12 Years On, Assessment of The Release Rehabilitation Program of Yucatán Black Howler Monkeys, *Alouatta Pigra*, In the Northeastern Biological Corridor of Belize

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I dedicate this paper to Etti,

whose brief presence left a lasting impact.

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Abstract

Long-term monitoring of animals that have undergone wildlife rehabilitation is crucial to assess their long-term survival and adaptation after release. This study evaluates a primate rehabilitation centre in Belize, with a focus on the 78 Yucatán black howler monkeys, *Alouatta pigra*, released into the Northeastern Biological Corridor over the past 12 years. The objective was to locate the released howler monkeys and conduct an up-to-date survey of the population. To do this, we actively searched for primates using a combination of local knowledge and previous studies by walking forest trails and conducting surveys. When a troop was found, data was collected on the troop's composition, and their activity budgets, tree height, troop cohesion, and feeding behaviour, which was compared to wild populations of the species. When possible, three-day ranges of the howler monkey troops were calculated using Kernel density analysis. Between November 2022 and October 2023, 23 troops of howler monkeys, consisting of 118 individuals, were recorded. The howler monkey population showed a diverse diet, consuming 38 plant species from 20 distinct families, with activity budgets and behaviour comparable to that of their wild counterparts. This study demonstrated that the rehabilitated and released howler monkeys have remained in the Northeastern Biological Corridor and are contributing to a healthy, established population. The successful rehabilitation and release of these howler monkeys suggest that sharing the protocols used by Wildtracks, the primate rehabilitation centre, could improve outcomes for other howler monkey rehabilitation projects and benefit the wildlife involved.

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Chapter 1: Introduction

1.1. Wildlife Rehabilitation, Its Successes and Limitations

As anthropogenic disturbances continue to threaten wildlife populations, conservation strategies are becoming increasingly necessary to prevent extinction and maintain the biodiversity of species across the globe (Guy et al., 2014). One of these strategies is wildlife rehabilitation. This is defined as the temporary care for injured or orphaned wild animals and their eventual return to suitable habitats within their native range (Atkinson, 1997; Baker, 2002).

While rehabilitation as a conservation strategy has been strongly debated (Guy et al., 2014), it provides an alternative for survivors of the illegal pet trade, or animals injured or displaced due to habitat destruction. These animals would otherwise be limited to lifelong captivity or euthanasia (IUCN, 2002; Guy et al., 2014). The critical objective of wildlife rehabilitation is to benefit a single individual animal (Willette et al., 2023), emphasising its role as a welfare issue rather than a strategy towards conserving the species involved (Guy et al., 2014). This aspect of wildlife rehabilitation is often supported from a legal standpoint in some countries (Cope et al., 2022) and is expected to continue.

Below, I discuss the potential value of wildlife rehabilitation (in combination with species reintroductions), focusing on how its success is measured and the importance of research in the field.

1.1.1. <u>Value of Rehabilitation in Conservation</u>

Due to a lack of research, there is limited evidence that rehabilitation and rescues contribute directly to conservation, and the total conservation value of wildlife rehabilitation has not been recognised (Pyke & Szabo, 2018; Cope et al., 2022; Goldenberg et al., 2022). The main arguments against wildlife rehabilitation are the high costs associated with medical care and the maintenance of the animals throughout the rehabilitation process and the fear that these funds are being diverted from other conservation actions (Paterson et al., 2021; Kirkwood, 1992). However, most rehabilitation centres are self-funded and receive public and private donations and corporate sponsorship, with little to no reliance on government funding (Wimberger et al., 2010).

Nevertheless, releasing rehabilitated animals can have a valuable impact on the current wild population and the species (Cope et al., 2022; Pyke & Szabo, 2018). In a simulation of a species with a spectrum of life-history strategies, Paterson et al. (2021) deem wildlife rehabilitation particularly beneficial to species with slow life histories and small populations and when an injury is a regular reason for population declines. Yet, rehabilitation is considered to have a higher conservation value when combined with other conservation interventions, such as education and developing/ establishing protected areas (Paterson et al., 2021). This was the case for the California condor, *Gymnogyps californianus*, a critically endangered species. Along with other methods, successful rehabilitation and reintroduction significantly increased its population from 22 individuals in 1982 to over 350 in 2009, 180 of which are wild (Walters et al., 2010).

Combining Wildlife Rehabilitation with Reintroduction Conservation Strategies:

Rewilding as a conservation strategy has become increasingly popular. The goal of rewilding is to restore plant and animal interactions within an ecosystem by reintroducing species that have become locally extinct (Genes et al., 2018; Shin et al., 2022). The impact of reintroductions can vary depending on the area and the species, region and ecosystems involved (Shin et al., 2022). However, it is particularly beneficial in the case of reintroducing large mammal herbivores into ecosystems as they can help rebuild trophic cascades and promote overall system regeneration (Seddon et al., 2014; Shin et al., 2022). This, in turn, can, through trophic cascades, positively influence ecosystem restoration and ultimately, climate change mitigation through the regrowth of plants that remove carbon dioxide from the atmosphere, among many other benefits to Biodiversity (Shin et al., 2022). For example, the reintroduction of wolves, *Canis lupus*, to Yellowstone National Park has led to the return of elk predation, resulting in a decrease in elk browsing pressure (Smith & Bangs, 2009). This decrease in browsing has enabled the recovery of willow (*Salix spp*.) and aspen (*Populus tremuloides)*, an increase in beaver (*Castor canadensis)* colonies and the revival of songbird populations in willow stands (Smith & Bangs, 2009; Smith & Peterson, 2021).

The strategy of combining wildlife rehabilitation and reintroduction can be beneficial by releasing rehabilitated animals to their native locations (Estrada et al., 2017). This can help restore ecosystems where the animals are currently locally extinct (Estrada et al., 2017). Additionally, if the existing population is not viable and needs more individuals to avoid demographic or genetic depletion, this approach can contribute to the restoration of ecosystem functions (Estrada et al., 2017). This has been seen in a trial project, in which rehabilitation and reintroduction of the common wombat, *Vombatus ursinus,* caused an 80% increase in the activity of other wildlife species, which was linked to the ecosystem services they provided (Ridgeway, 2018). This approach has the potential to increase the conservation value of wildlife rehabilitation. However, considerations should be made as to why populations had previously been eradicated from the locations and what measures have been put in place to stop this from reoccurring (Baker, 2002).

1.1.2. Defining “Success” in Wildlife Rehabilitation and Reintroduction Projects

Regular evaluation of a rehabilitation and reintroduction project’s success is recommended as it helps in understanding the long-term adaptation of the released population (Baker, 2002). Regarding rehabilitation and reintroductions, it is often easier to recognise failures than successes. For instance, failures can include the extinction of a population or the return of an individual to captivity; however, the definition of 'success' can differ significantly between stakeholders (Hernandez, 2019; Cope et al., 2022). Some may define success as the release of an individual animal, while others may look at the impact on a populational level (Wimberger et al., 2010). This lack of a universally accepted definition leads to inconsistency across rehabilitation and reintroduction programs, making it difficult to compare their success. In addition, the assessment of the success of rehabilitation projects is constrained by time. The outcome of many re-introductions can be classed as 'unknown' for extended periods (Fischer & Lindenmayer, 2000). Therefore, establishing clear and agreed-upon criteria for defining success in these projects is crucial to ensure transparency and effective evaluation.

Based solely on the definition of wildlife rehabilitation, rehabilitation projects can be considered successful when individuals recover from their initial injuries and are eventually released back into the wild. From an ethical perspective, rehabilitators assessing their projects typically consider a release successful if the released animals remain alive for a specific period (Wimberger et al., 2010). This period of time varies from species to species and is typically constrained by the availability of post-release monitoring (Guy et al., 2014). For example, a rehabilitation project for the common wombat, *Vombatus ursinus*, was considered successful when 63% of the wombats taken into the rehabilitation centre survived through the rehabilitation process, and the released individuals were known to be alive in the wild past the critical post-release period of 42 days (Saran et al., 20). Whereas, in a study on a group release of sanctuary chimpanzees, *Pan troglodytes troglodytes*, the released individuals were monitored for a minimum of 2 years before the outcome of the release was reported (Humle et al., 2011). This highlights that success in rehabilitation is both species and context-specific (Cope et al., 2022).

Additional indicators of successful rehabilitation of an individual would be successful reproduction in the wild (Cope et al., 2022; Wimberger et al., 2010). For instance, in 1996, 20 wild-born rehabilitated orphaned chimpanzees, *Pan troglodytes troglodytes,* were released; 70% of the individuals were still alive 3.5 years after release, and none of the adult females reproduced (Gosseens et al., 2001). This could indicate a lack of ability to develop fundamental skills, for example, there is evidence that social bonds are linked to reproductive output in chimpanzees (Feldblum et al., 2021). Therefore, the development of social skills that encourage social bonds in rehabilitation is vital for long-term rehabilitation success. This lack of reproduction could potentially limit the rehabilitation programme's conservation value.

Introducing animals to current populations can improve genetic diversity and increase the population and species' evolutionary potential (Pyke & Szabo, 2018; Pacioni et al., 2019). Cope et al. (2022) highlighted indicators for successful rehabilitation and reintroduction on a population level; these include the maintenance of populations where the rehabilitated animals were released, the released individual's ability to contribute towards a reproductive population and the released animals' ability to maintain their own territories. In addition to this, considerations should be made to the impact of the current population, such as the risks of disease transmission between populations (Chaves et al., 2021) and the impacts on the conservation and management of the population receiving the rehabilitated individuals (Pyke & Szabo, 2018). Assessing the success of these populations requires additional research to ensure that the released individuals are not pushing the current population past their carrying capacity, introducing disadvantageous genetic alleles or diseases to the current population, or increasing competition within the population (Cope et al., 2022).

1.1.3. Post-Release Monitoring:

Post-release monitoring of released individuals is critical for determining rehabilitation programmes' successes or failures. Conducting research on rehabilitated and released animals can provide information on how their care and conditions can impact their progress towards and after the release (Pyke & Szabo, 2018). This can offer extremely important information that can benefit projects and, if used correctly, improve conservation management plans for species (Hernandez, 2019; Paim et al., 2019). However, post-release monitoring studies are rarely performed (Guy et al., 2013; Hernandez, 2019). This lack of post-release monitoring is typically due to limitations such as a lack of funds and staff and difficulty tracking the animals after they have been released (Baker, 2002; Guy et al., 2013). Wildlife rehabilitators prioritise their limited funds on animal food and medical expenses (Wimberger et al., 2010). Other limitations can include having too many animals that need to be monitored, as well as a lack of support of research from national parks and a lack of knowledge on how to track the released animals (Guy et al., 2013). As a result, there is limited research about the outcomes of rehabilitation and release, either for the animal or their contribution to populations and species (Cope et al., 2022).

When post-release monitoring occurs, it is usually for a short period to ensure the short-term survival of the individuals involved. For example, a group of rehabilitated brown capuchin monkeys, *Sapajus apella*, were monitored for six and a half months after their release (Suarez et al., 2001). The results of this study indicated that the group successfully adapted and survived in the short term, out of the eight animals involved in the study, five stayed together, two separated, and one was lost in the first month (Suarez et al., 2001). Studies such as these are beneficial for determining the initial outcome of the rehabilitation project. However, long-term post-release monitoring is required to understand the broader impacts of rehabilitation and release on the individual, population, and the species as a whole (Cope et al., 2022). Long-term post-release monitoring of reintroduced carnivores in South Africa (Banasiak et al., 2021a; Banasiak et al., 2021b) and of two reintroduced populations of the western lowland gorillas, *Gorilla gorilla gorilla* (King et al., 2011) have demonstrated that long-term monitoring is an essential part of evaluating and managing the success of conservation actions (Banasiak et al., 2021a). Both studies were able to determine longer-term survival rates and successes and failures in breeding in the released populations that were not identifiable in the previous shorter-term assessments, and identified new challenges that the released populations were facing, for example, the increase in human conflict (Banasiak et al., 2021b), and were able to suggest strengthening opportunities to ensure the success of the populations long-term (Banasiak et al., 2021b; King et al., 2011).

1.1.4. Evidence-based rehabilitation:

The lack of consistent definition of success and post-release monitoring limits information on the impact of rehabilitation methods on an animal's chances of release and survival in the wild (Cope et al., 2022; Pyke & Szabo, 2018; Wimberger et al., 2010). Rehabilitation centres mainly rely on their intuition or methods that have evolved through trial and error and knowledge shared between centres and guidelines created by wildlife authorities (e.g. Baker, 2002; Cope et al., 2022; Wimberger et al., 2010). This can result in varying success rates among centres, potentially due to differences in field experience (Cope et al., 2022). To improve this, research is needed to facilitate knowledge exchange, incorporating both failures and successes from the field (Goldenberg et al., 2022).

The negative implications of acknowledging failures, such as the potential impact on funding and publication, can limit the documentation or discussion of these failures (Webber et al., 2022). Yet, studies that demonstrate results as "failures" or difficulty in attaining successful conservation outcomes are just as crucial as those that are "successful". Identifying and reporting the context and the reasons that result in "failures" are important to ensure that the mistakes are not repeated (Oxley et al., 2022). For example, in the case of the rehabilitated pygmy slow lorises, *Nycticebus pygmaeus*, in which their release resulted in death, return to captivity or unknown outcomes, highlighted the need for specific measures to be put into place to increase the chances of survival (Kenyon et al., 2014). These measures included using a soft-release technique, considering the season when choosing a release date, and assessing the density of predators at the release site (Kenyon et al., 2014). This is vital information that could increase the success of future releases for this species.

Despite repeated appeals, the field of reintroduction biology has not fully realised its potential to provide the necessary evidence to support management decisions within its field (Taylor et al., 2017). Yet, the value of animal rehabilitation and reintroductions as a tool within conservation can be increased by having accepted criteria for assessing the success or failure of the reintroductions, increasing the post-release monitoring, and increasing the effort for publishing the results, even when they are considered unsuccessful (Fischer & Lindenmayer, 2000; Guy et al., 2014). To do this, organisations need to evaluate the success of their conservation interventions, share these outcomes with details (Junker et al., 2020) and develop evidence-based best practices that can be shared between rehabilitation centres (Taylor et al., 2017; Cope et al., 2022; Goldenberg et al., 2022). This in turn will enhance the effectiveness of reintroduction as an applied science (Taylor et al., 2017 and could considerably impact wildlife rehabilitation outcomes and the success of reintroductions (Goldenberg et al., 2022).

When options for post-release monitoring are otherwise unavailable, creating and strengthening existing long-term collaborations with field practitioners, in-country institutions, policymakers, and researchers can potentially help to conduct further research (Junker et al., 2020; Wimberger et al., 2010). These efforts can help predict consequences which can reduce the uncertainty of outcomes and provide tools for selecting the most suitable course of action in future reintroduction scenarios (Taylor et al., 2017). This will ensure that wildlife rehabilitation projects are as successful as possible and, in turn, have a valuable impact on the conservation of the species.

1.2. The Yucatán Black Howler Monkey, *Alouatta pigra*

1.2.1. Background to the Species

The *Atelidae* are the largest of the New World primates and have a fully prehensile tail adaptation for feeding, foraging behaviours, and social interactions (Strier, 2004; Rosenberger, 2020). Within this family, the *Alouatta* genus, commonly known as howler monkeys, are known for their enlarged hyoid bone, which allows the monkeys to produce loud howling calls to communicate within and between troops (Mitani & Stuht, 1998). These calls have multiple functions, such as defending feeding sites and infants and during encounters with extra-group males (Mitani & Stuht, 1998; Van Belle et al., 2014). The Yucatán black howler monkey, *Alouatta pigra,* is found in Belize, south-eastern Guatemala, and across the Yucatán Peninsula in Mexico (Cortes-Ortíz et al., 2020). They are primarily arboreal and prefer the upper and middle canopy but have occasionally been reported to utilise the ground in fragmented forests (Serio-Silva et al., 2019). However, this behaviour is associated with road injuries or deaths in some locations (Hetman et al., 2019).

Compared to other *Alouatta* species, the Yucatán black howler monkey has relatively small troop sizes, averaging 6.2 individuals, typically comprising of between one and three adult males, one and three adult females, and their young (Dias & Rangel-Negrin, 2014; Van Belle & Estrada, 2006). They are highly cohesive and display synchronised behaviour, with most of their time spent in close proximity to other troop members (Wang & Milton, 2003; Van Belle et al., 2013). Howler monkeys are known for spending most of their day resting with limited activity. Studies have shown that, on average, Yucatán black howler monkeys are inactive for 66.33% of the time, feed for 18.57% of the time, locomote for 7.49% of the time, and are social for 3.67% of the time (Pavelka & Knopff, 2004). In the Cockscomb Wildlife Basin in Belize, howler monkeys spent 61.9% of their time inactive, 9.8% locomoting, 24.4% feeding, 2.3% socialising, and 1.6% involved in other behaviours (Silver et al., 1998).

The estimated home range for the species varies significantly between populations. For instance, in Belize, estimates range between 1-4 ha in the Community Baboon Sanctuary (Marsh & Loiselle, 2003), 10.4-15.8 ha in Bermudian Landing (Ostro et al.,1999) and 15.3 ha in Lamanai (Gavazzi et al., 2008). In Palenque National Park, Mexico, different studies show estimates at 6.45 ha and 7.13 ha (Amato & Estrada, 2010; Van Belle et al., 2013), and 100 ha in Tikal Guatemala (Caywood et al., 1979). This is possibly due to the availability of resources and the variety of vegetation the howler monkeys can inhabit (Gavazzi et al., 2008). The home ranges of howler troops can overlap substantially with their neighbours (Gavazzi et al., 2008). However, research indicates howler monkeys can uphold territory when necessary and show a gradient in territoriality, dependent on the level of competition in the area (Asensio et al., 2018).

The Yucatán black howler monkey has a generational length of 10 years (Cortes-Ortíz et al., 2020). They reach sexual maturity between the ages of three to four years old. Births have been recorded year-round, but there is some indication of seasonality within the species (Dias et al., 2015). For example, an assessment conducted by Brockett et al. in 2000 on the reproductive seasonality of the black howler monkey (Alouatta pigra) suggests a peak in births during months with low rainfall, possibly due to the abundance of fruit during gestation. The study found that the proportion of births from 1992-1999 varies significantly by month, with more births occurring from December to May. This coincides with an annual peak in fruit from July to December, indicating that female monkeys adjust their gestation and lactation periods according to environmental conditions.

The interbirth intervals for the species are typically around 16 months; this can be reduced to around 10 months if the infant dies during this period (Crockett & Eisenberg, 1986). The howler monkeys exhibit bisexual dispersal, with males and females emigrating from their original troops, typically upon puberty (Van Belle & Di Fiore, 2021). Studies show sex biases in the dispersal rate, with males dispersing more often than females and females dispersing further than males (Van Belle & Di Fiore, 2022). This emigration between troops is expected to result from cost-benefit trade-offs of remaining in their original troops or dispersing (Van Belle & Di Fiore, 2022). It can be related to population density, indicating that an increase in population density will result in a shift from single to multi-male groups or larger group sizes (Ostro et al., 2001).

The species has a wide degree of flexibility in their diet (Silver et al., 1998). The primates consume a mix of foliage, fruit, and flowers, consuming both young and mature leaves throughout the year; however, fruit is preferred when available (Silver et al., 1998). As a result, the species has been identified as being as frugivorous as possible and as folivorous as necessary (Dias & Rangel-Negrin, 2014; Pavelka & Knopff, 2004). A review of the howler monkey species' diet across their range indicates that, on average, 50.4% of their diet consists of leaves, 38.5% of fruit, 8.3% of flowers, and 5% of other food sources (Dias & Rangel-Negrin, 2014). A study by Silver et al. in 1998 showed that the Yucatán black howler monkey's diet includes a significant amount of food from *Ficus* tree species, with nearly one-third of all feeding activity spent consuming food from these trees. The high adaptability in their diet has enabled them to inhabit a wide range of vegetation, including evergreen and semi-evergreen broad-leaved forests, deciduous and semi-deciduous broad-leaved forests, evergreen and semi-evergreen mixed needle-leaved and broad-leaved forests, and mangroves and swamps (Baumgarten & Williamson, 2007). This dietary flexibility and a broader range of habitat tolerance indicate the species' potential to adapt to new habitats naturally or with the help of conservation efforts (Silver et al., 1998).

1.2.2. Conservation Status

The howler monkeys' small troop size, ability to reside in small home ranges, and varied diet indicate low conservation concerns (Wyman et al., 2011). In spite of this, the Yucatán black howler monkey is currently listed as endangered on the IUCN Red List of Threatened Species (Cortes-Ortíz et al., 2020). The species are mainly threatened by substantial habitat loss, 56% within the howler monkey's range, and the hunting of individuals to sell in illegal pet trade (Van Belle & Estrada, 2006). Consequently, if the current trends continue, the species has a predicted population decline of 50% or more over the next three generations (Cortes-Ortíz et al., 2020).

1.2.3. Main Threats and Actions:

Hurricanes

Over the past century, Yucatán black howler monkey populations have reduced drastically due to anthropogenic disturbances, hurricanes, and the yellow fever epidemic (Friesner, 1993; Wildtracks, 2022). In Belize, three hurricanes had devastating impacts on the country in 1931, 1955, and 1978, affecting cities, agriculture, and forests and significantly impacting the howler monkey populations (Hartshorn, 1984). While hurricanes cause initial mortality within the howler monkey population, secondary impacts such as lack of food and habitat availability further reduce the primate's survival ability after a hurricane (Pavelka & Behie, 2005). This has been seen in Pavelka and Behie's (2005) study on the effect of Hurricane Iris on the food supply for black howler monkeys. This hurricane resulted in the death of 35% of the howler monkey feeding trees, 52% of which were trees relied on for fruit. As a result, Pavelka and Behie (2005) recorded changes in the howler monkeys' diet over the years after the hurricane, specifically the elimination of fruit from their diet for the first year, and it is expected to have reduced the population by 88% (Pavelka et al., 2006).

In Belize, translocation was used as a conservation strategy for the Yucatán black howler monkeys in 1992 (Horwich et al., 1993). The goal was to re-establish a viable population of howler monkeys in the Cockscomb basin, a protected area where howler monkeys became locally extinct in the 1970s due to hurricanes (Horwich et al., 1993). In this translocation project, 14 troops of 62 wild-caught howler monkeys from a healthy population 100 km north were translocated into the Cockscomb basin (Horwich et al., 1993; Horwich et al., 2002). During a recent survey, researchers observed 67 monkeys when a third of the area was resurveyed in 2017, but it is estimated that over a hundred are now residing in the Cockscomb Nature Reserve (Sliver & Ostro, 2017).

Deforestation

Deforestation is one of the main threats to the Yucatán black howler monkey species. This is evident by the loss of 23% of the forest area in the three countries that the species of howler monkey inhabits between 1990 and 2020 (FAO, 2020). Although howler monkeys have the ability to adapt to both conserved and disturbed environments, both the populations and the species as a whole are negatively affected by high levels of habitat loss, fragmentation, and degradation (Arroyo-Rodríguez & Dias, 2010). Long-term impacts of habitat loss for the surviving populations of howler monkeys have been studied, with indications that habitat loss is linked to the decrease in food availability impacting gut health and increasing anthropogenic pressures, such as hunting and logging (Arroyo-Rodríguez & Dias, 2010; Fernández et al., 2022). As a result, it is recommended that primate conservation efforts should prioritise establishing new protected areas and enhancing enforcement in existing ones (Fernández et al., 2022).

In the case of the Yucatán black howler monkeys, an estimated 40% of their range was protected in 2015 (Estrada, 2015), with further areas protected since this study, such as the Northeastern Biological Corridor in Belize, which was declared by law in 2020 (CSFI, 2022). Establishing these protected areas is expected to help preserve primate habitats, which in turn can reduce habitat fragmentation and potentially deter illegal hunting activities and the illegal trade of primates (Fernández et al., 2022). In addition to this, a study in Campeche State, Mexico, found that the levels of stress in Yucatán black howler monkeys living in unprotected and highly fragmented forests were higher than those of those living in protected areas (Rangel-Negrín et al., 2014).

When the preservation of pristine forests is not feasible, the Community Baboon Sanctuary, Belize, is an example of how farming practices can be adapted to serve the goals of conservation, education, research, and tourism (Horwich & Lyon, 1988). This sanctuary was established in an area where howler monkeys, commonly known as baboons in Belize, were concentrated on the private lands of subsistence farmers along the Belize River. This project's premise derives from a collaborative approach, where farmers and landowners were directly involved, forming agreements that benefited both howler monkeys and the farmers (Horwich & Lyon, 1988). This project's success has brought positive publicity to the conservation of howler monkeys and has also led to the development of an ecotourism program, which in turn, has helped improved the economic conditions of the villagers (Horwich & Lyon, 1988).

