Park, Madagascar. Madagascar Conservation & Development 2:11-16.

Patel, E. R. 2007b. Non-maternal infant care in wild Silky Sifakas (*Propithecus candidus*). Lemur News 12:39-42.

Patel, E. R. 2006. Activity budget, ranging, and group size in silky sifakas (*Propithecus candidus*). Lemur News 11:42-45.

Patel, E. R. 2005a. Silky sifaka predation (*Propithecus candidus*) by a fossa (*Cryptoprocta ferox*). Lemur News 10:25-27.

Patel, E. R., J. J. Marshall, and H. Parathian. 2005b. Silky sifaka (*Propithecus candidus*) conservation education in northeastern Madagascar. Laboratory Primate Newsletter 44:8-11.

Pebsworth, P. A. and M. LaFleur. 2014. Advancing primate research and conservation through the use of camera traps: Introduction to the special use. International Journal of Primatology 35:825-840.

Pochron, S. T., W. T. Tucker, and P. C. Wright. 2004. Demography, life history, and social structure in *Propithecus diadema edwardsi* from 1986-2000 in Ranomafana National Park, Madagascar. American Journal of Physical Anthropology 125:61-72.

Rabearivony, J., M. Rasamoelina, J. Raveloson, H. Rakotomanana, A. P. Raselimanana, N. R. Raminosoa, J. R. Zaonarivelo. 2015. Roles of a forest corridor between Marojejy, Anjanaharibe-Sud and Tsaratanana protected areas, northern Madagascar, in maintaining endemic and threatened Malagasy taxa. Madagascar Conservation & Development 10:85-92.

Schuurman, D., and P. P. Lowry II. 2009. The Madagascar rosewood massacre. Madagascar Conservation & Development 4:98-102.

Styger, E., H. M. Rakotondramasy, M.J. Pfeffer, E. C.M. Fernandes, and D. M. Bates. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. Agriculture, Ecosystems and Environment 119:257-269.

Weir, J. W. 2014. Infant Development and Maternal Strategies in the Two Largest Lemurs: The Diademed Sifaka (*Propithecus diadema*) and the Indri (*Indri indri*). Disertation, University of Victoria, British Columbia, Canada.

Appendix A:

Silky Sifaka Survey

Circle one unless otherwise indicated.

1. Are you aware of silky sifakas as a unique species?

Yes No

2. Are you aware that it is an endangered species?

Yes No

3. Have you seen a living specimen?

Yes No

4. Silky sifaka diet consists of which of the following? (Circle as many as apply)

    a. Leaves b. Fruit/seeds

    c. Small mammals d. Insects

5. Which of the following are threats to the silky sifaka? (Circle as many as apply)

    a. Deforestation b. Predation

    c. Hunting by humans d. Lack of food

6. How long do silky sifakas live?

    a. <5 years b. 5-10 years

    c. 10-15 years c. 15+ years

7. Would you be interested in finding out more about silky sifakas?

    Yes No

8. Are you aware of the conservation efforts already in place to protect silky sifakas?

    Yes No

9. Do you think silky sifakas should be protected?

   Yes No

10. Of what country do you currently reside in?

Appendix B:

Illegal Harvest Survey

Circle one unless otherwise indicated.

1. Are you aware that it is illegal to cut down trees within Marojejy National Park?

Yes No

2. Are you aware of what the most common reasons trees are cut down?

Yes No

3. If you answered yes above, what are they?

4. Have you illegally cut down trees in Marojejy National Park in the last six months?

Yes No

5. Do you know anyone who has illegally cut down trees in Marojejy National Park in the last six months?

Yes No

6. Have you or anyone you know illegally cut down trees in Marojejy National Park in the last year?

Yes No