Illegal Pet Trade

Howler monkeys are amongst the most frequently traded species in the illegal trade of wild animals in Latin America, with reports indicating that the Yucatán Black howler monkey is frequently traded across Guatemala, Mexico and Belize (Pastor-Nieto, 2015; Tricone, 2018; Batres, 2015). Although it is challenging to determine exact numbers, a study has estimated that 38 *Alouatta pigra* individuals are taken from their natural habitat each year for the illegal primate trade in Mexico (Esparza-Rodríguez et al., 2023). This has led to an estimated annual reduction in population size of 1.3% in Mexico (Esparza-Rodríguez et al., 2023). The illegal trade of these individuals often leads to a high mortality rate, with options for the surviving howler monkeys limited to captivity in zoos, rehabilitation centres, or euthanasia (Guy et al., 2014; Pastor-Nieto, 2015). Increasing conservation actions to reduce the trade of pets, such as increasing education, is needed.

Education as a conservation action has been reported across 12 Mexican communities that are within the Yucatán black howler monkey range (Franquesa-Soler et al., 2020). When this education is directed at school-age children, evidence suggests that incorporating arts-based educational programs, such as storytelling, that is supported by scientific information, is an effective way of teaching students about animals and promoting conservation (Franquesa-Soler et al., 2020). When primates are victims of the pet trade, primate rehabilitation programmes should be utilised to return the individuals to the wild when possible. There are several Yucatán black howler monkey rehabilitation centres within the species range, for example, ARCAS in Guatemala (https://arcasguatemala.org), and Wildtracks in Belize (https://www.wildtracksusa.org).

1.3. Wildtracks, Belize's only Primate Rehabilitation Centre

Wildtracks is a non-profit organisation founded in 1990 by Paul and Zoe Walker in Northern Belize (Figure 1). It aims to preserve endangered species and biodiversity through sustainable development, education and outreach, and conservation and research programs.

The organisation obtained a non-profit conservation status in Belize in 1996 and is funded entirely by grants, donations, and volunteers; some of its funding partners include the Save the Manatee Club, Burgers' Zoo and Twycross Zoo. As an organisation, they work with the Belize Forest and Fisheries Departments and non-governmental organisations such as the National Biodiversity Office and the Sarteneja Alliance for Conservation and Development.

Wildtracks works with their local village, Sarteneja, which is the largest traditional fishing community in Belize. Their aim is to increase the sustainability of the fishery, strengthen community capacity, and encourage the diversification of income. Nationally, Wildtracks focuses on national planning for biodiversity and sustainable development. Wildtracks protects wildlife through the conservation of habitat, improving species conservation planning and conservation education, focusing mainly on local schools. In addition, Wildtracks is the only facility in Belize that rehabilitates primates and manatees.

1.3.1. Primate Rehabilitation

Wildtracks' primate rehabilitation programme was established in 2010. The programme provides care for Belize’s primate species, the *Alouatta pigra*, and Geoffroy's spider monkey, *Ateles geoffroyi*. These species are listed as endangered on the IUCN Red List of Threatened Species (Cortes-Ortíz et al., 2020; Cortes-Ortíz et al., 2021).

The process of rehabilitating young animals, especially group-living animals, can be challenging as they often do not possess the necessary skills to survive in the wild, which are typically learned from parents or other members of the group (Baker, 2002; Shier & Owings, 2007; Cheyne et al., 2007). Primates, for example, may struggle with climbing trees, foraging for food, defending their territory, and understanding troop dynamics (Baker, 2002). Subsequently, individuals raised in captivity may not have the same competency in these skills compared to their wild counterparts. To address this, studies suggest that living in a natural environment can help promote these behaviours and help generate more positive rehabilitation results (Schwartz et al., 2016). In the case of Wildtracks, the development of these skills is encouraged during every stage of the rehabilitation process, and the individual's abilities are assessed to ensure they are ready before their release (P. Walker, personal communication, 2022).

Stages of Wildtracks Primate Rehabilitation Programme

Rehabilitation care at Wildtracks focuses on providing emotional support for animals undergoing rehabilitation and gradually reducing human contact over time, shifting the animal's focus from human interaction to members of their species and ensuring that the primates are physically and mentally healthy before release (P. Walker, personal communication, 2022). While the care provided is specific to each intake, there are five stages that primates go through during their rehabilitation process.

The first stage of any animal entering the Wildtracks rehabilitation programme is quarantine. Upon arrival, animals undergo a mandatory 30-day quarantine period to prevent the spread of diseases (Guy et al., 2014). Once this period is completed and if the primate is an infant, they enter the nursery unit; this is considered the second rehabilitation stage. This stage is designed to provide a nurturing environment for infant primates with long-term caregivers who offer emotional support and comfort (P. Walker, personal communication, 2022). This stage fosters the emotional development of the primates by introducing them to other nursery-stage monkeys and providing them with enrichment, such as wooden structures, ropes, and hammocks, to encourage the development of climbing skills (P. Walker, personal communication, 2022).

One important aspect of rehabilitating group-living animals is encouraging group formation and group bonds, as problems maintaining these can result in higher mortality rates and potentially a lack of breeding (Guy et al., 2012; Van Belle et al., 2013). In rehabilitation, fostering troop behaviour is recommended as early as possible (Goldenberg et al., 2022). As a result, Wildtracks encourages troop formations, introducing howler monkeys to those of similar ages as soon as the quarantine period is over, increasing the primate's ability to form strong social connections with their troop members, with the aim that this will continue post-release (P. Walker, personal communication, 2022).

The third stage for primates undergoing rehabilitation is the movement to forest enclosures; in this stage, the contact between caregivers and primates is gradually reduced, encouraging the primates to become less reliant on their human caregivers and more on other troop members. This stage fosters natural troop bonds and prepares the primates for the wild by providing them with natural wooden structures to encourage more natural movements across the enclosure (P. Walker, personal communication, 2022).

The fourth stage is the pre-release stage, where the troop is released into small patches of forest surrounded by an electric fence. This stage aims to improve the primates' climbing and foraging skills before release. The pre-release enclosures are divided into three separate areas: pre-release one, two, and three. The tree heights increase gradually from pre-release one to pre-release three, allowing the monkeys to acclimate to the heights of the trees at their own pace, ensuring their readiness for the wild (P. Walker, personal communication, 2022).

The fifth and final stage for the primates is the release stage, where individuals are considered ready for release when they demonstrate good climbing skills, function well as a fully formed troop, and are not interested in human caregivers. Monkeys released into the wild are monitored for 6-12 months to ensure their survival and to gather data on their behaviour and interactions with other wild primates (P. Walker, personal communication, 2022). Fireburn Nature Reserve and Northeastern Biological Corridor (see 2.1.1 below) are the primary release sites for the primates, with 78 howler monkeys and seven spider monkeys released into these areas (P. Walker, personal communication, 2022). Additionally, 11 howler monkeys have been released into the Runaway Creek Nature Reserve in central Belize (see Figure 1) (P. Walker, personal communication, 2022).

Over the past 13 years, the population of released primates is expected to have increased with 2nd and 3rd-generations (P. Walker, personal communication, 2022). A thorough count has not been conducted since 2015 (Tricone, 2018). In 2015, 28 howler monkeys had been released into Fireburn Nature Reserve, of these 28, 75% were found alive, 21% were not found, 4% were known to be deceased, and three wild-born infants were recorded (Tricone, 2018). These results indicate early success within the wildlife rehabilitation programme and show similar results to rehabilitation projects that are considered successful (Cope et al., 2022; Saran et al., 2011; Suarez et al., 2001; Wimberger et al., 2010). Since the time of this study, 50 more howler monkeys have been released into the Northeastern Biological Corridor.

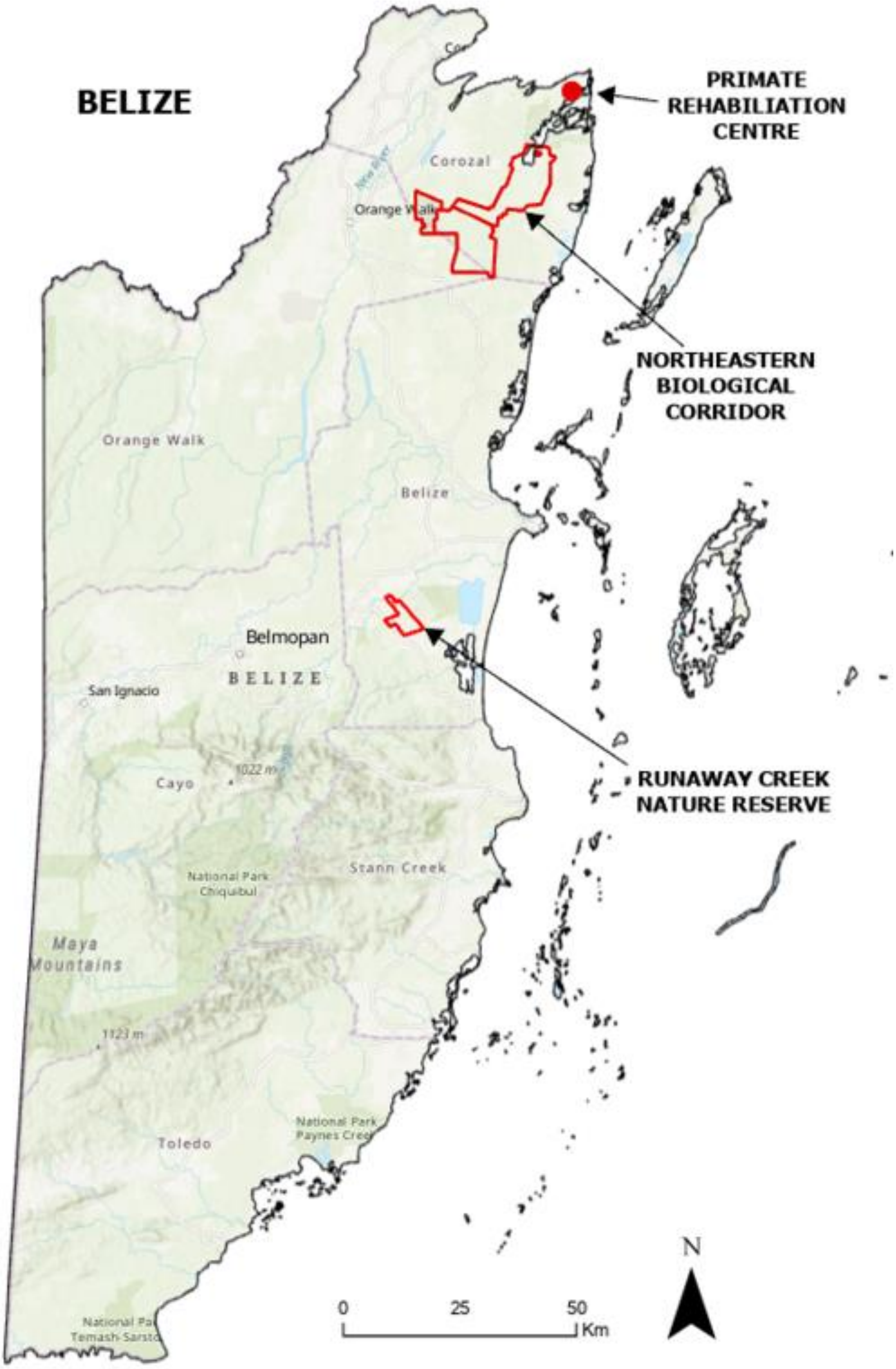

Figure 1- A map of the location of the primate rehabilitation centre, Wildtracks, in Belize and the 2 release sites for the howler monkeys undergoing rehabilitation at Wildtracks

1.4. Aims and Objectives

1.4.1. Aim

A reintroduction project's success should be evaluated regularly to better understand the released population's long-term survival and adaptation to the habitat (Baker, 2002). This study aims to assess the success of the rehabilitation and release of the Yucatán black howler monkeys in the Northeastern Biological Corridor.

For the purpose of this study, I am using Cope et al.'s (2022) definition of success for rehabilitation and release as an outline. This definition incorporated perspectives from wildlife rehabilitators, the individual animals, and the population as a whole. As a result, rehabilitation projects will be considered successful on an individual level if the individual recovers from their initial injuries, is released back into the wild, survives in the wild long-term and successfully reproduces in the wild. This study mainly focuses on assessing the rehabilitation programme's success at a population level. The rehabilitation project would be considered successful on a broader, population level if a population remains where the rehabilitated animals were released; the released animals have maintained individual territories or home ranges and are contributing to a reproductive population. This population of rehabilitated and released howler monkeys presents a unique opportunity: Before the reintroductions, no howler monkeys inhabited the area, making assessing potential impacts on a naturally occurring population unnecessary.

In addition, to the indicators stated above, I will incorporate an assessment of the released population's activity budget, ensuring that the rehabilitation process is not impacting their ability to perform natural behaviours. Baker's (2002) guidelines highlight the importance of behavioural demographics of the released population. This study aims to establish a monitoring program of the rehabilitated and released population of Yucatán black howler monkeys in the Northeastern Biological Corridor by including a detailed data on the population's demographics, behaviour and ecology.

1.4.2. Objectives

This study aims to evaluate the success of the program of rehabilitation and release by Wildtracks in the Northeastern Biological Corridor to assess the persistence of the released population. In particular, this study aims:

1) To conduct an up-to-date survey of the Yucatán black howler monkey population released in the Northeastern Biological Corridor

2) To evaluate the released population's ability to maintain individual territories, the current troop distribution across the Northeastern Biological Corridor will be mapped, and the results will be compared to previous studies conducted in the area.

3) To determine the long-term survivorship of the howler monkeys that have been located by identifying the released individuals through an identification key.

4) To record the current troop compositions, including the number of individuals in the troop and their age and sex, to assess the reproductive abilities of the released population and understand the population dynamics within individual troops. The results will be compared to wild populations of the species.

5) To ensure that the population is displaying the species' natural behaviours, by assessing the population activity budgets, use of the trees, cohesion within troops and feeding behaviours.

Chapter 2: Methods

2.1. Study Site - Background of Fireburn and Northeastern Biological Corridor

2.1.1. Location

The Northeastern Biological Corridor in Belize spans 280 km^2 of natural habitats, with 136 km^2 being private lands and the remaining 144 km^2 comprising of nature reserves (Bjileveld, 2022; CSFI, 2022). It connects several protected areas, including Shipstern Conservation Management Area, Fresh Water Creek, and Honey Camp National Park (Bjileveld, 2022; CSFI, 2022). While the corridor's plans were first recorded in the early 2000s (Meerman et al., 2000), it was officially declared by law on January 22nd, 2022 (CSFI, 2022). The corridor includes various habitats, including mangroves, broadleaf forests, littoral forests, wetlands, and freshwater lagoons (CSFI, 2022). The previously independent protected areas, Fireburn Nature Reserve (7.36km^2) and Kakantulix Archaeological Reserve (1.13km^2) are now part of the Northeastern Biological Corridor.

Fireburn Nature Reserve was the initial release site for Wildtracks rehabilitated howler monkeys, followed by releases in Kakantulix Archaeological Reserve, Shipstern Nature Reserve (82.42Km^2), and throughout the Northeastern Biological Corridor (P. Walker, personal communication, 2022). Figure 2 illustrates the location of the Northeastern Biological Corridor in Belize, focusing on the Yucatán black howler monkeys' release site in this project.

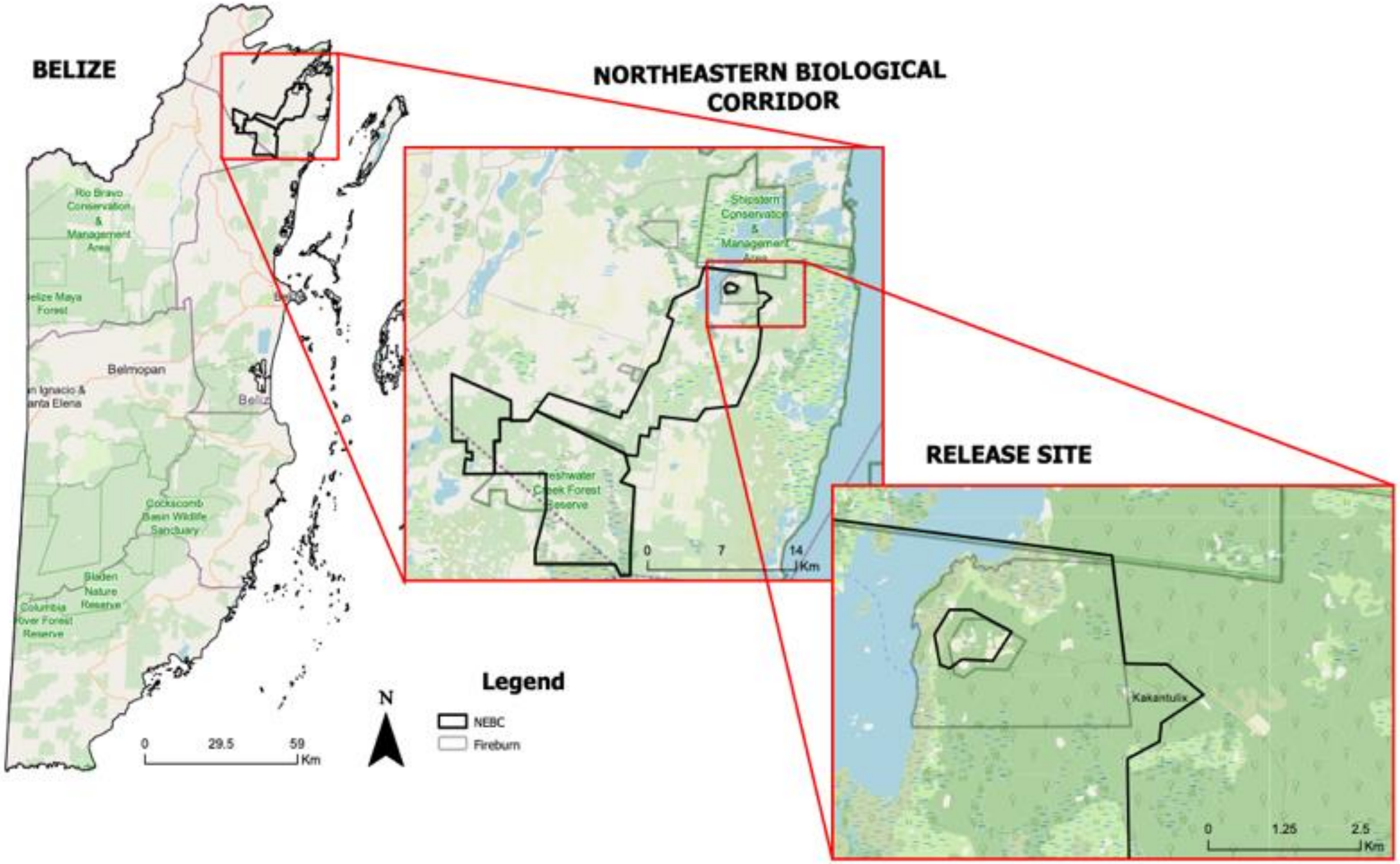

Figure 2- A map depicting the study site in the Northeastern Biological Corridor, Belize

2.1.2. History and Fireburn Community

Fireburn Nature Reserve is protected and managed due to a partnership between Wildtracks, Shipstern and the Fireburn community. The Fireburn community have resided in the area since the 1880s (Wildtracks, 2010). The population of the Fireburn community fluctuates depending on the availability of work but typically comprises between 30 and 40 people (Wildtracks, 2010). The community initially started as a logging camp, and many people within the village are financially dependent on logging tree species such as Mahogany, *Swietenia macrophylla*, Ciricote, *Cordia dodecandra*, and harvesting Chicle, *Manilkara sapotesince* (Wildtracks, 2010; Maskell et al., 2010). Unfortunately, this is often illegal, which has resulted in conflict between the community and Shipstern Nature Reserve (Wildtracks, 2010).

An additional 80 hectares of community land are within Fireburn Nature Reserve. This land is used for farming, mainly plantain and other crops for sale and personal use (Maskell et al., 2010; Wildtracks, 2010). In addition, community farms are located outside the Northeastern Biological Corridor. In 1998, Wildtracks Sustainable Development Programme established a primary school in Fireburn Village, which is now managed by the Ministry of Education and allows children to stay in the village for education (Wildtracks, 2010).

2.1.3. Vegetation

Fireburn Nature Reserve is located on the edge of the Shipstern Lagoon and is surrounded by low-canopy forests and mangrove swamps. Due to this, the reserve is only accessible by boat, crossing the Shipstern Lagoon. Due to a combination of anthropogenic land use and natural weather occurrences, there is a large variety of habitats within the protected area, many of which are at different stages of regeneration (Maskell et al., 2010). Most notable is the impact of a series of hurricanes starting in the 1940s and, as a result, most of the forest is no more than 65 years old (Friesner, 1993; Maskell et al., 2010; Wildtracks, 2022).

Fireburn Nature Reserve's habitat consists mainly of tropical evergreen seasonal broad-leafed lowland forest over calcareous soil and tropical evergreen seasonal broad-leafed lowland swamp forest, tall variant, with patches of Caribbean mangrove forest, dwarf mangrove shrub, basin mangrove, and marine salt marsh (Figure 3). Areas of micro-habitats, such as dense, shorter or scattered cohune palms, *Attalea cohune,* as well as medium height lowland moist forest, lowland moist forest with cohune and secondary growth pioneer species are scattered within the tropical evergreen seasonal broadleaf forest (Maskell, 2000). Additional microhabitat communities include Bajo, a unique seasonally flooded community with a mixed species forest; seasonal swap forests; mangrove communities, freshwater ponds; agricultural lands; and recently abandoned lands, typically with regrowth but without a developed community (Maskall, 2000).

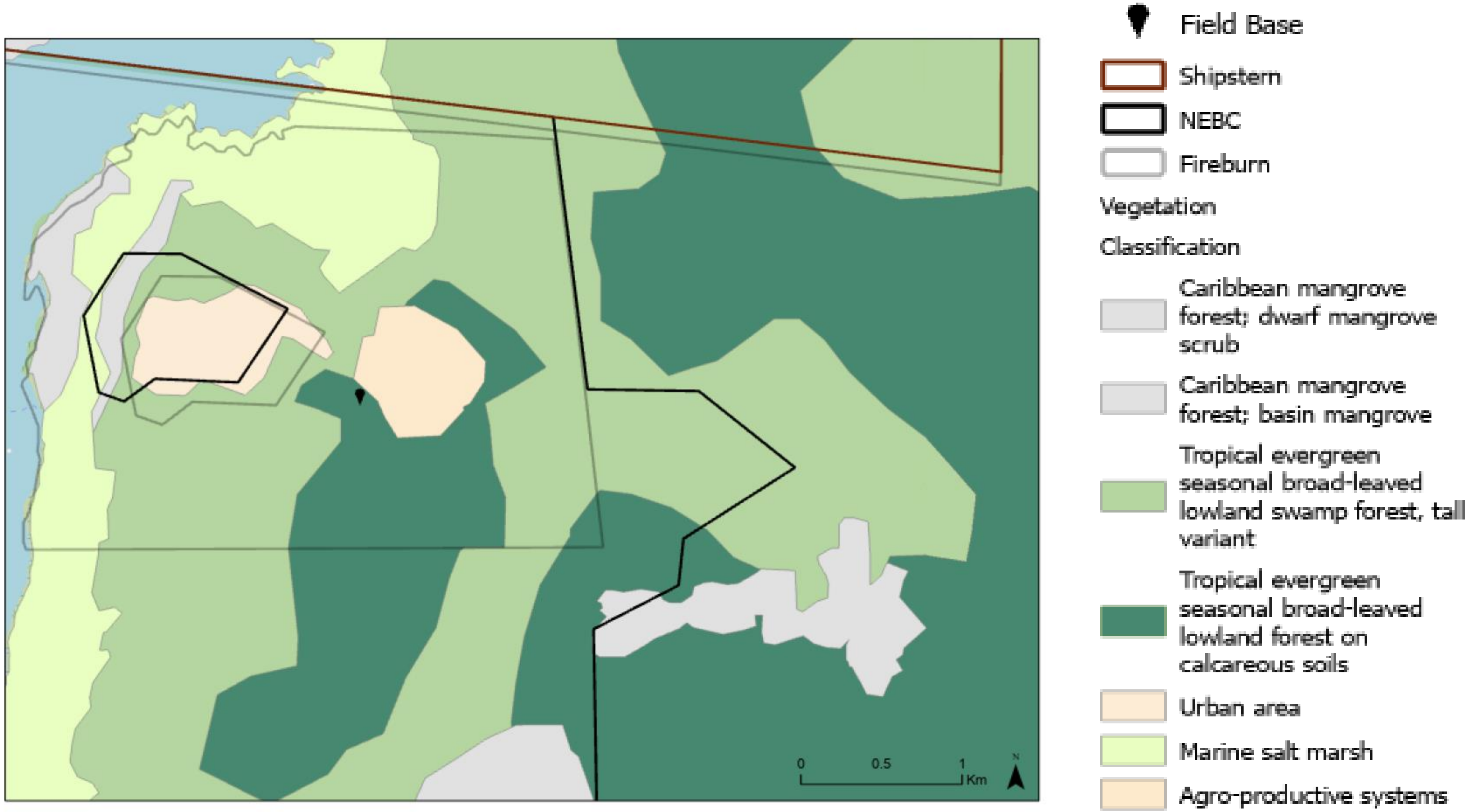

Figure 3 - A description of the vegetation of the study site, located in the Northeastern Biological Corridor, Belize.

2.1.4. History of *Alouatta pigra* in Area

Evidence that howler monkeys resided in the Fireburn area before the rehabilitation programme is lacking (Fanigliulo, 2005). However, the impacts of the hurricanes, along with the yellow fever epidemic between 1955 and 1957 in Central America, eradicated all but a few populations of howler monkeys (Boshell, 1955; Hartshorn, 1984). As a result, howler monkeys are not expected to have inhabited the Fireburn Nature Reserve and the surrounding area for an estimated 70 years, before the Wildtracks release (Wildtracks, 2022).

2.1.5. Suitability of Release Site

According to the IUCN Guidelines for Reintroductions (2013), suitable release sites for reintroductions meet all the practical needs of the released organisms with minimal stress, have adequate connectivity to suitable habitats and meet all the species' biotic and abiotic requirements. In addition, Baker's guidelines (2002) state that the release site should be within the species' historical range and protected from the threats that the species had previously faced in that area (Baker, 2002).

In 2005, a study was conducted in Fireburn Nature Reserve to assess whether the abundance of food species and canopy structure were suitable for releasing howler monkeys (Fanigliulo, 2005). The study identified five suitable habitats within the area: dense *Attalea cohune* palms, lowland moist forest with cohune, medium-sized lowland moist forest, secondary growth with pioneer species, and shorter lowland moist forest (Fanigliulo, 2005). Over the course of this assessment, 14 feeding tree species were identified, and 10 were considered good food sources for Yucatán black howler monkeys (Fanigliulo, 2005). This study also noted the low abundance of *Ficus* species trees, which are recorded as a significant food source for howler monkeys in different study sites (Dias & Rangel-Negrin, 2014; Fanigliulo, 2005; Pavelka & Knopff, 2004). The average canopy height of areas in Balan, Tabasco, Mexico, where a known population of *Alouatta pigra* resides, is estimated at 14.9m (Pozo-Montuy et al., 2008). The mean canopy height in areas suitable for howler monkeys in Fireburn Nature Reserve ranges from 9.6 to 12.6m (Fanigliulo, 2005). However, this is a 20-year-old study, and the canopy height is expected to have changed. According to Fanigliulo's Study in 2005, the Fireburn forest has a lower species richness and species density than the Community Baboon Sanctuary in central Belize and the Cockscomb Basin Wildlife Sanctuary in southern Belize, both of which have thriving howler monkey populations. Nevertheless, the flexibility of howler monkeys' diet and their ability to thrive in a wide range of habitats indicate that this is not a determining factor as to the suitability of the release site (Cristóbal-Azkarate et al., 2013; Pavelka & Knopff, 2004).

Fanigliulo's assessment (2005) determined that the most suitable release sites for the howler monkeys within Fireburn Nature Reserve are those with the habitat type of lowland moist forest with dense cohune and secondary growth. Regarding the IUCN guidelines mentioned above, the release site is a protected area within the species' historical range and provides connectivity to other protected areas, such as the Conservation Management Area, Fresh Water Creek, and Honey Camp National Park (Bjileveld, 2022; CSFI, 2022). In addition, the release site meets the species' practical, biotic, and abiotic requirements through canopy height, the variety of habitats in the area and the variety of feeding tree species. As a result, Fireburn Nature Reserve and the surrounding areas were considered a suitable release site for the Yucatán black howler monkey (Flanigiulo, 2005).

2.1.6. The Released Population

At the start of the primate rehabilitation programme, 78 howler monkeys have been released into Fireburn Nature Reserve, with the first troops released in 2011 and the most recent occurring in 2021 (Table 1).

Table 1- The Name, Age, Sex and Intake Circumstances of the rehabilitated and released howler monkeys that have undergone rehabilitation at Wildtracks and have been released into the Northeastern Biological Corridor. This table also indicates whether the individuals were found during the previous 5-year assessment. In cases where individuals were not released at the time of this assessment (2015), "Not Applicable" (N/A) is used.

Release Groups	***Name***	***Sex***	***Intake Reason***	***Intake Circumstances***	***Year of Intake***	***Estimated Age at Intake***	***Year of Release***	***Age at Release***	***Found at 5 year update (2015)***
Clyde's Troop	Agatha	Female	Rehabilitation	Confiscated Pet	2010	Juvenile 2	2011	Juvenile 3	No
	Bonnie	Female	Rehabilitation	Confiscated Pet	2010	Juvenile 2	2011	Juvenile 3	Yes
	Clyde	Male	Rehabilitation	Confiscated Pet	2010	Juvenile 1	2011	Juvenile 2	Yes
	Holly	Female	Rehabilitation	Confiscated Pet	2010	> Juvenile 3	2011	> Juvenile 3	No
Dudley's Troop	Dudley	Male	Rehabilitation	Confiscated Pet	2010	Juvenile 3	2012	Sub-Adult	Yes
	Igor	Male	Rehabilitation	Confiscated Pet	2010	Juvenile 1	2012	Sub-Adult	No
	Eden	Female	Rehabilitation	Confiscated Pet	2010	Juvenile 1	2012	Sub-Adult	No
	Mo	Male	Rehabilitation	Surrendered Pet	2011	Infant 2	2012	Juvenile 3	Yes
	Minnie	Female	Rehabilitation	Surrendered Pet	2011	Infant 2	2012	Juvenile 3	Yes
Nicky's Troop	Nicky	Male	Rehabilitation	Surrendered Pet	2011	Infant 2	2013	Juvenile 3	Yes
	Hazel	Female	Rehabilitation	Confiscated Pet	2012	Sub-Adult	2013	Sub-Adult	Yes
	Willow	Female	Rehabilitation	Confiscated Pet	2012	Sub-Adult	2013	Sub-Adult	Yes
Charlie's Troop	Charlie	Male	Rehabilitation	Confiscated Pet	2012	Juvenile 2	2013	Juvenile 3	Yes
	Fern	Female	Rehabilitation	Confiscated Pet	2012	Juvenile 3	2013	Sub-Adult	Yes
	Richie	Female	Rehabilitation	Confiscated Pet	2012	Juvenile 1	2013	Juvenile 3	Yes
	Mia	Female	Rehabilitation	Wild rescue	2013	Adult	2013	Adult	Yes
Solo Male	Coco	Male	Translocation	Translocation	2013	Adult	2014	Adult	Yes
Solo Male	Kong	Male	Translocation	Translocation	2013	Adult	2014	Adult	Yes

Tower Hill Troop	TH Male	Male	Translocation	Translocation	2014	Adult	2014	Adult	Yes
	TH Female A	Female	Translocation	Translocation	2014	Adult	2014	Adult	Yes
	TH Female B	Female	Translocation	Translocation	2014	Sub-Adult	2014	Sub-Adult	N/A*
	TH Female C	Female	Translocation	Translocation	2011	Juvenile 1	2014	Juvenile 1	Yes
Sultan's Troop	Sultan	Male	Rehabilitation	Surrendered Pet	2011	Infant 1	2014	Sub-Adult	No
	Livvy	Female	Rehabilitation	Surrendered Pet	2011	Infant 3	2014	Sub-Adult	Yes
Paz's Troop	Paz	Male	Rehabilitation	Confiscated Pet	2011	Infant 3	2014	Sub-Adult	Yes
	Kofi	Female	Rehabilitation	Confiscated Pet	2010	Juvenile 2	2014	Adult	No
Barton Creek Troop	BC Female	Female	Rehabilitation	Surrendered Pet	2014	Adult	2014	Adult	Yes
	BC Male	Male	Rehabilitation	Surrendered Pet	2014	Adult	2014	Adult	Yes
Spartacus's Troop	Spartacus	Male	Rehabilitation	Surrendered Pet	2011	Infant 2	2015	Sub-Adult	N/A
	Jenny	Female	Rehabilitation	Confiscated Pet	2013	?	2015	?	N/A
Elliot's Troop	Elliot	Male	Rehabilitation	Confiscated Pet	2012	?	2015	?	N/A
	Athena	Female	Rehabilitation	Wild rescue	2014	?	2015	?	N/A
Sam's Troop	Sam	Male	Rehabilitation	Confiscated Pet	2012	Infant 3	2015	Sub-Adult	N/A
	Peanut	Male	Rehabilitation	Wild rescue	2012	Infant 2	2015	Sub-Adult	N/A**
	Pebbles	Female	Rehabilitation	Surrendered Pet	2012	Infant 2	2015	Sub-Adult	N/A
	Polly	Female	Rehabilitation	Confiscated Pet	2012	?	2015	?	N/A
Ty's Troop	Ty	Male	Rehabilitation	Surrendered Pet	2013	?	2015	?	N/A
	Beth	Female	Rehabilitation	Confiscated Pet	2013	?	2015	?	N/A
Jaz's Troop	Jaz	Male	Rehabilitation	Confiscated Pet	2012	Infant 2	2016	Sub-Adult	N/A
	Little Pea	Female	Rehabilitation	Wild rescue	2011	Infant 1	2016	Sub-Adult	N/A
JW's Troop	JW	Male	Rehabilitation	Surrendered Pet	2013	?	2016	?	N/A
	Hobbes	Male	Translocation	Translocation	2013	?	2016	?	N/A
	Suri	Female	Rehabilitation	Surrendered Pet	2013	?	2016	?	N/A

	Jessie	Female	Rehabilitation	Wild rescue	2013	?	2016	?	N/A
	Kenya	Female	Rehabilitation	Confiscated Pet	2014	?	2018	?	N/A
Teddy's Troop	Teddy	Male	Rehabilitation	Confiscated Pet	2013	?	2016	?	N/A
	Tilley	Female	Rehabilitation	Confiscated Pet	2013	?	2016	?	N/A
Solo Male ?	Auggy	Male	Translocation	Translocation	2015	?	2016	?	N/A
Solo Male ?	King	Male	Translocation	Translocation	2016	?	2016	?	N/A
Darwin's Troop	Sansa	Female	Rehabilitation	Confiscated Pet	2014	?	2017	?	N/A
	Darwin	Male	Rehabilitation	Confiscated Pet	2014	?	2017	?	N/A
The Teens	Kat	Female	Rehabilitation	Surrendered Pet	2014	?	2017	?	N/A
	Finn	Male	Rehabilitation	Surrendered Pet	2014	?	2017	?	N/A
	Balou	Male	Rehabilitation	Surrendered Pet	2015	?	2017	?	N/A
	Innie	Male	Rehabilitation	Wild rescue	2014	?	2017	?	N/A
	Vicki	Female	Rehabilitation	Confiscated Pet	2014	?	2017	?	N/A
	Maggie	Female	Rehabilitation	Wild rescue	2014	?	2017	?	N/A
	Annie	Female	Rehabilitation	Wild rescue	2015	?	2018	?	N/A
?	Molly	Female	Rehabilitation	Surrendered Pet	2016	?	2018	?	N/A
?	Joe	Male	Rehabilitation	Wild rescue	2015	?	2018	?	N/A
?	Jem	Male	Translocation	Translocation	2016	?	2018	?	N/A
?	Rambo	Male	Translocation	Translocation	2017	?	2017	?	N/A
?	Brea	Female	Rehabilitation	Wild rescue	2016	?	2018	?	N/A
Mile 40 Troop?	Scout	Male	Translocation	Translocation	2016	Adult	?	Adult	N/A
	Harper	Female	Translocation	Translocation	2016	Adult	?	Adult	N/A
	Boo	Male	Born In Care	Born in Care	2016	Infant 1	?	?	N/A
	Lily	Female	Rehabilitation	Wild rescue	2017	?	?	?	N/A

?	Fyffe	Male	Rehabilitation	Wild rescue	2018	?	?	?	N/A
Franklins Troop	Franklin	Male	Rehabilitation	Confiscated Pet	2017	Infant 2	2020	Sub-Adult	N/A
	Tuli	Female	Rehabilitation	Surrendered Pet	2017	Infant 2	2020	Sub-Adult	N/A
	Prim	Female	Rehabilitation	Confiscated Pet	2017	Infant 2	2020	Sub-Adult	N/A
Po's Troop	Piper	Female	Rehabilitation	Surrendered Pet	2017	Infant 2	2021	Sub-Adult	N/A
	Po	Male	Translocation	Translocation	2021	Adult	2021	Adult	N/A
Alfie's Troop	Alfie	Male	Rehabilitation	Surrendered Pet	2018	Infant 2	2021	Juvenile 2	N/A
	Ivy	Female	Rehabilitation	Confiscated Pet	2016	?	2021	Adult	N/A
Elena's Troop	Elena	Female	Rehabilitation	Wild rescue	2017	?	2022	Adult	N/A
	Trudy	Female	Born In Care	Born in Care	2018	Infant 1	2022	Juvenile 2	N/A
	Teya	Female	Born In Care	Born in Care	2020	Infant 1	2022	Juvenile 1	N/A

**Found Deceased (Suspected fall)*

***Died of injuries resulting from Tayra attack*

2.2. Study Period

Between November 2022 and October 2023, we (the team, see below) spent 146 days in the field, finding, tracking, and collecting data on the released and rehabilitated howler monkeys. The field team consisted of me and an experienced primate tracker as a field assistant. Wildtracks employs such assistants, and they have extensive knowledge of the howler monkeys in the area. Field assistants were interchanged depending on availability for trips.

Trips in and out of the field occurred on 11^{th}-17^{th} November; 5^{th}-17^{th} December; 4^{th}-12^{th} January; 21^{st}-28^{th} January; 3^{rd} -10^{th} February; 23^{rd}-28^{th} February; 8^{th}-15^{th} March; 22-28^{th} March; 31^{st} March- 6^{th} April; 15^{th} – 25^{th} April; 2^{nd} -10^{th} May; 23^{rd} – 1^{st} June; 26^{th} August – 7^{th} September; 11^{th} September – 19^{th} September; 23^{rd} September –5^{th} October and 7^{th}; October – 14^{th} October. Out of these 146 days, 21 were spent travelling, 55 were spent searching and 70 days collecting data on troops. Primates were tracked from dawn to dusk, 7 am-5 pm, resulting in 700 hours of observational data. The medium temperature during the project was 28.5°C, with an average of 14 monthly rainy days.

2.3. Locating Howler Monkeys

This study aimed to find previously released monkeys; therefore, the focus was on encountering primates and not characterising the population size. For efficiency purposes, we actively searched for primates using a combination of local knowledge and previous studies by walking forest trails and conducting surveys. As a result, the data collected is exploratory data. We focused on areas where monkeys had previously been recorded, using the 5-year assessment conducted on the same population by Tricone (2018) as a base knowledge.

According to Fanigliulo's assessment of Fireburn Nature Reserve (2005), five habitats were most suitable for Yucatán black howler monkeys: dense cohune, lowland moist forest with cohune, medium-sized lowland moist forest, secondary growth with pioneer species, and shorter lowland moist forest. As a result, we considered these habitats as key areas to search for howler monkeys, while unsuitable habitats such as Bajo, Mangrove Forests, Savanna, and agriculture and recently abandoned land were excluded from the search areas.

We began searching for howler monkeys at Fireburn Nature Reserve. We walked forest trails, looking for howler monkeys or any signs that they had recently been there. We took more time around large resting trees and key-feeding trees such as Fig, *Ficus spp.*, Ramon, *Brosimum alicastrum*, and Cecropia, *Cecropia peltata*. We also listened for the noises of howler monkeys travelling within or between trees while exploring the forest. On the ground, we looked for key indications that monkeys had been around, such as the presence or smell of faecal matter and feeding signs, such as partially eaten fruit or broken branches. If we found or smelled faecal matter, we conducted more intense searching, looking for howler monkeys in a smaller radius around the matter or smell. When we heard howling, we roughly estimated the direction and distance of the howling, and if it was close, we would head towards the sound. After finding a few troops of howler monkeys in Fireburn Nature Reserve, we continued our exploratory methods into Shipstern Nature Reserve and Kakantulix Archaeological Reserve.

In addition to exploratory methods, we conducted surveys throughout the suitable habitats to ensure more thorough coverage of the areas and establish any additional signs of howler monkeys. These survey lines were 1 kilometre long and 250 metres apart, located throughout Fireburn Nature Reserve, Kakantulix Archaeological Reserves, and Shipstern Nature Reserve (Figure 4). During these surveys, we walked in straight lines, stopping every 100 metres and expanding 20 metres on each side of the survey line. If there were signs that howler monkeys had recently been in the area, we continued with further exploratory methods, as mentioned above. If there were no indications of the primates around, we moved on to the next survey line. A total of 26 surveys were conducted over the study period.

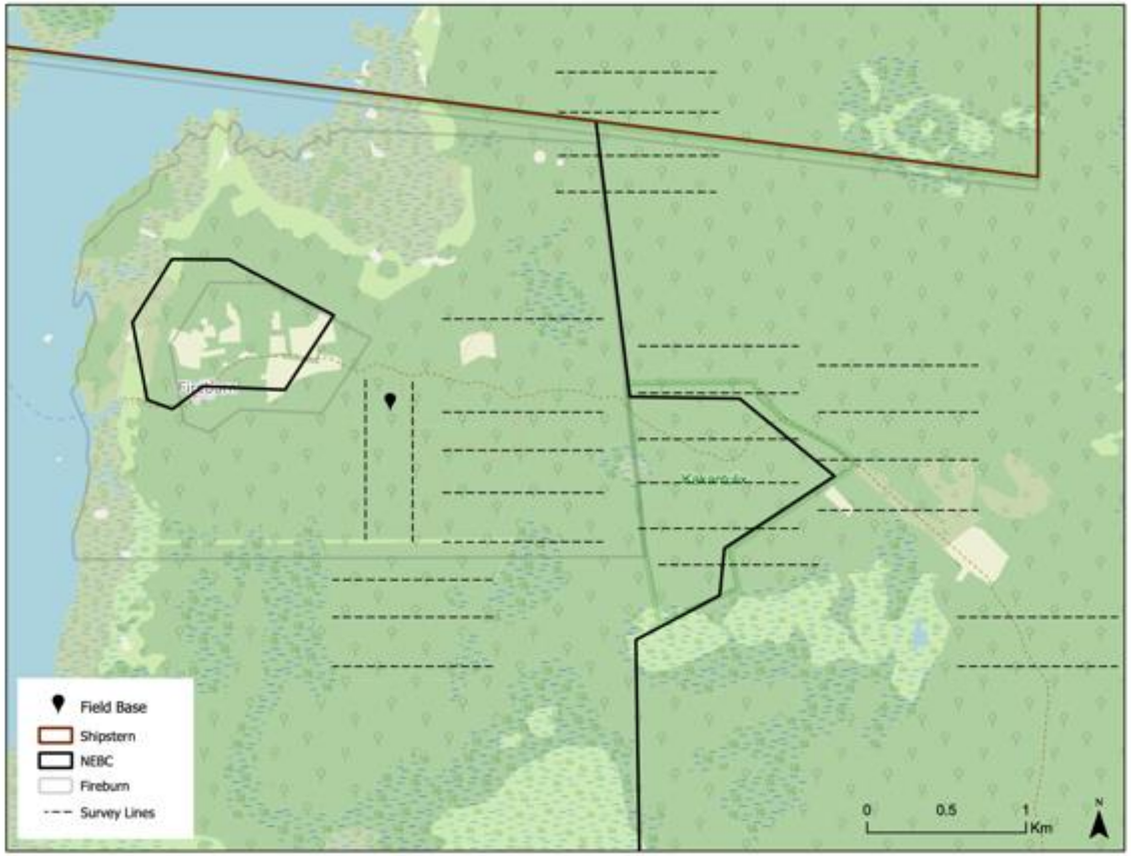

Figure 4 - A map of the study site for a project in which rehabilitated and released howler monkeys were located in Belize and the survey lines (dashed lines) used as exploratory methods.

2.4. Data Collection

For the purpose of this study, we conducted age estimations for each monkey and gathered data on the troop's activity patterns, tree heights, and overall cohesion. Additionally, we examined the feeding behaviours of the released population.

2.4.1. Identifying Howler Monkeys

When a troop of howler monkeys were located, a GPS point was taken, the troop composition was noted, and photographs of each member of the troop's face and rear (genitals) were taken for identification purposes. These genital photographs were analysed for the genital markings, which are pigmented spotting on the genitals that can be used as unique identification characteristics (Horwich, 1983), this tool was used to identify the released population in Tricone's (2018) identification key.

This was later compared to photographs of released howler monkeys. The age of the howler monkeys was classified as adult, sub-adult, juvenile stages 1,2,3 and infant stages 1,2,3, adapted from a combination of Rumiz's (1990) classification of *Alouatta caraya* and Balcells and Baro's (2009) classification of *Alouatta palliate Mexicana* in addition from my field knowledge (Table 2).

Table 2 -Classification system used to determine the age of howler monkeys.

Category	Stage	Age	Description
Infant	**1**	0-3 months	● Carried ventrally by mother. ● Attempts to explore surroundings but will not let go of mother. ● Only nursing, no solid foods
	2	3-9 months	● Carried dorsally by mother. ● Explores nearby surrounding when the mother is resting but remains close. ● Mainly nursing, but will eat some solid foods
	3	9-12 months	● Carried dorsally by mother for long or difficult distances, follows mother independently for shorter periods. ● Rests with mother ● Still nurses but increasingly eating more solid foods
Juvenile	**1**	1 -1.5 years	● Males sex organs are small, females have long thin clitoris and thin vulvar lips ● Significantly smaller body size than adults ● Rests with mother ● Independent movements but still follows mother. ● Some suckling still seen
	2	1.5 -2 years	● No longer nursing. ● Larger than stage 1 juveniles ● Independent movements

			● May rest near mother
	3	2-2.5 years	TYPICAL EMIGRATION STAGE ● Slightly smaller than sub-adults ● Independent ● Mother not obvious
Sub Adult		2.5-5 years	Male: ● Younger-looking faces than adult males but their beard is starting to develop. ● Similar size to adult females Female: ● Body size is slightly smaller than adult female. ● Clitoris is shorter than juveniles, vulvar lips thin
Adult		5+ years	Male ● Larger than females ● Beard fully developed. ● When howling, often preform an additional “croak” that is not heard in younger males ● Typically, only one per troop, sometimes two Female ● Clitoris hardly noticeable, larger vulvar lips ● Signs of nursing/pregnancy/with infant ● Smaller than an adult male, but larger than a Sub-adult female

2.4.2. Behavioural Data

Scan sampling technique to collect behavioural data followed Altmans (1971), using a 15-minute interval period. The troops' behaviours were classified into six categories, namely "Rest", "Travel", "Feed", "Play", "Howl", and "Out of Sight", as outlined in Table 3. We conducted the data collection process over three consecutive days for each of the identified troops. The observation period started at 7 a.m. and continued until 5 p.m. each day. In addition to the activity budgets, we recorded additional information to understand the troop's behaviour and activities more accurately. We determined the height of the canopy and whether the troop members were in the top, middle and lower third of the canopy or on the ground at 15-minute intervals (Table 4). For the assessment of troop cohesion, we recorded whether troop members were together or apart from other troop members, within 5 meters of their closest individual at 15-minute intervals (Table 5).

Table 3 - An ethogram of the behaviours recorded during the scan sampling surveys for the Yucatán black howler monkeys in Belize.

Behaviour	**Description**
Rest	Laying down or sitting with no activity
Feed	Eating or looking for food, name of tree should be noted
Travel	Moving between the trees, but not feeding
Play	Two or more individuals interacting with fast movements can be demonstrated through touching, biting, and chasing without causing harm or injury.
Howl	Loud vocal calls, location should be marked
Out of sight	No visible at time of recording

Table 4 - An ethogram of the troop cohesion

Cohesion	**Description**
Together	The whole troop is in sight and within 5 metres of the closest individual
Apart	Some of the troop members are out of sight or further than 5 metres from the closest individual
Out of sight	The whole troop is not visible at the time of recording

Table 5- An ethogram for the height in the canopy

Height in the Canopy	**Description**
Top	Troop is using the top 1/3 of the canopy
Mid	Troop is using the middle 1/3 of the canopy
Low	Troop is using the lower 1/3 of the canopy
Ground	Troop is on the ground
Out of Sight	The troop is out of sight at the time of recording

2.4.3. Feeding Behaviour

During the observational period, the location of any feeding trees was recorded using GPS waypoints, and the tree species and part of the plant eaten were recorded. Feeding trees were identified using local knowledge from experienced primate trackers. When the tree species was unknown, photographs of the fruit, leaves, and trunk were taken and identified using available resources, such as plant identification keys, local knowledge, and primate trackers' experience. An up-to-date plant log was produced at the end of the study period.

2.4.4. Movement in Forest

Throughout the study period, waypoints were taken using the Garmin GPS 66s. On days when howler monkeys were being studied, GPS waypoints were taken every 15 minutes during the behavioural data collection. Additional points were taken for the howler monkey feeding, resting tree and sleep sites. At the end of the study period, these points were exported from Garmin Basecamp into CSV files, separated by troops, and named and imported into ArcGIS for mapping.

Using the Kernel density tool on ArcGIS, the 3-day ranges were estimated for each of the troops, highlighting the more frequently used areas. The parameters used for this geoprocessing tool, are population field, "none", search radius, "default", Area units, "square kilometres", output cell values, "densities", and method, "geodesic". Under Environments, the extent was changed to the "current processing extent"; the other environmental properties were left in the default settings. Once the program was run, the symbology was changed to "Stretch", using the stretch type "minimum maximum", and, under the mask tab, "display background value" was checked. Additionally, the resampling type was changed to "Bilinear".

Once the kernel densities were run, contour lines were produced using the "Contour line" 3D analyst tool, with a contour interval of "50" used for all of the troops. The "Greater Than or Equal" spatial analysis tool was used to construct 0-1 grid codes for the areas used by the howler monkeys. These were constructed with the kernel density tools output, and under "Input Raster or Constant Value 2", 100 was inputted for each of the troops. These rasters were then converted into polygons using the "Raster to Polygon" feature.

The area of these polygons was produced using the "Calculate Geometry" feature in the attribute table of the polygons. Under this feature, the property "Area (geodesic)" was selected, and the area unit selected was "Square Kilometres". This gave an estimate of the 3-day range for the recorded troops by providing the area of each of the polygons.

Chapter 3: Results

3.1. Wildtracks Intake and Outtake Statistics

Since the establishment of the rehabilitation program, a total of 166 primates have been received at Wildtracks. The majority of these primates, approximately 61.54%, were brought in through illegal pet trade, while 18.93% of the primates were rescued from the wild. A small percentage of primates, around 11.24%, required translocations, and 8.28% were born in captivity (Table 6). Out of the 166 primates, approximately 56.8% have been released back into their natural habitat. Around 24.26% of these primates are still undergoing rehabilitation. A small proportion of primates, around 4.73%, were deemed unsuitable for release and have become sanctuary animals, 14.02% of these primates have died upon intake or during the rehabilitation process (Table 7).

Table 6 - The number of primates that have entered the rehabilitation centre in Belize since its commencement in 2011 and the circumstances of their intake.

Species	*Intake Information*				
	Surrendered/ Confiscated Pet	Wild Rescue	Translocation	Born In Care	Total
Alouatta pigra	77	31	19	12	139
Ateles geoffroyi	26	1	x	2	29
Cebus imitator	1	x	x	x	1
Total	104	32	19	14	169

Table 7 - The outcome results for the total number of primates that have entered the rehabilitation centre in Belize since its commencement in 2011.

Species	*Outcome Information*				
	Currently undergoing Rehabilitation	Released	Sanctuary	Deceased	Total
Alouatta pigra	23	89	4	23	139
Ateles geoffroyi	18	7	3	1	29
Cebus imitator	x	x	1	x	1
Total	41	96	8	24	169

3.2.Population

During the study period, a total of 23 howler monkey troops were recorded, comprising a population of 118 individuals. Out of these 118 monkeys, 51 were male, 65 were female, and the sex of two individuals was unidentified. The population of howler monkeys was comprised of 58% mature individuals, with 52% being adults and 5% being subadults. The remaining 42% were immature, with 23.7% being juveniles and 18% being infants. On average, the troop size was 5.65 individuals, ranging from 1 to 12 individuals. There were two troops that consisted of only one male member, these were Solo Male 1 (SM1) and Solo Male 2 (SM2). Table 8 provides the troop composition of each of the 23 recorded troops.

Noteworthy changes were observed in the composition of four troops during the year-long study; Five individuals previously members of Troop 3 in December 2022 were identified as part of Troop 19 in September 2023, along with a different adult male and adult female. Similar changes in troop composition were observed in Troop 14 and Troop 23, in which six individuals from Troop 14 in April 2023 were photographed and identified in Troop 23 in October 2023. Figure 5 shows the overlapping troop members in Troops 3 and 19 and Troops 14 and 23. Furthermore, seven new offspring were observed in previously identified and recorded troops, indicated in red font in Table 8.

Table 8—The number of howler monkeys identified during the November 2022—October 2023 study period. The different Troops (T) are categorised by age, Adult, Sub-Adult, Juvenile, and Infant, as well as Sex, Male (M), Female (F), and Undetermined (Un) of each troop. The red font shows infants *born during the study period.*

Age	Adult		Sub Adult		Juvenile							Infant							Troop Size
					Stage 3			Stage 2		Stage 1		Stage 3		Stage 2		Stage 1			
Sex	M	F	M	F	M	F	UN	M	F	M	F	M	F	M	F	M	F	UN	
Troop ID																			
T1	1	3							2		2						1	1	10
T2	1	2							2	1				1					7
T3/T19*	2	3	3			1			1		1				1				12
T4	1	1																	2
T5	1	2											1						4
T6	1	2									1	1							5
T7	1	2											2						5
T9	1	2				1			1	1				1					7
T10	1	2	1													1			5
T11	1	3				1									2				7
T12	1	2			1										1	1			6
T13	1	1		1															3
T14/T23*	1	2	1				1	2	2					2					11
SM1	1																		1
T16	1	2			1								1						5
T17	1	1	1																3
T18	1	1			1			1				1							5
T20	2	2				2		1				1							8
T21	1	3						1				2							7
SM2	1																		1
T22	1	2										1							4
Total Sex	23	38	6	1	3	5	1	5	8	2	4	6	4	4	4	2	1	1	
Total Age	61		7		9			13		6		10		8		4			
Total	118																		

* Have overlapping troop members

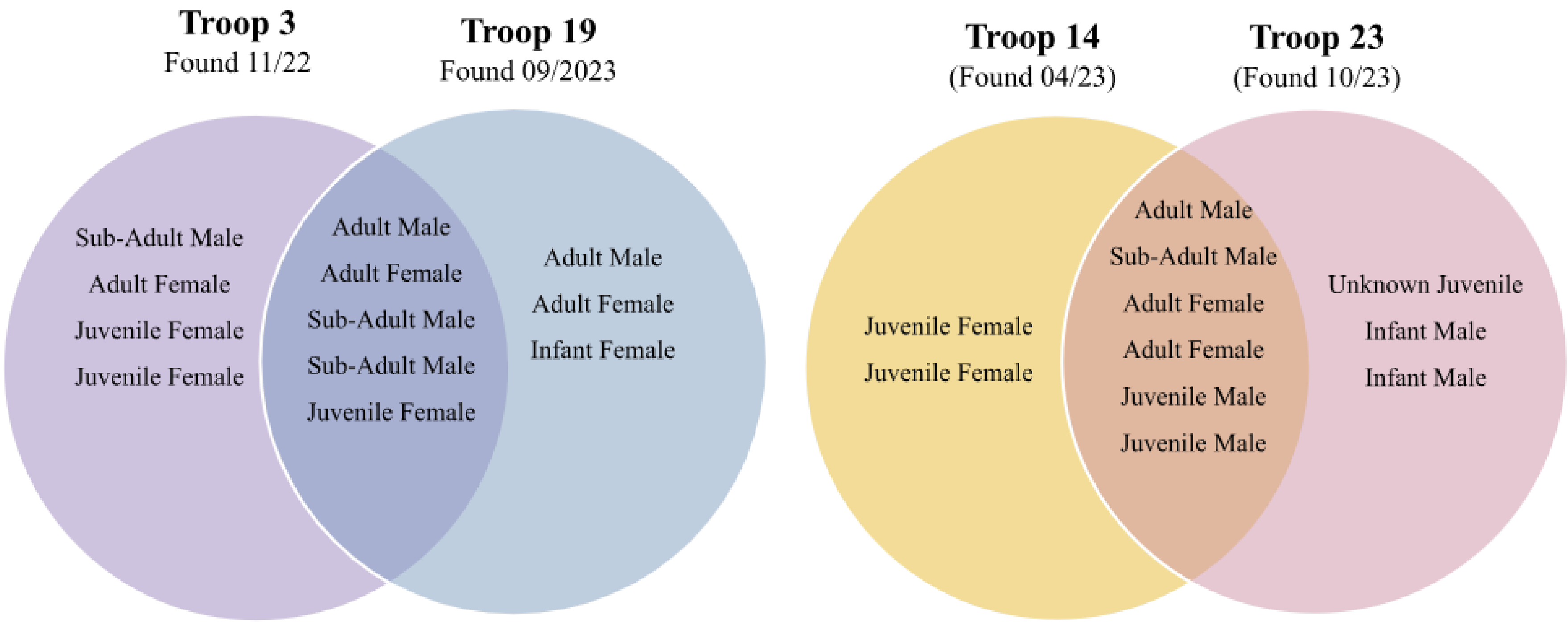

Figure 5 - Venn Diagrams explain the overlap of troop members in Troops 14 and 23 and Troops 3 and 19.

3.3. Identified Primates

After each of the 118 howler monkeys was photographed, an updated identification key (Appendix F) was created to enable further data collection on the troops and individuals found in the study. This key includes the date the individual was found, the estimated age at the time of the study, their sex, and the troop composition. A snapshot of the identification can be seen in Figure 6.

When comparing howler monkeys found in this study to the previous identification key created by Tricone (2017), 11 individuals have been identified as likely to be released (Table 9). The remaining released howler monkeys in this project were not able to be identified due to challenges in identifying the monkeys found during the study. However, based on the survival rate identified in the Tricone 2018 study and the monitoring of the released individuals post-release, it is expected that the released individuals are still alive and are likely to be members of the population documented during this study.

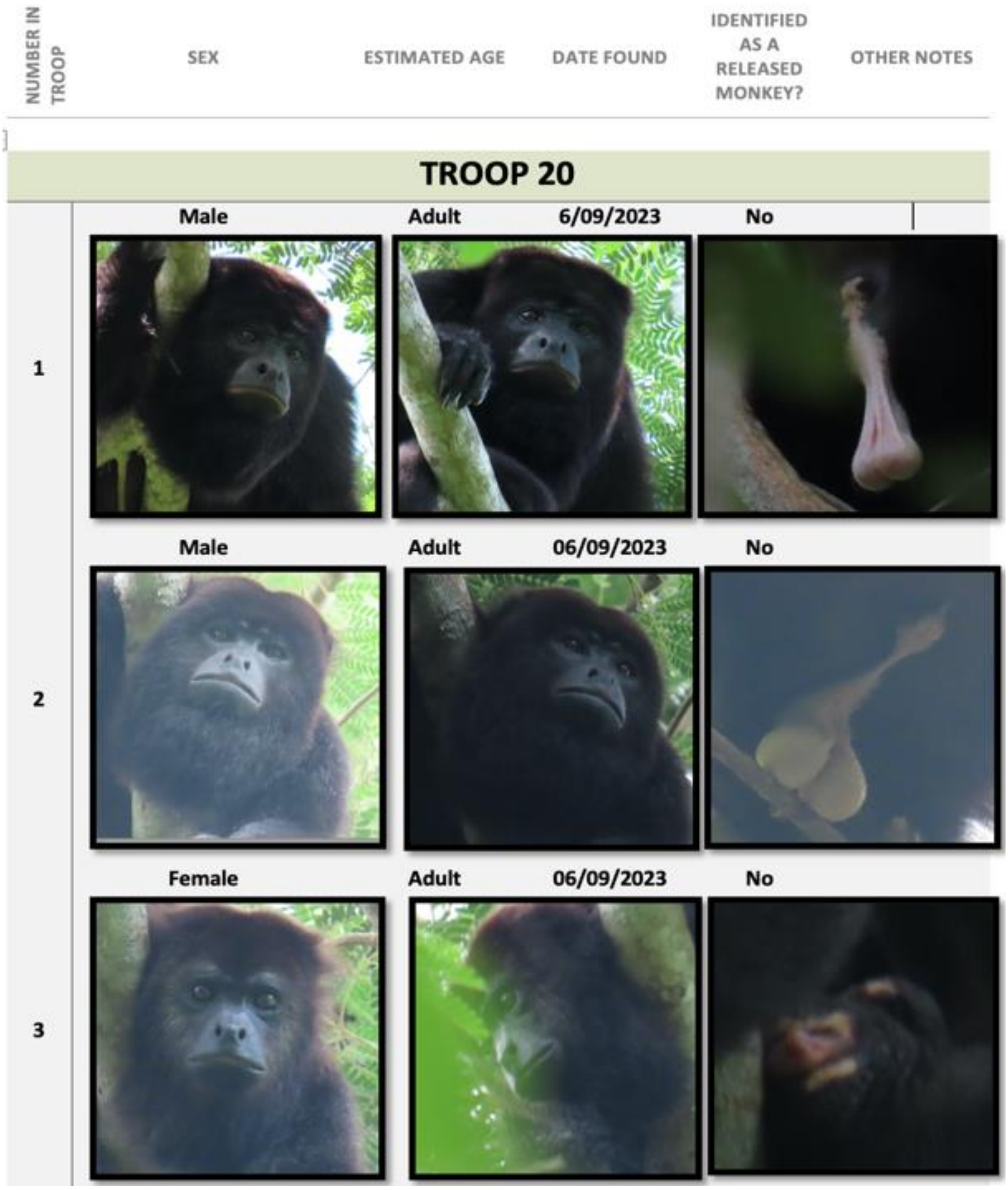

Figure 6 - Part of the identification key of the howler monkeys found in the Northeastern Biological Corridor during the study period, November 2022—October 2023.

Table 9- A list of the primates identified as rehabilitated and released individuals.

Troop	Sex	Age	Date Found	Potentially Identified as…
T2	Female	Adult	14/11/2022	Richie
T2	Female	Adult	14/11/2022	Fern
T3	Male	Adult	16/11/2022	Dudley
T3 and T19	Female	Adult	16/11/2022	Livvy
T19	Male	Adult	05/09/2023	Clyde
T4	Male	Adult	16/12/2022	Jaz
T5	Male	Adult	17/12/2022	Nicky
T11	Male	Adult	26/01/2023	Tower Hill Male
T11	Female	Adult	26/01/2023	Tower Hill Female C
T12	Female	Adult	09/02/2023	Tillie
T13	Female	Adult	12/03/2023	Polly

3.4. Behavioural Data

Activity Budget

On average, the troops of howler monkeys spent 53.23% of their time resting, 8.13% travelling, 1.05% playing, 25.71% feeding, 0.54% howling and 11.23% out of sight at the time of recording (Figure 7). Individual troop activity budgets are located in Appendix A. Resting behaviour ranged from 36.59% with Troop 7 to 71.54% with Troop 17. The occurrence of feeding behaviour ranged from 13.82% with Troop 13 to 36.59% with Troop 9. Drinking was only recorded once within the scan sampling period with Troop 11. Troop 22 spent the least amount of time travelling, only 2.44%, compared to Solo Male 2, who was travelling 13.82% of the time. Howling was recorded within the scan sampling period in five of the troops, with Troop 17 howling for the most amount of time (4.07%). Grooming behaviour was only recorded in 2 troops, Troop 9 and Troop 14, and only 0.81% of the time for both of the troops. Troop 1 and Troop 23 spent the most time playing, with play behaviour occurring 4.88% of the time during the three days of observations. Twelve of the 23 troops did not present play behaviour at all during the study period.

Canopy Height

The troops spent an average of 96.56% of their time in the top 1/3 of the canopy, 3.46% in the mid 1/3 and 0% in the lower 1/3 of the canopy (Figure 8), this data is separated by troop in Appendix B. Over the total study period, howler monkeys were not seen or recorded coming to the ground. Eleven of the 23 troops only stayed in the top third of the canopy. Solo Male 1 spent the least amount of time in the tops of the trees (67.33%) and the most time in the middle part of the trees (32.67%).

Troop Cohesion

Over the recording period, the troops spent an average of 76.08% of the time within 5 metres of the closest individual and 15% of their time further than 5 metres away. During the scan sampling recording period, 10.78% of the time, the howler monkeys were recorded as "Out of Sight" (Figure 9). Data for the cohesion of each troop can be seen in Appendix C. The two solo males were not included in these results as it was not applicable. Troop 3 spent the longest amount of time apart from each other (46.34%), the troop was recorded together 49.59% of the time and out of sight for 4.07% of the study period. Troop 7 spent the most time together (99.19%), only more than five metres apart for 0.81% of the study period. During the recorded period for each of the troops, Troop 9's male slept separately (more than 50 metres away) from the females in the troop. Troop 3 also separated for one night, with two males leaving the troop and spending the night with two unknown females.

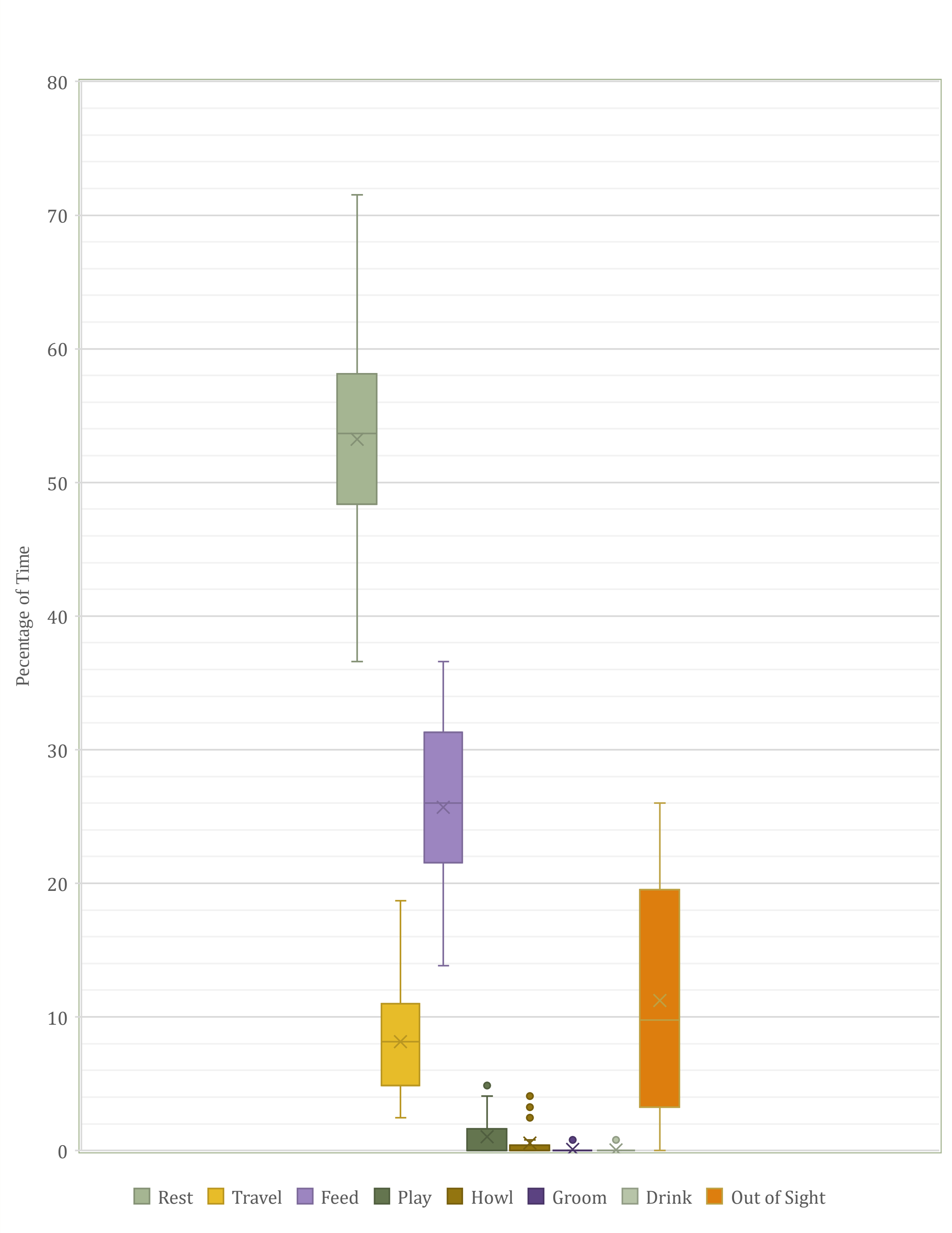

Figure 7- A box plot for the activity budgets for the troops of Yucatán black howler monkeys studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize.

Figure 8 – This box plot depicts the time spent at different heights of trees for the troops of Yucatán black howler monkeys studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize. "Top" is the top 1/3 of the tree, "Mid" is the mid 1/3 of the tree, and "Out of Sight" is when they were not in sight at the time of recording.

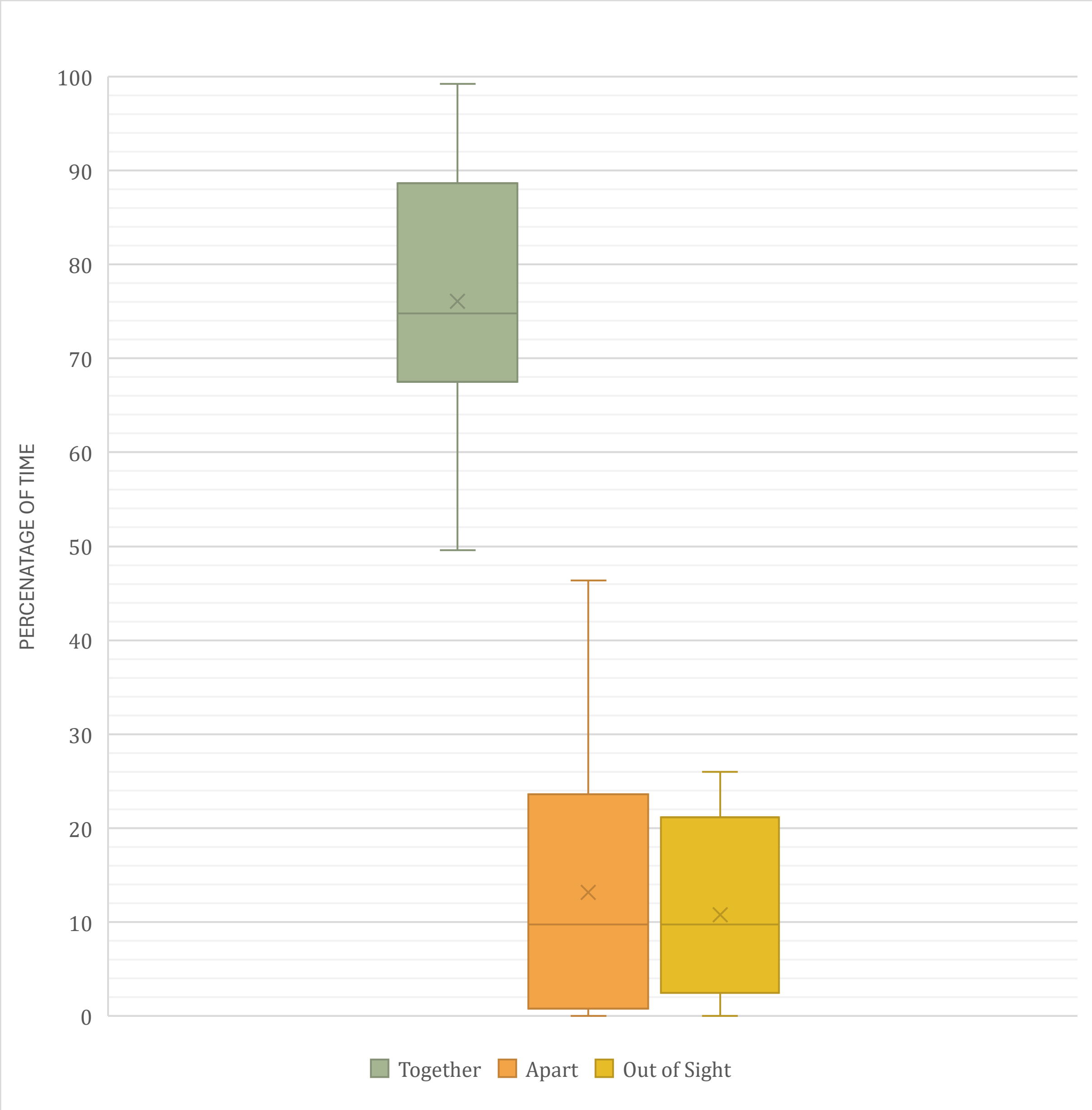

Figure 9- The cohesion of Yucatán black howler monkeys' troops studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize. "Together" was recorded when the troop members were within 5 meters of the closest individual, "Apart" was recorded when some of the troop members were out of sight or further than 5 metres from the closest individual, and "out of sight" was recorded when the troop was out of sight at the time of recording.

3.5. Feeding Behaviour

Throughout the study period, the howler monkey population demonstrated a diverse diet, consuming a total of 38 different plant species from 20 distinct families. Table 10 provides a comprehensive list of these plant species, detailing the specific parts of each plant that were consumed. Notably, the population utilised 22 species for fruit consumption, 20 species for leaf consumption (both mature and immature), and eight species for both fruit and leaf consumption. Flowers were a less common dietary component, with only four plant species being utilised for this purpose. The only species in which the howler monkey consumed every part of the plant was Cecropia, *Cecropia peltata.*

The most prevalent plant species in the howler monkey's diet was the Fig, *Ficus spp*., accounting for 19.45% of their total diet. This was followed by Ramon, *Brosimum alicastrum* (16.72%) and Cecropia, *Cecropia peltata* (13.37%). These three species alone constituted almost half (49.54%) of the howler monkey's diet. Figure 10 provides a visual representation of the percentage of time that different plant species were consumed. The category 'Other' includes all plant species consumed for less than 1% of the study period, which can be found in Table 11.

Fruit was the part of the plant most commonly consumed, accounting for 56.08% of the howler monkey's diet, followed by mature leaves (28.57%) and young leaves (9.42%) (Figure 11). This information is separated for each troop in Appendix D. Table 11 provides a breakdown of the different plant species consumed by the howler monkeys, along with the percentage of time spent eating each part of the plant. The fruit of *Ficus* tree species was the most commonly consumed food, making up 15.81% of the total diet. The species of tree that was most relied upon for mature leaves was *Havardia albicans*, with the plants' mature leaves making up 6.84% of the diet. Young leaves were most commonly consumed in *Brosimum alicastrum*, although this species was more widely used for its fruits (10.79%).

Flowers were only consumed from 4 species and consisted of 0.76% of the howler monkeys' total diet; in three of these plant species, only the flower was consumed, excluding the plant Cecropia.

Table 10- A list of the plant species that Yucatán black howler monkeys (Alouatta pigra) were documented eating in the Northeastern Biological Corridor of Belize between November 2022 and October 2023 and the part of the plant that they were seen eating. Separated by mature leaf (ML), young leaf (YL), fruit (FR), flower (FL), stem (ST) and petiole (PE)

Family	**Scientific Name**	**Common Name**	**Part of Plant Eaten**					
			ML	**YL**	**FR**	**FL**	**ST**	**PE**
Anacardiaceae	*Metopium brownei*	Black Poison Wood			x			
	Spondias mombin	Hogpulm	x	x	x			
Araceae	*Syngonium podophyllum Scott*	Ephyiate 1	x					
	Philodendron hederaceum	Heartleaf Philodendron	x					
	Philodendron radiatum	Philodendron	x					
Araliaceae	*Dendropanax arboreus*	White Gumbo limbo			x			
Arecaceae	*Sabal mauritiiformis*	Botan Palm			x			
Burseraceae	*Protium copal*	Copal			x			
	Bursera simaruba	Gumbo limbo	x	x				
Calophyllaceae	*Mammea americana*	Mammee			x			
	Calophylum brasilense	Santa Maria		x				
Ebenaceae	*Diospyros anisandra*	Diospyros 1			x			
	Diospyros yucatanensis	Diospyros 2			x			
Fabaceae	*Enterolobium cyclocarpum*	Guanacaste	x	x				
	Caesalpinia gaumeri	Warree wood	x	x				
Lamiaceae	*Vitex gaumeri greenm*	Ya'axnik			x			
Leguminosae	*Swartzia cubensis*	Katalosh (k'aatal oox)	x	x				
	Lysiloma latisiliquum	Tsalam	x	x				
	Havardia albicans	My Waterwood	x	x				
Malvaceae	*Ceiba pentandra*	Ceiba	x	x				

	Guazuma ulmifolia	Pissoi	x	x	x			
Moraceae	*Ficus spp.*	Fig	x	x	x			
	Brosimum alicastrum	Ramon (aka Breadnut)	x	x	x			
	Trophis racemosa	Red Ramon	x	x	x			
Polygonaceae	*Coccoloba diversifolia*	Pigeon Plum			x			
	Coccoloba?	Unknown Tree 3			x			
Sapindaceae	*Cupania belizensis*	Grande betty	x	x				
Sapotaceae	*Chrysophyllum mexicanum Brandegge*	Caimitillo/Chicki			x			
	Manilkara zapota	Sapote			x			
	Pouteria amygdalina	Silion	x	x				
Simaroubaceae	*Simarouba amara*	Negrito	x	x	x			
Urticaceae	*Cecropia peltata*	Cecropia	x	x	x	x	x	x
Verbenaceae	*Petrea volubilis*	Queens Wreath				x		
Vitaceae	*Vitis tiliifolia*	Water vine	x	x	x			
		Purple flower vine 2				x		
		Unknown Tree 2			x			
		Red Vine			x	x		
		Unknown Vine 2	x	x				

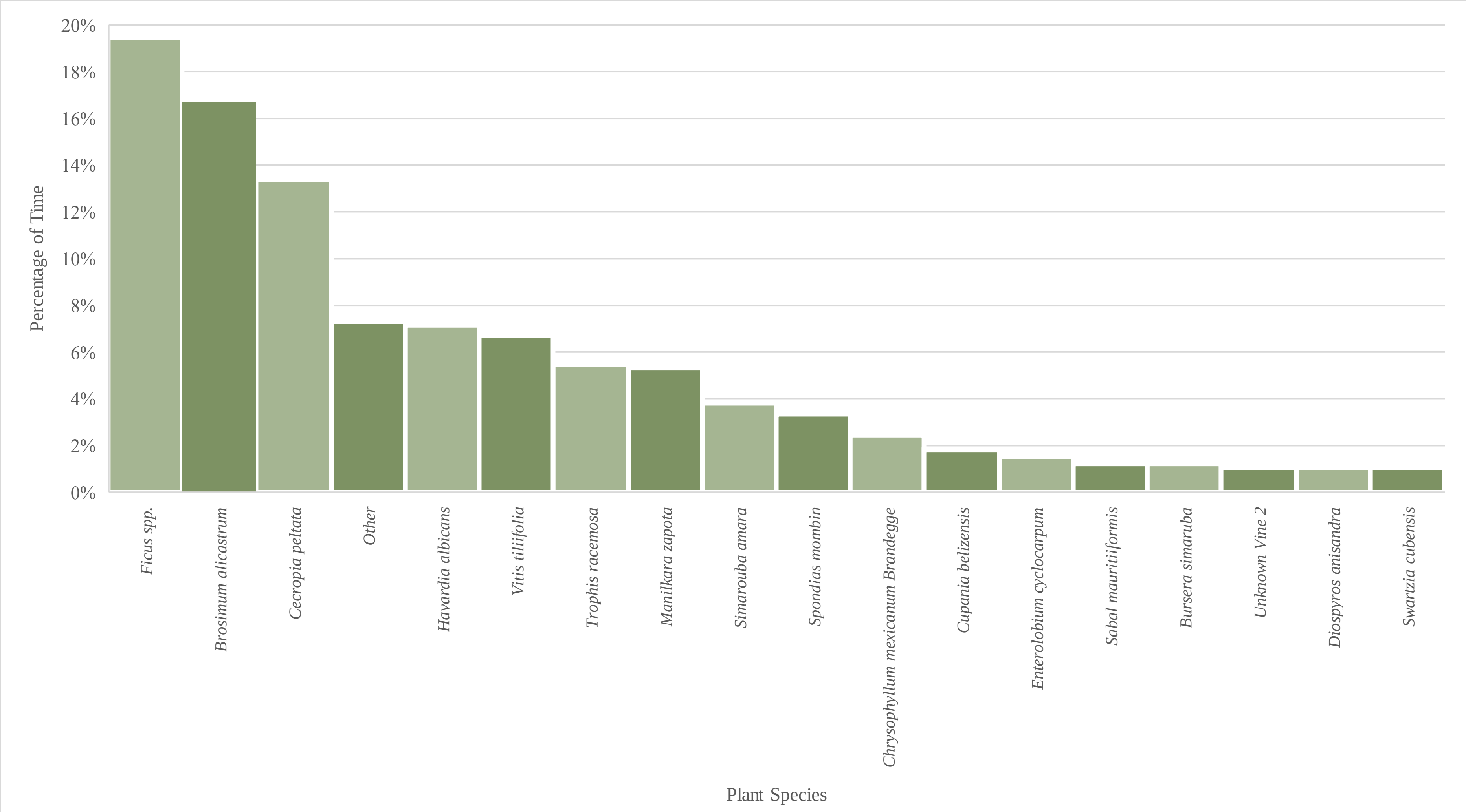

Figure 10 – Plant species eaten by Yucatán black howler monkeys (Alouatta pigra) in the Northeastern Biological Corridor of Belize between November 2022 and October 2023, and the percentage of time that population spent eating these different species. The category "Other' applies to any species of plant occupies less that 1% of the population feeding time.

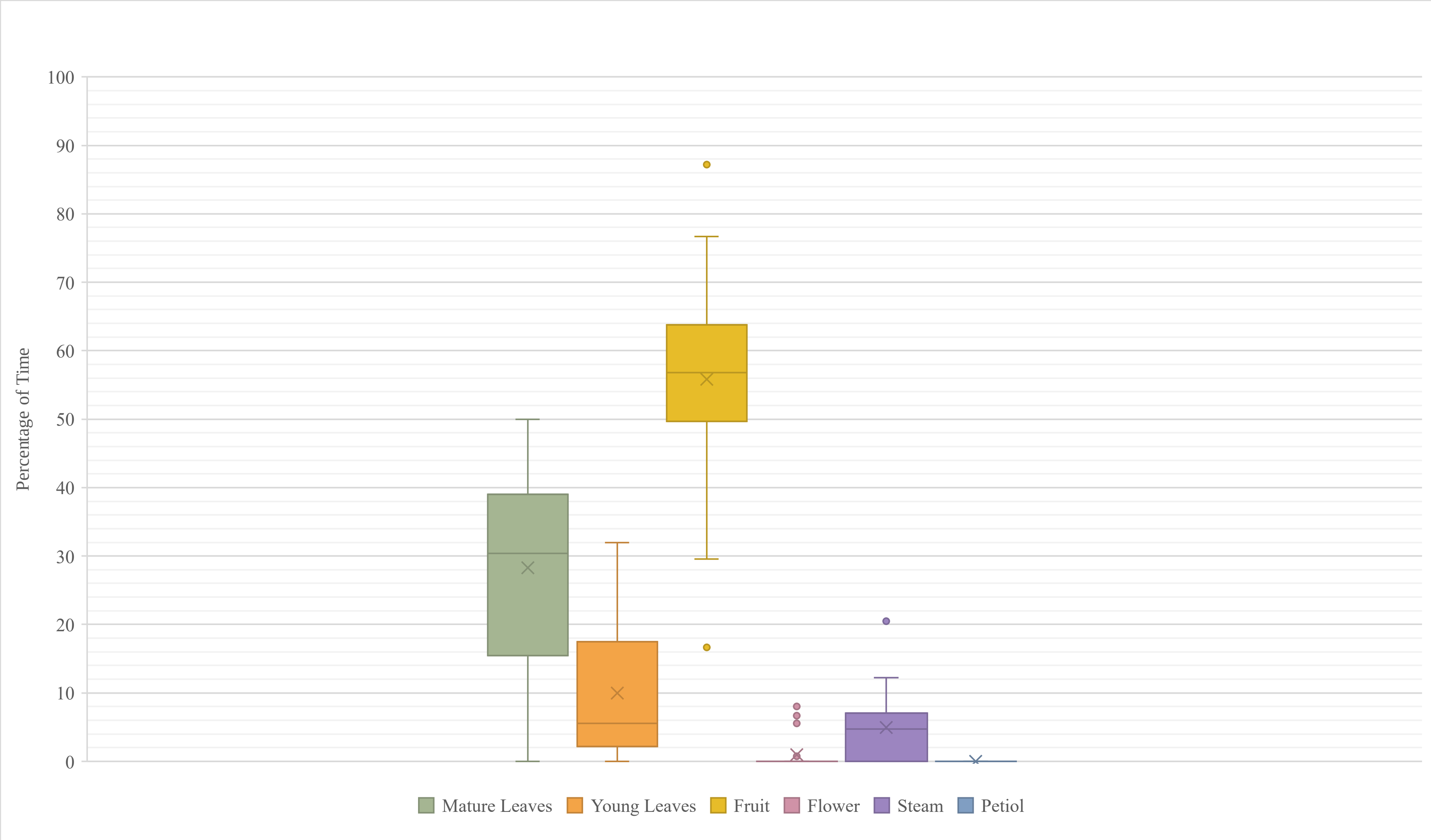

Figure 11- The percentage of time Yucatán black howler monkeys (Alouatta pigra) spent eating different parts of the plant in the Northeastern Biological Corridor of Belize between November 2022 and October 2023

Table 11—The different plant species that the Yucatán black howler monkeys (Alouatta pigra) were documented eating in the Northeastern Biological Corridor of Belize between November 2022 and October 2023, and the percentage of time spent eating different parts of the plant.

Plant Species	% of the Part of Plant Eaten for Each of the Tree Species						Total % of Tree Species Eaten
	Mature Leaves	Young Leaves	Fruit	Flower	Stem	Petiole	
Ficus spp.	2.13	1.52	15.81	0.00	0.00	0.00	19.45
Brosimum alicastrum	4.10	1.82	10.79	0.00	0.00	0.00	16.72
Cecropia peltata	5.78	1.52	0.91	0.00	5.17	0.00	13.37
Havardia albicans	6.84	0.30	0.00	0.00	0.00	0.00	7.14
Vitis tiliifolia	0.15	0.46	6.08	0.00	0.00	0.00	6.69
Trophis racemosa	0.00	0.30	5.17	0.00	0.00	0.00	5.47
Manilkara zapota	0.00	0.00	5.32	0.00	0.00	0.00	5.32
Simarouba amara	0.00	0.00	3.80	0.00	0.00	0.00	3.80
Spondias mombin	1.82	0.46	1.06	0.00	0.00	0.00	3.34
Chrysophyllum mexicanum Brandegge	0.00	0.00	2.43	0.00	0.00	0.00	2.43
Cupania belizensis	1.37	0.46	0.00	0.00	0.00	0.00	1.82
Enterolobium cyclocarpum	0.91	0.61	0.00	0.00	0.00	0.00	1.52
Sabal mauritiiformis	0.00	0.00	1.22	0.00	0.00	0.00	1.22
Bursera simaruba	0.46	0.76	0.00	0.00	0.00	0.00	1.22
Unknown Vine 2	1.06	0.00	0.00	0.00	0.00	0.00	1.06
Diospyros anisandra	0.00	0.00	1.06	0.00	0.00	0.00	1.06
Swartzia cubensis	0.76	0.30	0.00	0.00	0.00	0.00	1.06
Coccoloba diversifolia	0.15	0.00	0.76	0.00	0.00	0.00	0.91

Dendropanax arboreus	0.15	0.30	0.30	0.00	0.00	0.00	0.76
Pouteria amygdalina	0.61	0.00	0.00	0.00	0.00	0.00	0.61
Lysiloma latisiliquum	0.61	0.00	0.00	0.00	0.00	0.00	0.61
Metopium brownei	0.00	0.00	0.46	0.00	0.00	0.00	0.46
Coccoloba?	0.00	0.00	0.46	0.00	0.00	0.00	0.46
Protium copal	0.46	0.00	0.00	0.00	0.00	0.00	0.46
Philodendron hederaceum	0.46	0.00	0.00	0.00	0.00	0.00	0.46
Petrea volubilis	0.00	0.00	0.00	0.46	0.00	0.00	0.46
Calophylum brasilense	0.00	0.46	0.00	0.00	0.00	0.00	0.46
Guazuma ulmifolia	0.30	0.00	0.00	0.00	0.00	0.00	0.30
Purple flower vine 2	0.00	0.00	0.00	0.30	0.00	0.00	0.30
Caesalpinia gaumeri	0.30	0.00	0.00	0.00	0.00	0.00	0.30
Ceiba pentandra	0.00	0.15	0.00	0.00	0.00	0.00	0.15
Diospyros yucatanensis	0.00	0.00	0.15	0.00	0.00	0.00	0.15
Syngonium podophyllum Scott	0.15	0.00	0.00	0.00	0.00	0.00	0.15
Vitex gaumeri greenm	0.00	0.00	0.15	0.00	0.00	0.00	0.15
Vitex gaumeri greenm	0.00	0.00	0.15	0.00	0.00	0.00	0.15
Philodendron radiatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown Tree 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total % of Part of Plant Eaten	**28.57**	**9.42**	**56.08**	**0.76**	**5.17**	**0.00**	**100.00**

3.6. Location of the Troops Found During the Study Period

Over the year-long study, 23 troops were recorded, photographed, and tracked for a minimum of three days. Figure 12 shows the location of the troops of Yucatán black howler monkeys that were recorded in the Northeastern Biological Corridor of Belize between November 2022 and October 2023. The polygons encompass the 1848 GPS waypoints that were taken during the study period. Figure 13 includes any signs of howler monkeys in areas where a troop had not been located. Specifically, 92 GPS waypoints that indicated the smell of faecal matter were taken over the study period, eleven GPS waypoints were taken when the faecal matter was found, and 24 signs indicated howler monkeys had been feeding in the area. Maps for the individual troops, highlighting points of key behaviours presented in the study period are outlined in Appendix E.

Eight troops were located and tracked in the Fireburn area: Troop 1, Troop 2, Troop 3, Troop 5, Troop 17, Troop 19, Troop 20, and Solo Male 2. One additional monkey sighting occurred in this area: two female and two juvenile howler monkeys (indicated by the yellow star in Figure 9); however, due to a lack of information, these individuals were not included in the total count of howler monkeys.

One troop was located in Shipstern Nature Reserve, Troop 4, which was a troop of one male and one female.

In Kakantulix Archaeological Reserve and the surrounding area, 13 Troops were located and tracked for three days for each troop. These troops were Troop 6, Troop 7, Troop 9, Troop 10, Troop 11, Troop 12, Troop 13, Troop 14, Troop 16, Troop 21, Troop 22, Troop 23, Solo Male 1. In this area, Troop 15 was located when the male was howling. However, the troop was unable to be tracked, and no data was able to be collected.

One troop, Troop 18, was found outside the Northeastern Biological Corridors protected area. Due to time constraints, limited time was spent searching this area. This area has recently been used as a release site for the rehabilitated monkeys. Therefore, it is expected that more troops will be located in this area.

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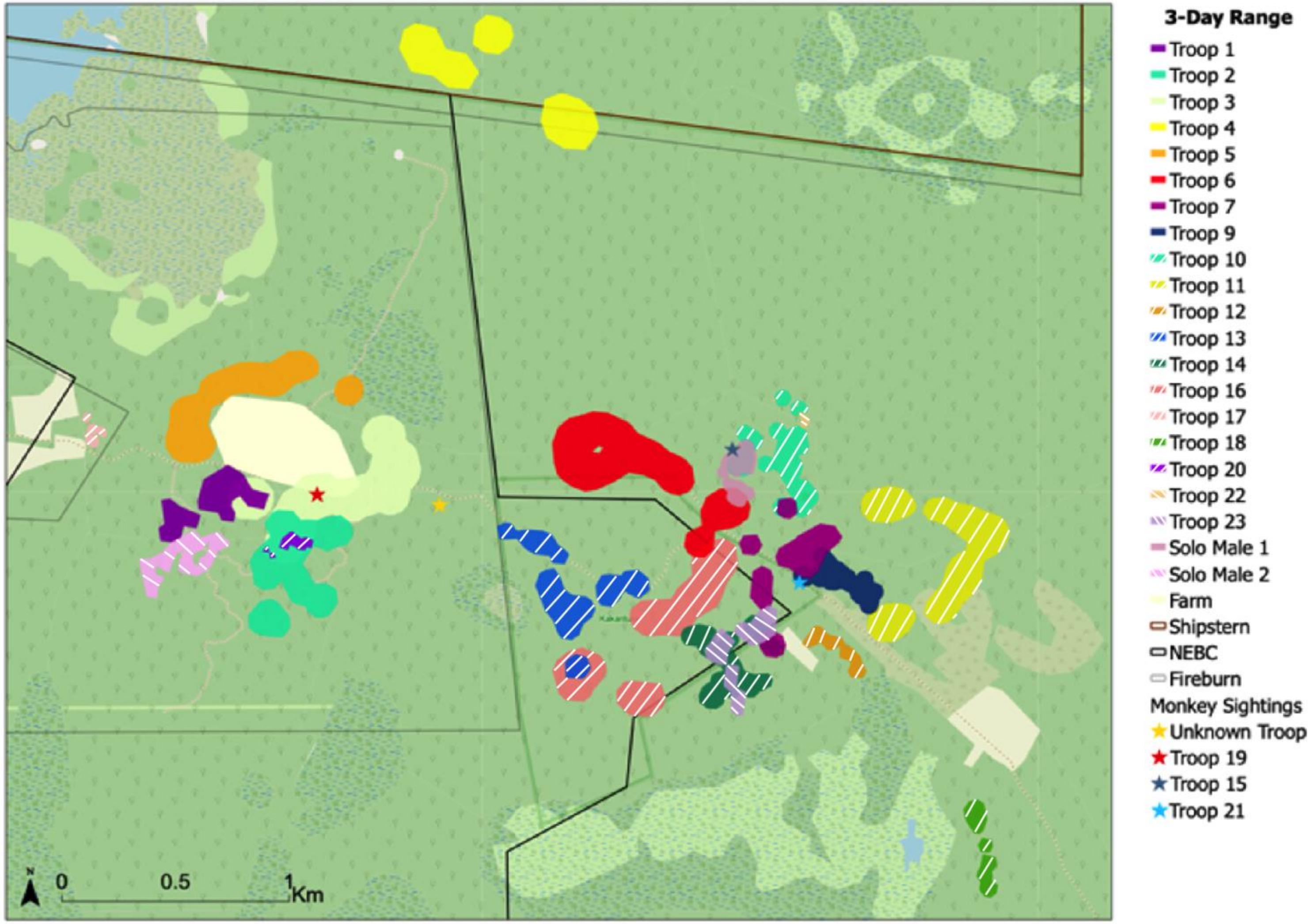

Figure 12 – Polygons portraying the location of the troops of Yucatán black howler monkeys (Alouatta pigra) recorded in the Northeastern Biological Corridor of Belize between November 2022 and October 2023.

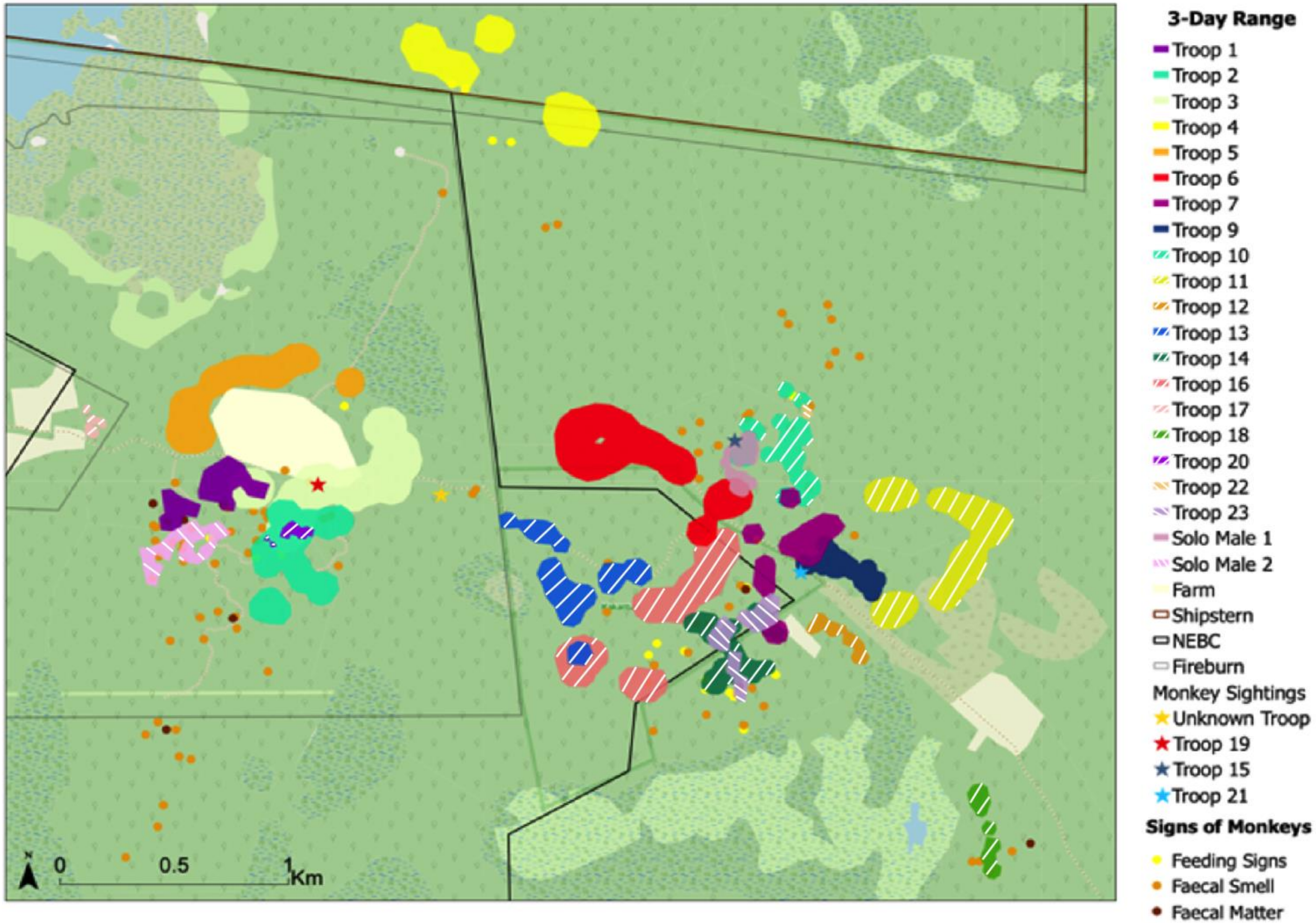

Figure 13 - Polygons portraying the location of the troops of Yucatán black howler monkeys (Alouatta pigra) recorded in the Northeastern Biological Corridor of Belize between November 2022 and October 2023 with additional signs of monkeys in the area, faecal matter, faecal smell, and feeding signs

3.7. Ranging Behaviour

During the three days of data collection for each troop, an estimated three-day home range was created, as can be seen in Table 12. On average, this was 7.65 hectares for the three-day tracking period, ranging from 0.24 hectares in Troop 22 to 15.27 hectares in Troop 16. Due to a lack of data, Troop 15, Troop 19 and Troop 21 were not included in this analysis.

Kernel Density analysis was used to identify key areas for the howler monkey troops. These results are displayed for Fireburn Nature Reserve (Figure 14), Kakantulix Archaeological Reserve (Figure 15), Shipstern Nature Reserve (Figure 16) and outside the Northeastern Biological Corridor (Figure 17). In the kernel density maps below, darker-coloured areas represent a higher concentration of GPS waypoints, indicating that the troop spent more time in those specific areas during the study period. This behaviour varied among troops. For instance, Troop 17 predominantly occupied a single location, while Troop 5's GPS waypoints were more evenly distributed across their home range. Most troops exhibited 1 or 2 main areas where they spent the majority of their time. The darkest spots typically corresponded to the howler monkeys' sleeping sites, whereas lighter areas indicated locations used for travel or feeding, where the troops did not stay for extended periods.

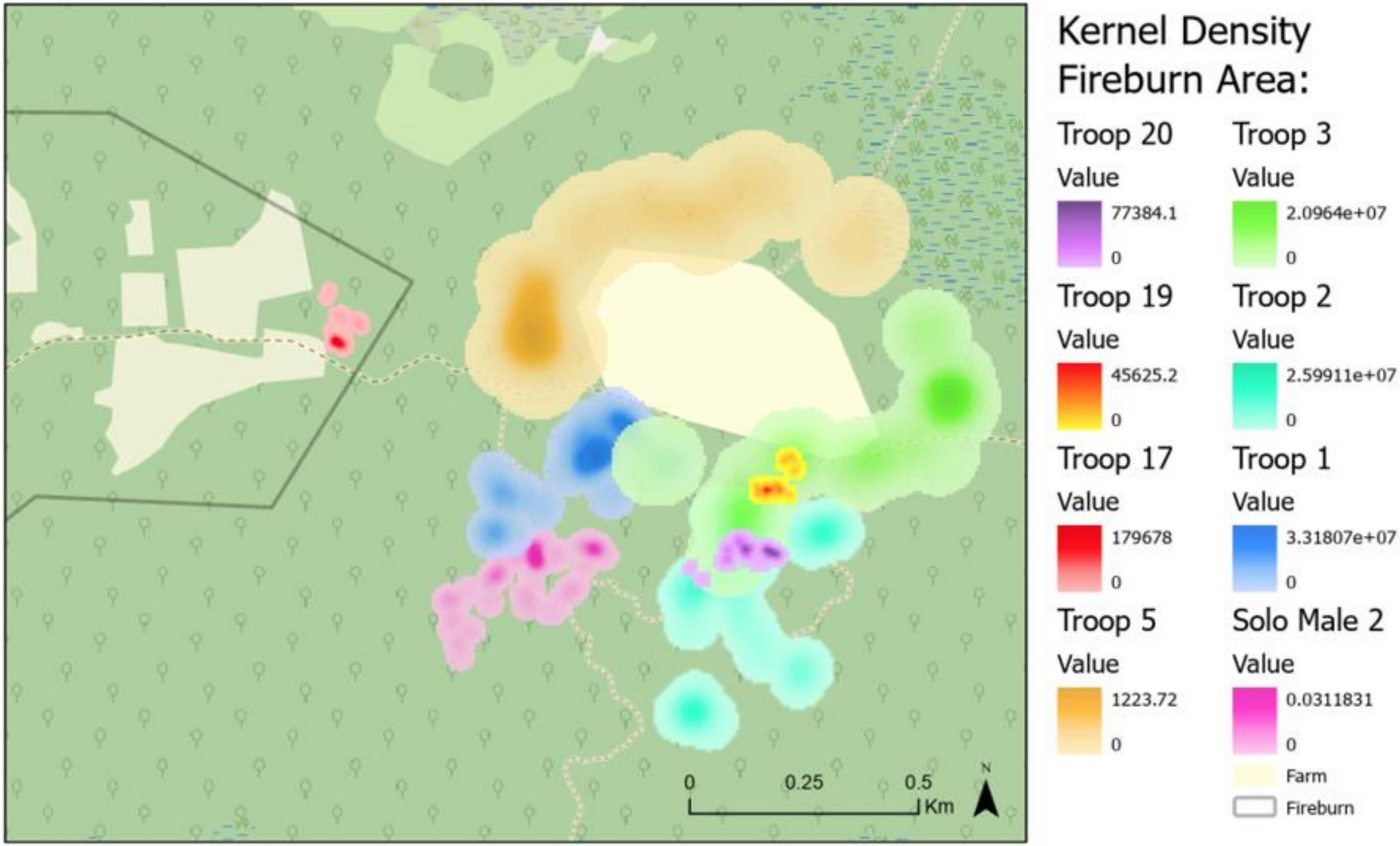

Figure 14 - Kernel density analysis for the eight troops of howler monkeys found in the Fireburn Nature Reserve

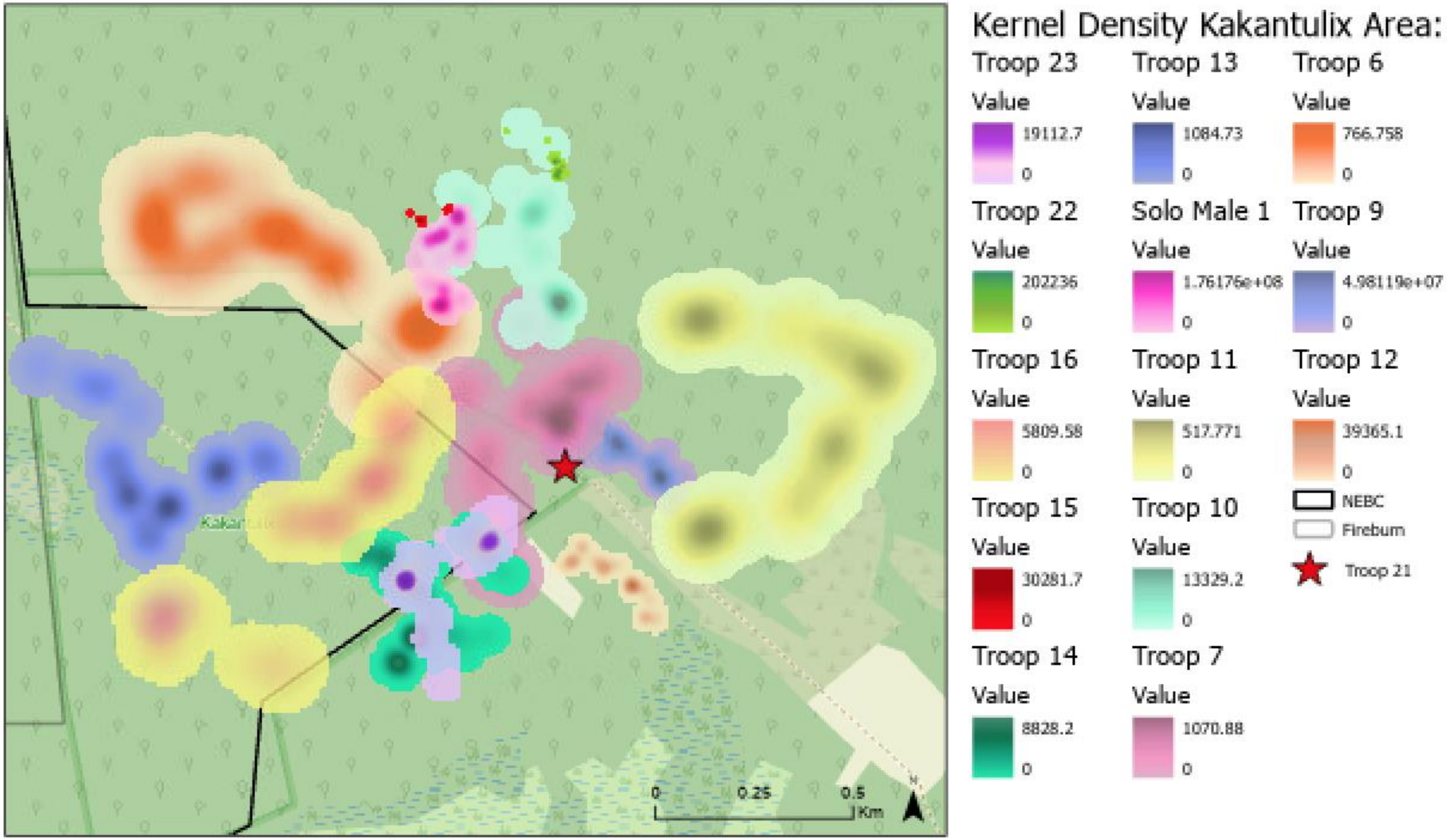

Figure 15- Kernel density analysis for the thirteen troops of howler monkeys found in and around Kakantulix Archaeological Reserve

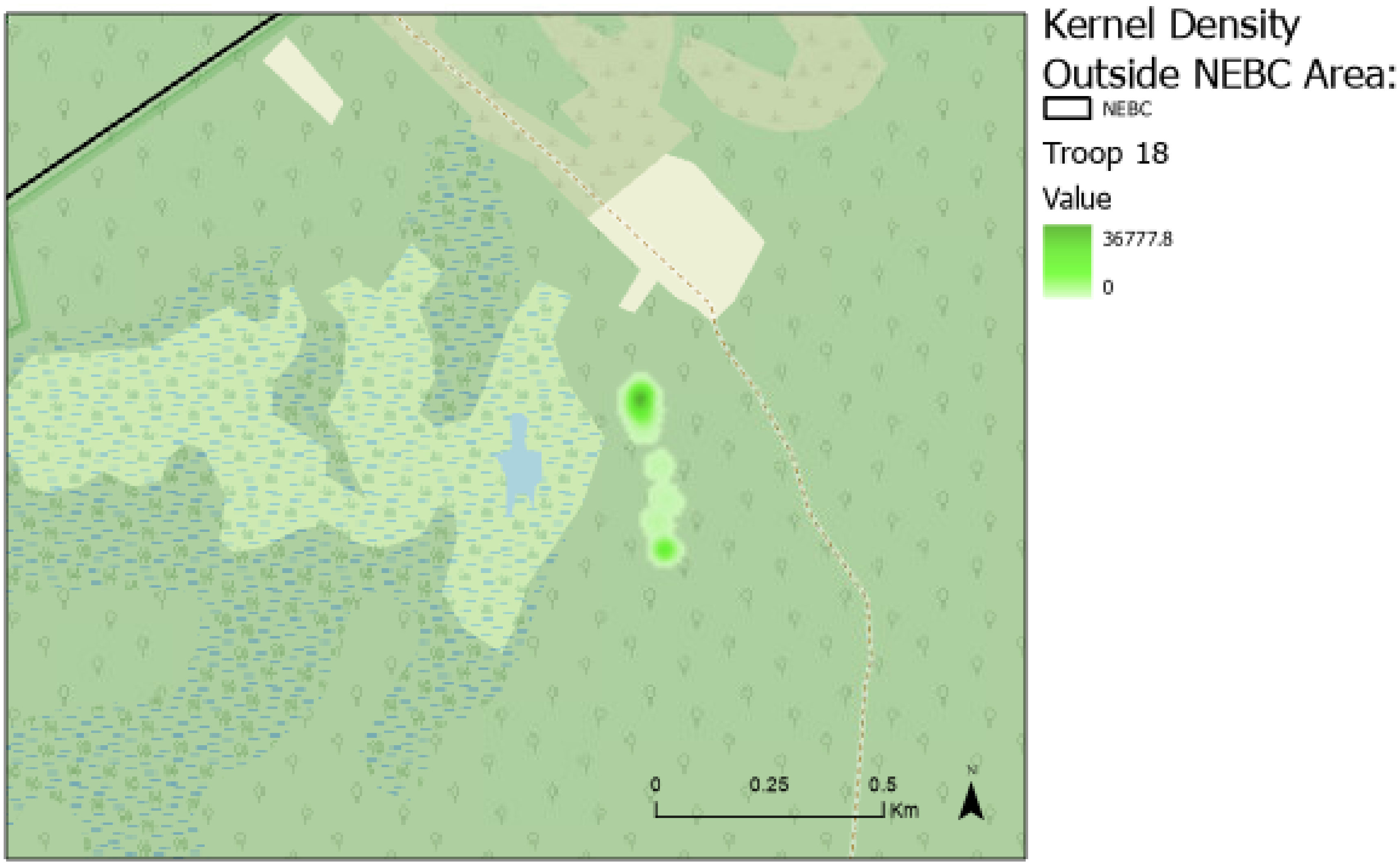

Figure 16 - Kernel density analysis for a troop of howler monkeys, Troop 18, found just outside of the Northeastern Biological Corridor

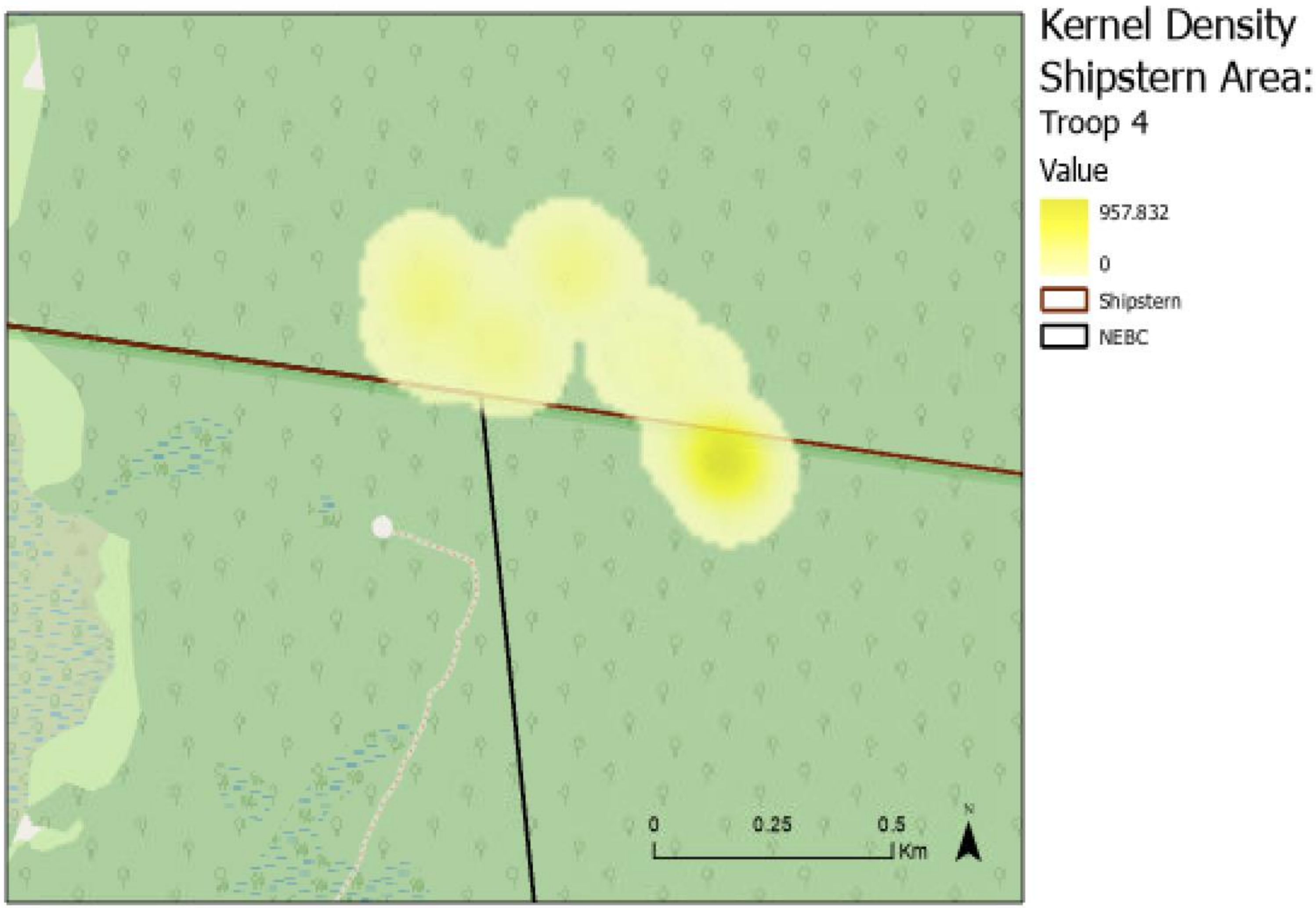

Figure 17 - Kernel density analysis for a troop of howler monkeys, Troop 4 in Shipstern Nature Reserve

Table 12- The 3-day home range estimation for the 23 troops of howler monkeys found in the Northeastern Biological Corridor of Belize.

	3 Day Home Range Estimation (Hectare)
Troop 1	5.89
Troop 2	13.05
Troop 3	20.60
Troop 4	11.56
Troop 5	12.84
Troop 6	17.92
Troop 7	7.51
Troop 9	4.71
Troop 10	7.88
Troop 11	15.02
Troop 12	2.06
Troop 13	9.69
Troop 14	7.74
Troop 15	No Data
Troop 16	15.27
Troop 17	0.74
Troop 18	2.48
Troop 19	No Data
Troop 20	0.79
Troop 21	No Data
Troop 22	0.24
Troop 23	4.36
Solo Male 1	2.97
Solo Male 2	4.40

Chapter 4: Discussion

4.1. Assessing Success on an Individual Level

4.1.1. Analysing Intake and Outtake Reports

Initial indicators of success in wildlife rehabilitation can be identified through analysing intake and outtake statistics of wildlife rehabilitation. While there is limited information accessible to the public, some rehabilitation centres have made this data available. For example, a British Wildlife Rehabilitation Centre published that they released 42.6% of animals back into the wild over ten years (2012-2022), while 19.2% died in captivity, and 37.2% were euthanised (Mullineaux & Pawson, 2023). In the state of New South Wales, Australia, 64.6% of mammals died, less than 1% escaped, 6.3% were left and observed, less than 1% received permanent or long-term care, and 28.4% were released (Kwok et al., 2021). When looking at the primate taxa, specifically Indonesia's slow lorises, *Nycticebus spp*., between 2008 and 2011 found that out of 180 that entered rehabilitation, over 85% were deemed unsuitable for reintroduction. As a result, 23 slow lorises that were deemed suitable were eventually released back into the wild between 2010 and 2013 (Moore et al., 2014). In Wildtracks case, out of the 139 howler monkeys that were admitted, 64% were released back into the wild, 16.5% are still undergoing rehabilitation, 2.8% are considered sanctuary animals, and 16.5% died upon intake or in care. While it is important to note that injuries and admission rates are widely variable and would impact the outcome of the rehabilitation centres across the taxa and while these studies are not limited to primate taxa, they demonstrate the high mortality and low release rates in rehabilitation programs across mammal species. In comparison, Wildtracks' current release statistic of 64%, with a further 16.5% expected to be released, this indicates an estimated percentage of 80.5% of the howler monkeys entering rehabilitation expecting to return to the wild. This demonstrates a high level of success during the rehabilitation process when compares to other rehabilitation centres.

4.1.2. Post Release Monitoring of Individuals

In the 2015 assessment of the rehabilitated and released population in Fireburn Nature Reserve, 75% of the 28 released primates were identified in the wild, and three births were recorded (Tricone, 2018), indicating a high level of success on this level. As the first release of the howler monkeys occurred 12 years ago, the population is expected to have grown, with second or third-generational members of the population that have yet to be recorded or photographed; therefore, identifying these individuals was not possible.

During the study period, eleven of the initially released individuals were successfully identified using Tricone's (2018) identification key, highlighting the success of Wildtracks howler monkey rehabilitation programme for these individuals. Notably, Clyde, one of the first released howler monkeys, was found and identified during this study. His survival in the wild 12 years after his release indicates success in achieving the goal of long-term survival on an individual level.

It was difficult to assess the success of each individual released primate due to the challenges in identifying the released individuals and determining new members of the population. This could have been a result of changes in facial characteristics due to age, potential new scaring, and movement away from their original release sites. In addition to facial features, identification focused on genital markings, however, long-term changes in pigmentation have not been assessed (Tricone, 2018). As a result, more consistent photos of the released population should be considered to ensure the ability to conduct long-term studies on the same individuals.

4.2. Assessing Success on a Population Level

This study has demonstrated the persistence of the population of howler monkeys at the release site, 12 years after their first release. This is a positive indication that the area meets all the necessary requirements outlined in Baker's (2002) guidelines, such as adequate connectivity to suitable habitats and fulfilling all the biotic and abiotic requirements of the species. Therefore, it can be concluded that the area is sustainable for the long-term establishment of a stable population of howler monkeys. This indicates that habitats with similar vegetation should be considered suitable release sites for future releases of the Yucatán black howler monkey.

4.2.1. Population Growth

Over the past twelve years, 78 howler monkeys have been released into the Northeastern Biological Corridor. During this study, 118 individuals were found residing in the area. There were indications, such as faecal signs, that suggest there are more individuals than those found in the Northeastern Biological Corridor. Therefore, the population has grown by a minimum of 40 individuals; this indicates a total growth rate of 51.28% over the last 12 years. The closest recorded population of howler monkeys is in Lamanai Archaeological Reserve, which is 70km from the released population (Gavazzi et al. 2008). While there is a possibility, migration of individuals from other areas is considered an unlikely reason for the increased population levels. Therefore, it is most likely that this population increase is a result of the population growth within the released population.

While studies on the translocation of howler monkeys indicate high growth rates among populations, there is a wide variety across these studies. For instance, a population of Mexican howler monkeys, *Alouatta palliata mexicana*, was introduced to an 8.4-hectare island called Agaltepec. This population grew from 9 to 57 individuals in ten years, indicating a high population growth rate (Rodriguez-Luna et al., 2003). Additionally, in a study on a translocated troop of Mexican howler monkeys into a managed reserve of agroforest, the population grew from 9 to 25 individuals over 14 years (Franquesa-Soler et al., 2022). This variety of population growth may suggest that population growth can vary between different forest systems; however, further research should be conducted to assess this hypothesis.

Within the population of howler monkeys, 42% of the individuals were categorised as juveniles (23.7%) and infants (18%), which indicates that the rehabilitated howler monkeys are successfully contributing to a reproductive population. This percentage of immature individuals is higher than previous research of studies of wild established populations. Such as Pozo-Montuy et al.'s (2008) study on the status of the habitat and population of the Yucatán black howler monkey in Balancán; in this researched population, 33% of the population was classed as immatures, 20.5% of which were juveniles, and 12.5% were infants. In addition to this, Van Belle and Estrada's (2005) study on Yucatán black howler monkey populations recorded that, on average, 34% of the mean troop members were immatures, 19.5% of which were juveniles and 14.5% of which were infants.

This higher level of immature individuals seen in the rehabilitated and released population, compared to established populations of Yucatán black howler monkeys, suggests that the population in the Northeastern Biological Corridor is in the growth phase of the three phases of reintroduced population dynamics, which have been outline by Sarrazin (2007). These three phases are release, growth, and regulation, and the high level of immature individuals in the population could be an indication that the population has not yet met its carrying capacity (Armstrong & Reynolds, 2012; Robert et al., 2015; Sarrazin, 2007). The high growth rates of the reintroduced populations are indicators of success within the rehabilitation program (Robert et al., 2015). According to Robert et al.'s (2015), the long-term conclusions on the success of reintroduction projects are more reliable when the population has entered the regulation phase. Therefore, further studies should be conducted on the population to assess the success at later stages of population development.

Over the study period, seven infants were born to troops that had already been recorded as part of the study. Four infants were categorised as infants in stage 1, age 0-3 months, at the time of discovery. Troop 1's infants were discovered in September, Troop 10's infant was recorded in January, and Troop 12's infant was recorded in February. This implies that two individuals were born in the dry season and two during the wet season. These results indicate that, during this study period, seasonality does not seem to have influenced the timing of births in the population. The presence of seasonal patterns in the Alouatta pigra species has been a subject of debate (Dias et al., 2015). When seasonality is observed, research indicates that black howler monkeys tend to give birth during months with low rainfall, likely because of the abundance of fruit (Brockett et al., 2000; Dias et al., 2015). However, the howler monkeys consumed a large amount of fruit throughout the entire study period, which could suggest that the environmental conditions in the area may reduce the necessity for seasonal births. However, it is unclear whether the lack of birth seasonality is influenced by environmental factors or if it could be due to other factors, such as social dynamics. Therefore, further investigation is needed to determine if seasonality in *Alouatta pigra* births is consistent across the species.

4.2.2. <u>Troop Size and Composition</u>

The study results show that the troop sizes of the rehabilitated howler monkey population are similar to those found in wild populations, with an average troop size of 5.65 individuals. This can be compared to previous studies by Van Belle & Estrada (2005), which reported an average troop size of 6.57 individuals, and Estrada et al. (2002), which found an average troop size of 5.9 individuals in *Alouatta pigra* in Palenque, Chiapas, Mexico. These findings suggest that the rehabilitated population of howler monkeys can form troops similar to their wild counterparts. This formation of groups similar to that of the wild population indicates that the rehabilitation process used in Wildtracks is successful towards the development of group bonds, which is a critical aspect of rehabilitating group-living animals as difficulties in maintaining these can lead to higher mortality rates and potential reproductive issues (Guy et al., 2012; Van Belle et al., 2013).

As noted in the results, changes in the population dynamics of howler monkey troops were recorded throughout the year-long study period, specifically between Troop 14 and Troop 23, and Troop 3 and 19. This movement of individuals between troops is not uncommon and has been recorded previously among both male and female howler monkeys (Ostro et al., 2001; Van Belle & Di Fiore, 2022). Therefore, there is no indication that the changes in the troops observed in this study are abnormal behaviour for the species. It is suggested that there are multiple reasons why howler monkeys migrate from their original troop (Van Belle & Di Fiore, 2022). This emigration of howler monkeys between troops is considered, in part, to be a result of the costs and benefits of staying in their original troops or dispersing to form new ones (Van Belle & Di Fiore, 2022). As a result, an individual's decision to emigrate from their original troop is likely to be linked to population density, indicating that an increase in population density leads to the formation of larger groups or groups with multiple adult males (Ostro et al., 2001).

During the study period, only one out of the 23 troops observed, Troop 22, had multiple adult males. This number of troops with multiple adult males is lower than what has been observed in other studies of the species. For instance, 60% of the 20 troops surveyed in the population of Yucatan black howler monkeys at Palenque had more than one adult male (Estrada et al., 2002). During the three-day observation period of Troop 22, the troop was recorded spending an average of only 2.44% of their time travelling and covered a small range of 0.24 hectares. The location of this troop is surrounded by three other troops and a solo male, which could suggest that the limited space in the surrounding area is preventing one of the males from dispersing (Van Belle & Di Fiore, 2022). While the limited number of troops with multiple adult males in the current Northeastern Biological Corridor population could suggest that the population density has not yet reached it carrying capacity, Troop 22 could be an indication that it is closer to reaching this capacity.

The high troop cohesion recorded in this study, 76% of the time within 5 metres of each other, further indicates the normality of the rehabilitated troops' behaviour, indicating that the rehabilitation process has not hindered the individual's ability to maintain troops and social bonds post-release.

4.2.3. Ranging Behaviour

This study estimated the three-day ranges for 20 of the 23 Yucatán black howler monkey troops over the data collection period. As a result, the troops in the Northeastern Biological Corridor had an average three-day range of 7.65 hectares, varying from 0.24 hectares in Troop 22 to 15.27 hectares in Troop 16. The average range estimated in this study is in line with previous studies that have estimated the long-term home ranges of Yucatán black howler monkeys in Belize, for example between 1-4 ha in the Community Baboon Sanctuary (Marsh & Loiselle, 2003) and in Bermudian Landing populations, which range from 10.4-15.8 hectares (Ostro et al.,1999). The highest home range recorded in this study is similar to that of the populations of howler monkeys in Lamanai, whose home ranges average of 15.3 hectares (Gavazzi et al. 2008). However, Troop 17, Troop 20 and Troop 22 are less than the recorded estimated home ranges in howler monkey populations, spending the three-day recording period in a less than one-hectare area. It is important to note that this study period was not long enough to estimate the howler monkeys' home range accurately. For instance, Troop 17 was found to have a range of 0.74 hectares during the study period. This troop spent most of its time resting, with an average of 71.54% over the three days. Consequently, it is not possible to determine whether the troops have a small home range or whether they travel longer distances without more long-term research on each of the recorded troops. In addition to this, previous studies have indicated that home ranges can overlap significantly with neighbouring groups (Gavazzi et al., 2008), which is evident across this study. The results of this study have demonstrated that the rehabilitated population of howler monkeys is capable of maintaining home ranges, however, longer-term studies are necessary to better understand each troop's home range. However, the estimated ranges can be used as a tool to locate the troops identified in this study for future research.

4.3. Assessing Success on a Behavioural Level

4.3.1. Activity Budgets

Within the study period, the troops of howler monkeys' activity budgets were in line with their wild counterparts, in which studies have demonstrated that this species of howler monkeys are inactive for an average of 66.33% of the time, fed for 18.57%, locomoted for 7.49% and social for 3.67% (Pavelka & Knopff, 2004). It is also similar to the howler monkeys in Cockscomb Wildlife Basin, in Belize, in which the translocated howler monkeys spent 61.9% of their time inactive, 9.8% locomoting, 24.4% feeding, 2.3% in social activities, and 1.6% involved in other behaviours (Silver et al., 1998). This indicates that the rehabilitated population are functioning similarly to its wild counterparts in Belize and the species as a whole.

According to a study by Asensio et al. (2022) on Mantled howler monkeys, *Alouatta palliata,* it was observed that play behaviour time in howler monkeys was relatively low. This study on the Northeastern Biological Corridor's population findings aligns with this conclusion, with play behaviour witnessed on average 1.05% of the time, ranging from 0 to 4.88%. During the three-day recording period for each troop, a high percentage of play behaviour was recorded in both Troops 1 and 16. In Troop 1, this play behaviour was witnessed between the juveniles, while in Troop 16, the behaviour was observed between the juveniles and the adult male. Asensio et al. (2022) suggest that adults played more with immature individuals when the immature-adult ratio increased. In the case of Troop 16, one infant was recorded in the troop composition; therefore, on this occasion, this troop of monkeys do not support this statement. The adult and immature play that was witnessed in Troop 16 is considered to play an important role in the socialisation of young individuals (Asensio et al., 2022). In addition to this, research indicates that more time spent foraging on fruits corresponded to more adult-adult play (Asensio et al., 2022). This indicates that play could be a mechanism for resolving conflicts related to contest competition (Asensio et al., 2022). A high level of play behaviour seen between adults could be a future indication of the howler monkeys in the Northeastern Biological Corridor meeting their carrying capacity, causing an increasing inter-troop conflict. However, the study did not test this hypothesis.

4.3.2. Height in the Trees

During previous studies of wild howler monkeys, it was observed that the species are primarily arboreal and typically spend most of their time in the upper and middle canopy (Serio-Silva et al., 2019). Over the course of this current study of the rehabilitated howler monkeys, it was recorded that the population used the top third of the canopy 96.56% of the time, indicating behaviour similar to their wild counterparts.

This finding is particularly important as in the previous assessment of the population in 2015, a troop of howler monkeys was recorded frequently coming down to the ground to feed on Piper, *Piper schiedeanum*, a shrub plant that grows up to 2 meters high and is used as a food source at the rehabilitation centre (Tricone, 2018). While wild howler monkeys have been observed to use ground-level terrain in fragmented forests, this behaviour has been linked to deaths or injuries among non-human primates in certain areas (Hetman et al., 2019). As a result, suggestions were made to minimise or avoid feeding Piper at the rehabilitation centre to reduce the risk of howler monkeys coming to the ground (Tricone, 2018). During this most recent study period, the howler monkeys were not observed in the lower third of the trees or on the ground at all, indicating that implementing these changes in the rehabilitation centre has helped reduce the risk of howler monkeys coming close to the ground.

4.3.3. Feeding Behaviour

Over the study period, the howler monkey population demonstrated their ability to consume a diverse diet. The population was recorded eating 38 different species, with 50% of their diet consisted of 3 species of plant, Fig, *Ficus spp*., Ramon, *Brosimum alicastrum* and Cecropia, *Cecropia peltata*. This feeding behaviour is similar to that of populations of wild howler monkeys, of which it is recorded that the species they concentrate a high percentage of feeding time on a low number of species (Dias & Rangel-Negrin, 2014; Pavelka & Knopff, 2004). As noted earlier, in a previous study conducted by Fanigliulo (2005), concerns were raised about the low abundance of *Ficus* trees in the release site. This current study shows that despite the lower abundance of Ficus compared to other study sites, the monkey population was still able to maintain them as a significant part of their diet, accounting for 19.45% of their food intake.

As a result, this study highlights the importance of these three feeding trees to the population of howler monkeys in the Northeastern Biological Corridor.

One substantial difference between the rehabilitated population of howlers and other researched populations is the increased amount of fruit in their diet; with an average of 56% of the released population's diet being fruit-based. This is higher than other howler monkey populations; for example, a review of the Yucatán black howler monkey's diet by Dias & Rangel-Negrin (2014) stated that, on average, the species ate fruit for 38% of the time, leaves for 50.4%, 8.3% Flowers and 5% other food items. While some studies show a slightly higher proportion of fruit in the Yucatán black howler monkey diet, this has not increased higher than 42% (Pavelka & Knopff, 2004; Silver et al., 1998). As a result, it should be investigated whether the difference is due to natural variations in vegetation across the howler monkeys' habitats and the potential increase in preferred fruiting trees in the study area. Additionally, this variation may be a result of the rehabilitation centre feeding the individuals undergoing rehabilitation a high-fruit diet, however, there is little information about this pattern in the broader literature and should therefore be explored across the field.

While the species is described as folivorous, studies show that howler monkeys prefer eating fruits when they are available, and the *Alouatta pigra* has been described as being as frugivorous as possible and as florivorous as necessary (Dias & Rangel-Negrin, 2014; Pavelka & Knopff, 2004). During peak fruit season, Yucatán black howler monkeys have been recorded spending up to 95% of their feeding time-consuming fruits for two-week periods and can be seen consuming no leaves for three up to consecutive days (Dias & Rangel-Negrin, 2014). While Howler monkeys' ability to adapt their diet and adjust feeding behaviours indicates that they can adapt to various ecological challenges (Behie & Pavelka, 2015); the change in population density and diet of the *Alouatta pigra* after Hurricane Iris, when fruit was unavailable for over one year, suggests that fruit is crucial towards population growth and stability (Pavelka & Behie, 2005). As a result, feeding behaviour is considered to be dependent on food availability and nutrient requirements and can vary individually (Behie & Pavelka, 2015). Therefore, the limited understanding of the importance of frugivory in the howler monkey's diet continues to be a challenge during research (Dias & Rangel-Negrin, 2014). As a result, while it is possible to determine whether the fruit intake at the rehabilitation centre influences the increased amount of fruit in the rehabilitated primates, the variety of diets across howler monkey populations indicates that the high fruit consumption is not a concern to the health of the population in the Northeastern Biological Corridor.

4.4. Challenges

4.4.1. Human Conflict

Any conservation project can only be considered successful with consideration for the human component (Marchini et al., 2019). The need to conserve species while limiting the impact on the local human population is an ethical dilemma within the conservation field (Hill, 2002). In the case of the howler monkey rehabilitation project in Belize, the protected area is managed in collaboration with Wildtracks, Shipstern Nature Reserve and the local Fireburn community. While this agreement has been successful in many ways, illegal selective logging is present both in and on the edge of the protected area. This has been recorded in other protected areas; for example, in the region of Los Tuxtlas, logging is prohibited, yet selective logging is still standard in the local community (Cristóbal-Azkarate & Dunn, 2013). Logging is a vital financial resource for the local community and conservation efforts should focus on the coexistence between the human and primate populations (Marchini et al., 2019). However, over the study period a large feeding tree, *Simarouba amara*, was logged in Troop 11's known range. As a result of this, I recommend using this botanical inventory as evidence of essential feeding trees in areas and finding alternatives for logging trees.

In 2018, the agricultural land in Fireburn Nature Reserve was expanded, this expansion of the farmland occurred directly through a troop of howler monkeys (Clyde's troops) home range (Tricone, 2018). This area was a high food source for the howler monkeys, with many Fig trees located in this area. While ethically, local communities should have greater control over natural resources (Hill, 2002), the long-term impact of changes should be monitored, and additional or alternative sources of more sustainable incomes should be considered, for example, beekeeping (Agera, 2011). Despite the changes in agriculture, Clyde was seen alive during this study, demonstrating the rehabilitated howler monkey's ability to adapt, similarly to wild population.

4.5. Long-term Implications of Reintroduction

Plant-animal interactions play a crucial role in ecosystem restoration, success, and biodiversity (Genes & Dirzo, 2022). Howler monkeys, for instance, contribute to forest regeneration by consuming larger seeded fruit, which typically are not dispersed by birds or bats; fulfilling the niche of the dispersal of larger seeds across the forest (Genes et al., 2018; González-Di Pierro et al., 2021). In addition to this, unlike many other neotropical mammals, howler monkeys have demonstrated a high resilience to disturbance by maintaining populations in disturbed habitats (González-Di Pierro et al., 2021). Therefore, the species can play a pivotal role in the regeneration of local plant species in disturbed habitats. (González-Di Pierro et al., 2021). Fireburn Nature Reserve and the surrounding areas contain a variety of habitats due to both human activity and natural weather patterns, most of which are in different stages of regeneration (Maskell et al., 2010). The impact of a series of hurricanes that occurred from the 1940s onwards is particularly notable, which resulted in the majority of the forest being less than 65 years old (Friesner, 1993; Maskell et al., 2010; Wildtracks, 2022).

A study conducted in Rio de Janeiro, Brazil, by Genes et al. (2018) showed that reintroducing howler monkeys could help reinstate ecological links and improve ecological processes in their reintroduced areas. This study highlights the importance of seed dispersal from howler monkeys. However, this study looked at the secondary effects of seed dispersal with dung beetles, which do not occur in Belize (Genes et al., 2018). Nevertheless, a study by González-Di Pierro et al. (2021) showed that seeds ingested by the Yucatán Black howler monkey germinated faster than seeds ingested by other primates. This faster germination benefits the seeds by reducing their predation risk and increasing the probability of the seedling establishing in the forest, highlighting the importance of howler monkeys as seed dispersers in small forest fragments and their contribution to forest restoration (González-Di Pierro et al., 2021).

These studies indicate that the reintroduction of howler monkeys in Fireburn Nature Reserve and the Northeastern Biological Corridor will help restore the ecological links in the area, further increasing the forest’s ability to regenerate. This has been seen in the reintroduction of howler monkeys in the Cockscomb basin in Belize (Horwich et al., 1993), in which the reintroduction project focused on the conservation of the howler monkeys and forest regeneration. A recent study of this area indicates that tree composition is likely to be returning (Sliver & Ostro, 2017). However, additional research is necessary to understand the broader conservation impacts of rehabilitation on the environment, particularly the howler monkeys' impact on plant species in the Northeastern Biological Corridor.

Chapter 5: Conclusions and Recommendations

The results of this study indicate that the rehabilitated and released howler monkeys collectively contribute to a healthy and established population in Fireburn Nature Reserve, Katalosh Archaeological Reserve.

Using Cope et al.'s (2022) definition of success for rehabilitation and release as an outline, rehabilitation projects will be considered successful on an individual level if the individual recovers from their initial injuries, is released back into the wild, survives in the wild long-term and successfully reproduces in the wild. The success of Wildtracks howler monkeys on an individual level was demonstrated in the 2015 study of the smaller released population, in which 75% of the individuals were found and identified five years post-release (Tricone, 2018). While this was more difficult to assess during this current study due to identification issues, identifying individuals such as Clyde further indicates long-term success on an individual level.

The main focus of this study was on assessing the rehabilitation programme's success at a population level. The rehabilitation project is considered successful as populations remain where the rehabilitated animals were released; the released animals have maintained individual territories and contribute to a reproductive population (Cope et al., 2022). This report has demonstrated success on this level, finding 118 howler monkeys in the release area and demonstrating the persistence of the population. The population growth from 78 individuals to 118 indicates the successful growth of the population, and the high level of immature individuals further indicates the successful reproduction within the released population. The study focused on 23 howler monkey troops; each troop was tracked for three days, and the troops demonstrated their ability to behave similarly to their wild counterparts, with three-day ranges comparable to other studies on howler monkey populations' home ranges. However, more long-term studies on each of the troops to estimate accurate home ranges for the population.

This study aimed to establish a thorough monitoring program of the rehabilitated and released population of Yucatán black howler monkeys in the Northeastern Biological Corridor by including more detailed data on the population's demographics, behaviour and ecology. However, continued studies are necessary to explore the behaviour of the released troops as they age and the long-term impacts of rehabilitation on the species. Therefore, this study can be used as a baseline for further research into the released population. This population of rehabilitated and released howler monkeys presents a unique scenario. Before the reintroductions, no howler monkeys inhabited the area, making assessing potential impacts on a naturally occurring population unnecessary. Such an assessment in the future is worth considering if the release site continues to be used. For instance, exploring whether the continued introduction of rehabilitated individuals would push the current population beyond the habitat's carrying capacity, potentially introduce deleterious genetic alleles or diseases to the current population, or intensify intraspecific competition (Cope et al., 2022).

This project incorporated an assessment of the released population's behaviour, ensuring that the rehabilitation process does not impact their ability to perform natural behaviours. The study concluded that the howler monkeys in this population behave similarly to their wild counterparts. However, the research indicates that this population of howler monkeys consumes more fruit than other research on the species. Further research is needed to determine whether this difference in diet results from a high-fruit diet at the rehabilitation centre or a higher fruit availability in the Northeastern Biological Corridor.

While this study investigated the success of rehabilitating and reintroducing howler monkeys into their natural habitat in the Northeastern Biological Corridor using Cope et al. (2022) as a baseline for this assessment. There is currently no widely accepted criteria for assessing the success of rehabilitation and reintroduction in primates (Hernandez, 2019; Cope et al., 2022). This lack of consistency makes comparing data collected in this study to those of other primate rehabilitation projects challenging. Therefore, a standard set of criteria for success would be helpful, enabling structured comparisons across rehabilitation centres (Fischer & Lindenmayer, 2000).

In addition to this, the study demonstrates that the success of rehabilitation and reintroduction programs depends on the context and species-specific protocols, with Yucatán black howler monkeys as the focus of this study. While the importance of developing species-specific, evidence-based, and context-specific protocols for rehabilitation programs to ensure their success and the species' long-term survival has been emphasised previously (Cope et al., 2022; Goldenberg et al., 2022); this has not yet been completed for the Yucatan black howler monkeys. The success of the rehabilitated and released population suggests that sharing the protocols used by Wildtracks, the organisation involved in this study, could increase the success of other howler monkey rehabilitation projects and improve outcomes for the wildlife involved (Goldenberg et al., 2022).

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Appendices

Appendix A: *The activity budgets for the troops of Yucatán black howler monkeys studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize.*

Troop ID	Activity Budget (%)								Total Scans	Number of "Out of Sight"
	Rest	Travel	Feed	Play	Howl	Groom	Drink	Out of Sight		
T1	49.59	8.94	33.33	4.88	0.81	0.00	0.00	2.44	123	3
T2	56.91	11.38	26.83	0.00	2.44	0.00	0.00	2.44	123	3
T3	56.10	11.38	27.64	0.81	0.00	0.00	0.00	4.07	123	5
T4	60.16	8.13	31.71	0.00	0.00	0.00	0.00	0.00	123	0
T5	39.84	18.70	31.71	0.00	0.00	0.00	0.00	9.76	123	12
T6	51.22	13.01	27.64	0.00	0.00	0.00	0.00	8.13	123	10
T7	36.59	8.13	30.89	1.63	0.00	0.00	0.00	22.76	123	28
T9	50.41	4.88	36.59	0.00	0.00	0.81	0.00	7.32	123	9
T10	40.65	9.76	22.76	0.00	3.25	0.00	0.00	23.58	123	29
T11	56.91	10.57	18.70	0.00	0.00	0.00	0.81	13.01	123	16
T12	56.10	4.88	28.46	0.81	0.00	0.00	0.00	9.76	123	12
T13	66.67	6.50	13.82	0.81	0.00	0.00	0.00	12.20	123	15
T14	53.66	4.88	14.63	0.00	0.00	0.81	0.00	26.02	123	32
SM1	54.47	4.07	23.58	0.00	0.00	0.00	0.00	17.89	123	22
T16	63.41	8.13	24.39	4.07	0.00	0.00	0.00	0.00	123	0
T17	71.54	4.88	19.51	0.00	4.07	0.00	0.00	0.00	123	0
T18	59.35	3.25	22.76	2.44	0.81	0.00	0.00	11.38	123	14
T20	47.15	3.25	26.02	1.63	0.00	0.00	0.00	21.95	123	27
SM2	52.85	13.82	20.33	0.00	0.00	0.00	0.00	13.01	123	16
T22	42.28	2.44	34.15	0.00	0.00	0.00	0.00	21.14	123	26
T23	52.03	9.76	24.39	4.88	0.00	0.00	0.00	8.94	123	11
Average	**53.23**	**8.13**	**25.71**	**1.05**	**0.54**	**0.08**	**0.04**	**11.23**	***123***	***13.81***

Appendix B: *This table depicts the time spent at different heights of trees for the troops of Yucatán black howler monkeys studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize. "Top" is the top 1/3 of the tree, "Mid" is the mid 1/3 of the tree, and "Out of Sight" is when they were not in sight at the time of recording.*

Troop ID	Height in Canopy %			Number of Scans Included Data	Number of "Out of Sight" Scans
	Top	Mid	Low		
T1	83.33	16.67	0.00	120	3
T2	95.00	5.00	0.00	120	3
T3	96.61	3.39	0.00	118	5
T4	99.19	0.81	0.00	123	0
T5	96.40	3.60	0.00	111	12
T6	98.23	1.77	0.00	113	10
T7	96.84	3.16	0.00	95	28
T9	100.00	0.00	0.00	114	9
T10	100.00	0.00	0.00	94	29
T11	100.00	0.00	0.00	107	16
T12	100.00	0.00	0.00	111	12
T13	100.00	0.00	0.00	108	15
T14	100.00	0.00	0.00	91	32
SM1	67.33	32.67	0.00	101	22
T16	95.93	4.07	0.00	123	0
T17	99.19	0.81	0.00	123	0
T18	100.00	0.00	0.00	109	14
T20	100.00	0.00	0.00	96	27
SM2	100.00	0.00	0.00	107	16
T22	100.00	0.00	0.00	97	26
T23	100.00	0.00	0.00	112	11
Average	**96.56**	**3.46**	**0.00**	**109.737**	**13.81**

Appendix C: *The cohesion of Yucatán black howler monkeys' troops studied between November 2022 and October 2023 in the Northeastern Biological Corridor of Belize. "Together" was recorded when the troop members were within 5 meters of the closest individual, "Apart" was recorded when some of the troop members were out of sight or further than 5 metres from the closest individual, and "out of sight" was recorded when the troop was out of sight at the time of recording.*

Troop ID	Troop Cohesion %			Total Scans	Number of "Out of Sight" Scans
	Together	Apart	Out of Sight		
T1	73.98	23.58	2.44	123	3
T2	80.49	17.07	2.44	123	3
T3	49.59	46.34	4.07	123	5
T4	72.36	27.64	0.00	123	0
T5	74.80	15.45	9.76	123	12
T6	91.06	0.81	8.13	123	10
T7	71.54	5.69	22.76	123	28
T9	56.10	36.59	7.32	123	9
T10	61.79	14.63	23.58	123	29
T11	85.37	1.63	13.01	123	16
T12	90.24	0.00	9.76	123	12
T13	87.80	0.00	12.20	123	15
T14	54.47	19.51	26.02	123	32
SM1	x	x	x	123	22
T16	95.12	4.88	0.00	123	0
T17	99.19	0.81	0.00	123	0
T18	88.62	0.00	11.38	123	14
T20	76.42	1.63	21.95	123	27
SM2	x	x	x	123	16
T22	69.11	9.76	21.14	123	26
T23	67.48	23.58	8.94	123	11
Average	**76.08**	**13.14**	**10.78**	**123**	**13.81**

Appendix D: *The percentage of time Yucatán black howler monkeys (Alouatta pigra) spent eating different parts of the plant in the Northeastern Biological Corridor of Belize between November 2022 and October 2023*

Troop ID	Troop Diet Composition, in reference to Parts of Plants (%)					
	Mature Leaves	Young Leaves	Fruit	Flower	Stem	Petiole
T1	39.02	0.00	48.78	0.00	12.20	0.00
T2	39.39	6.06	45.45	0.00	9.09	0.00
T3	41.18	2.94	50.00	0.00	5.88	0.00
T4	12.82	0.00	87.18	0.00	0.00	0.00
T5	35.90	5.13	58.97	0.00	0.00	0.00
T6	25.71	5.71	62.86	0.00	5.71	0.00
T7	35.14	5.41	51.35	0.00	8.11	0.00
T9	45.45	4.55	29.55	0.00	20.45	0.00
T10	32.14	3.57	64.29	0.00	0.00	0.00
T11	27.27	0.00	63.64	0.00	9.09	0.00
T12	28.57	20.00	51.43	0.00	0.00	0.00
T13	0.00	16.67	72.22	5.56	5.56	0.00
T14	50.00	27.78	16.67	0.00	5.56	0.00
SM1	34.62	3.85	57.69	0.00	3.85	0.00
T16	13.33	0.00	76.67	6.67	3.33	0.00
T17	39.13	0.00	56.52	0.00	4.35	0.00
T18	32.14	7.14	57.14	0.00	3.57	0.00
T20	16.13	12.90	70.97	0.00	0.00	0.00
SM2	24.00	32.00	36.00	8.00	0.00	0.00
T22	11.90	26.19	61.90	0.00	0.00	0.00
T23	10.00	30.00	53.33	0.00	6.67	0.00
Average	28.57	9.42	56.08	0.76	5.17	0.00

Appendix E: *The Home Range Estimation for the Individual Troops*

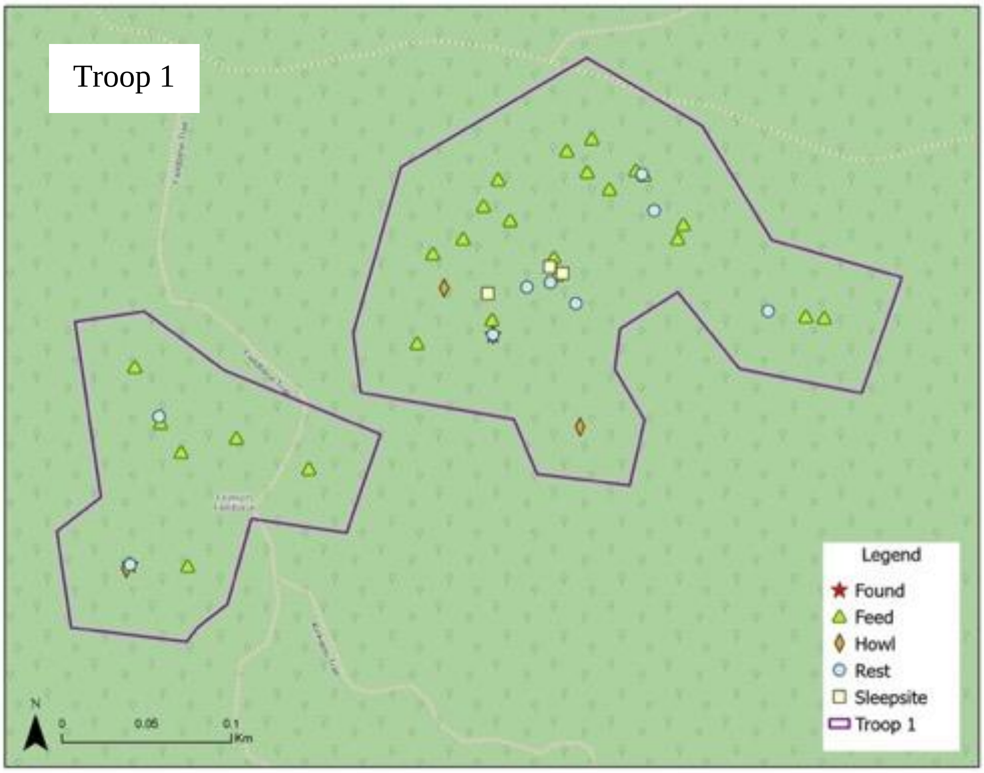

Figure 18 -Polygons developed to display the 3-day range for Troop 1, highlighting points of key behaviours presented over the study period.

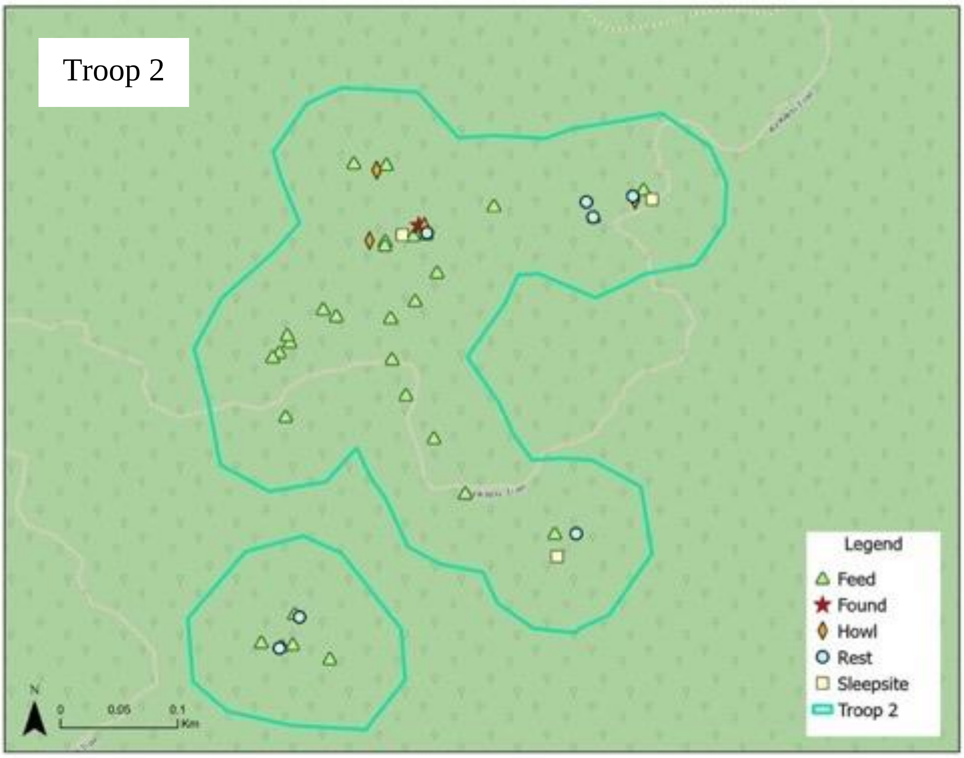

Figure 19 - Polygons developed to display the 3-day range for Troop 2, highlighting points of key behaviours presented over the study period.

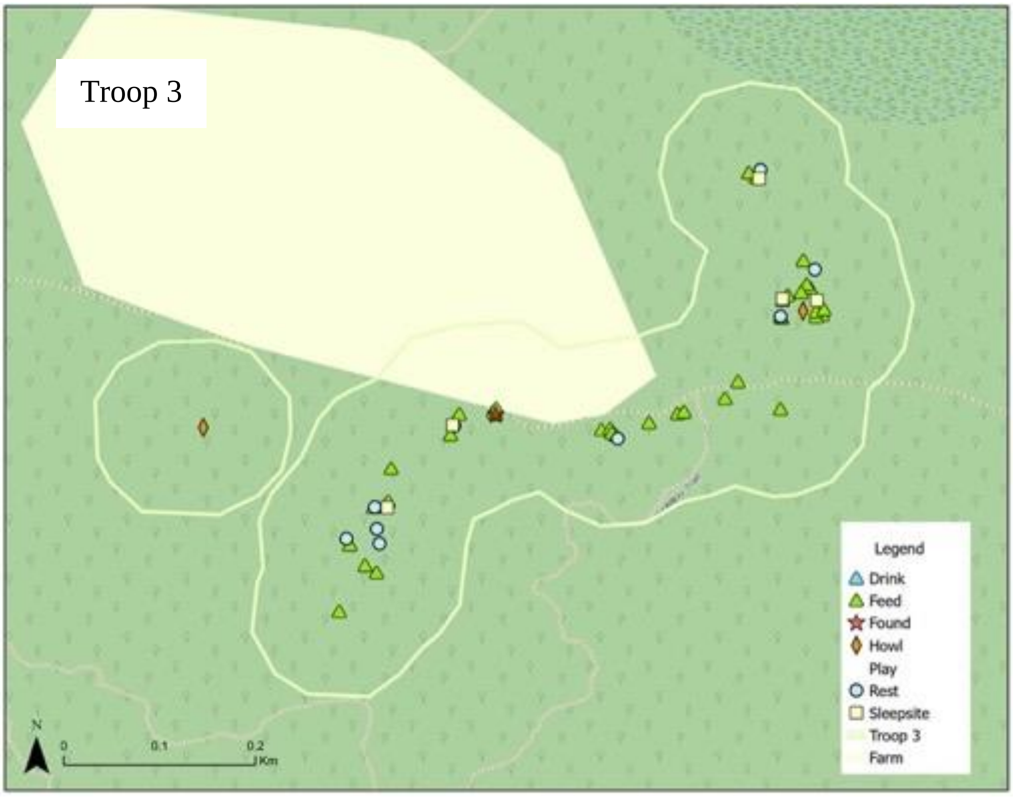

Figure 20 - Polygons developed to display the 3-day range for Troop 3, highlighting points of key behaviours presented over the study period.

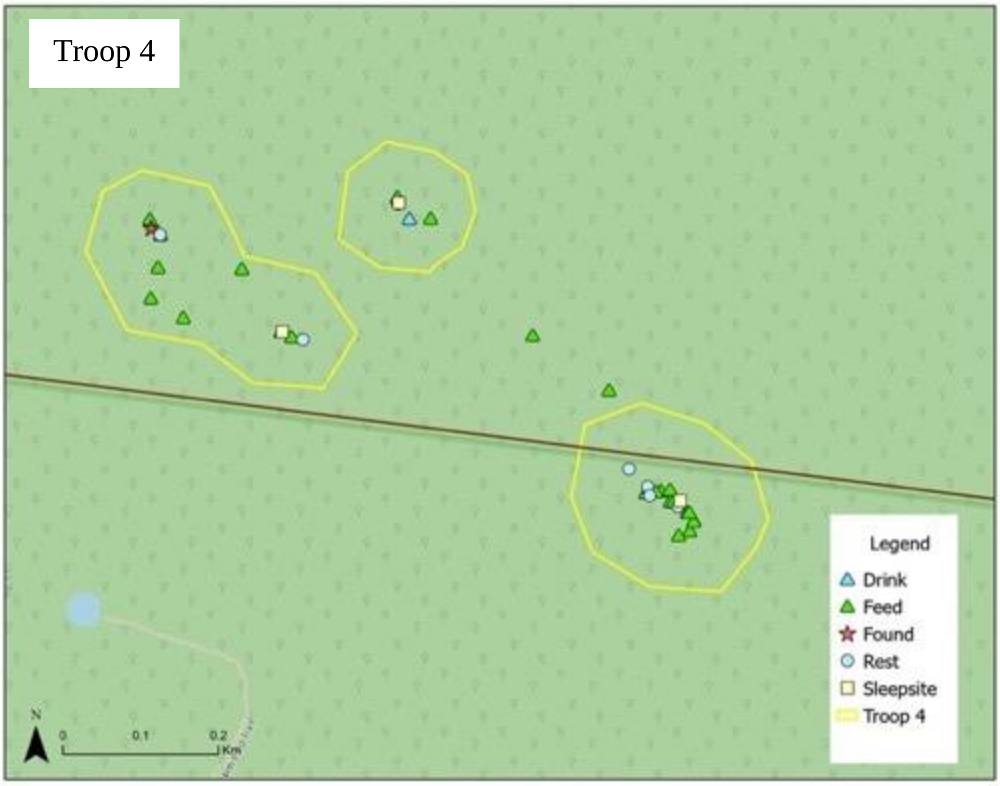

Figure 21 - Polygons developed to display the 3-day range for Troop 4, highlighting points of key behaviours presented over the study period.

Figure 22 - Polygons developed to display the 3-day range for Troop 5, highlighting points of key behaviours presented over the study period.

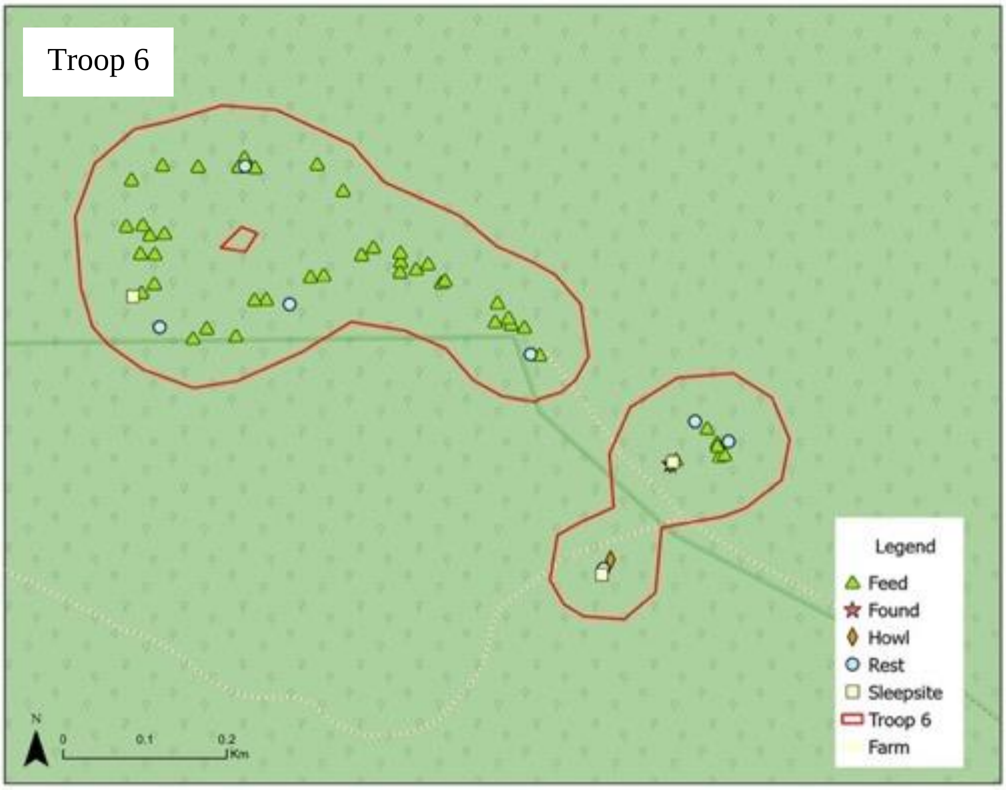

Figure 23 - Polygons developed to display the 3-day range for Troop 6, highlighting points of key behaviours presented over the study period.

Figure 24 - Polygons developed to display the 3-day range for Troop 7, highlighting points of key behaviours presented over the study period.

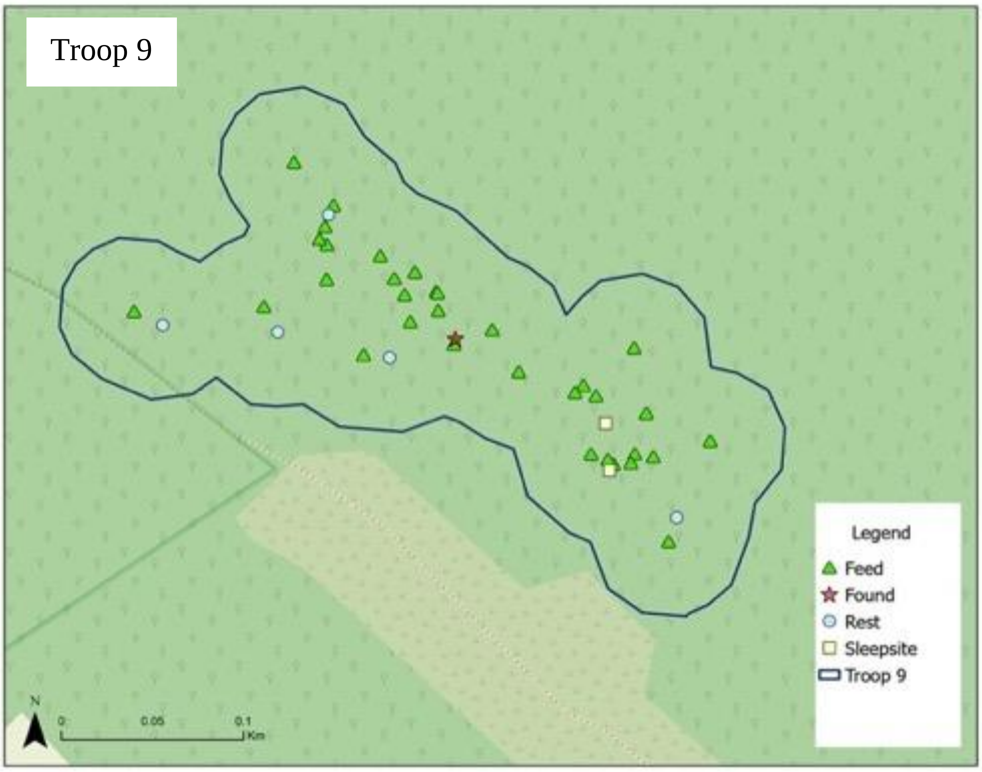

Figure 25- Polygons developed to display the 3-day range for Troop 9, highlighting points of key behaviours presented over the study period.

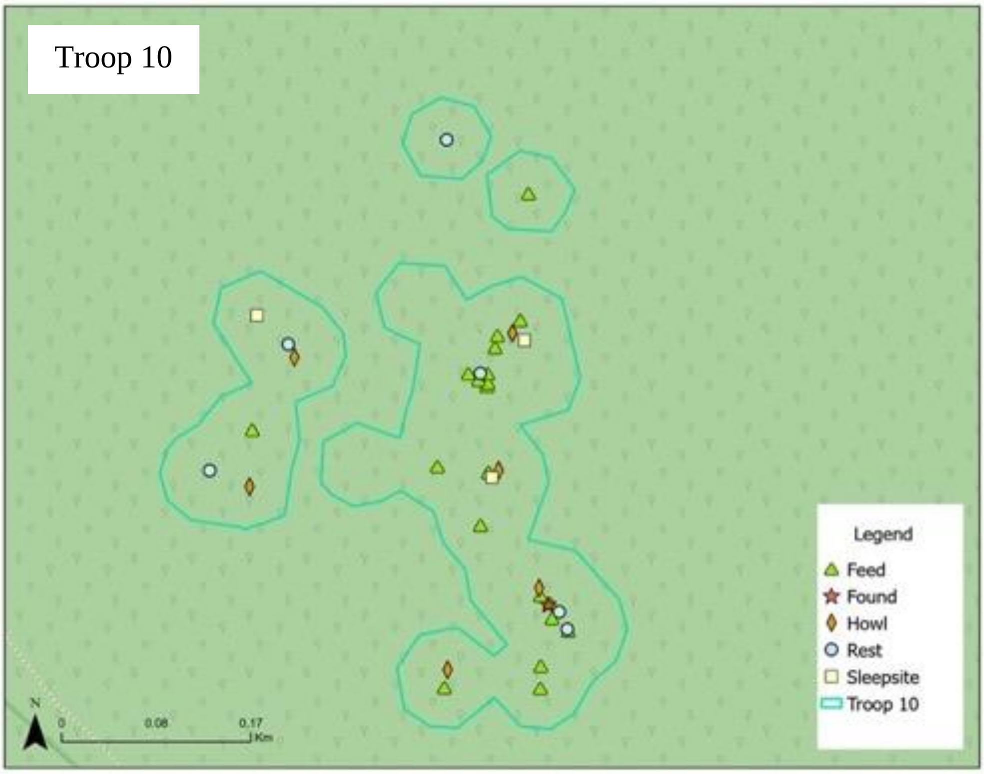

Figure 26 - Polygons developed to display the 3-day range for Troop 10, highlighting points of key behaviours presented over the study period.

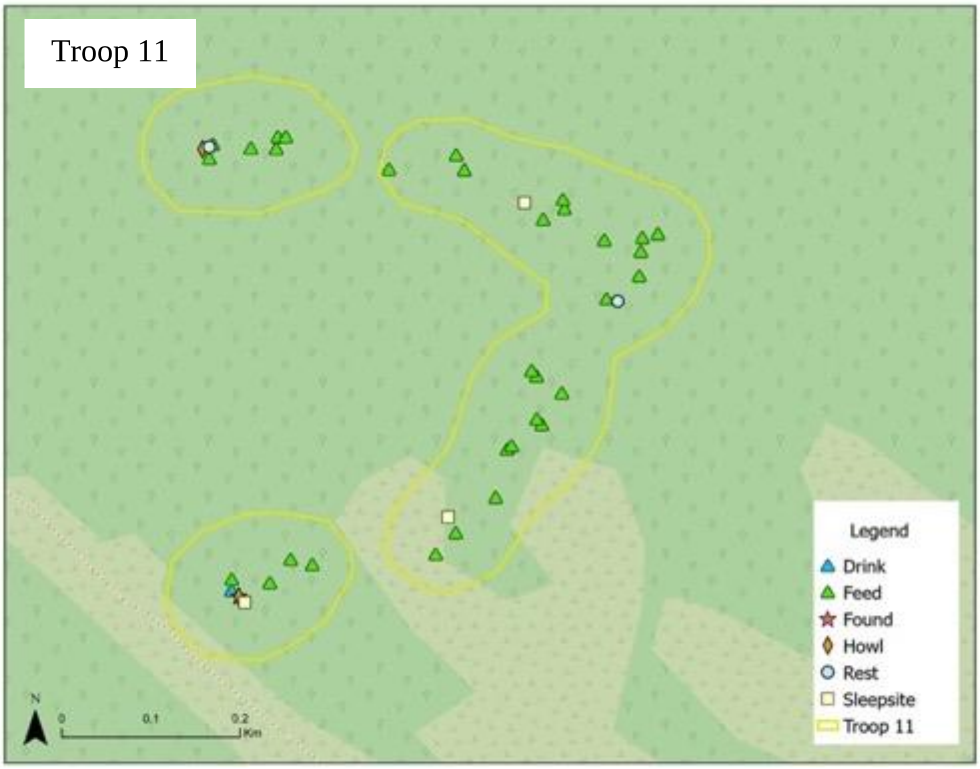

Figure 27 - Polygons developed to display the 3-day range for Troop 11, highlighting points of key behaviours presented over the study period.

Figure 28 - Polygons developed to display the 3-day range for Troop 12, highlighting points of key behaviours presented over the study period.

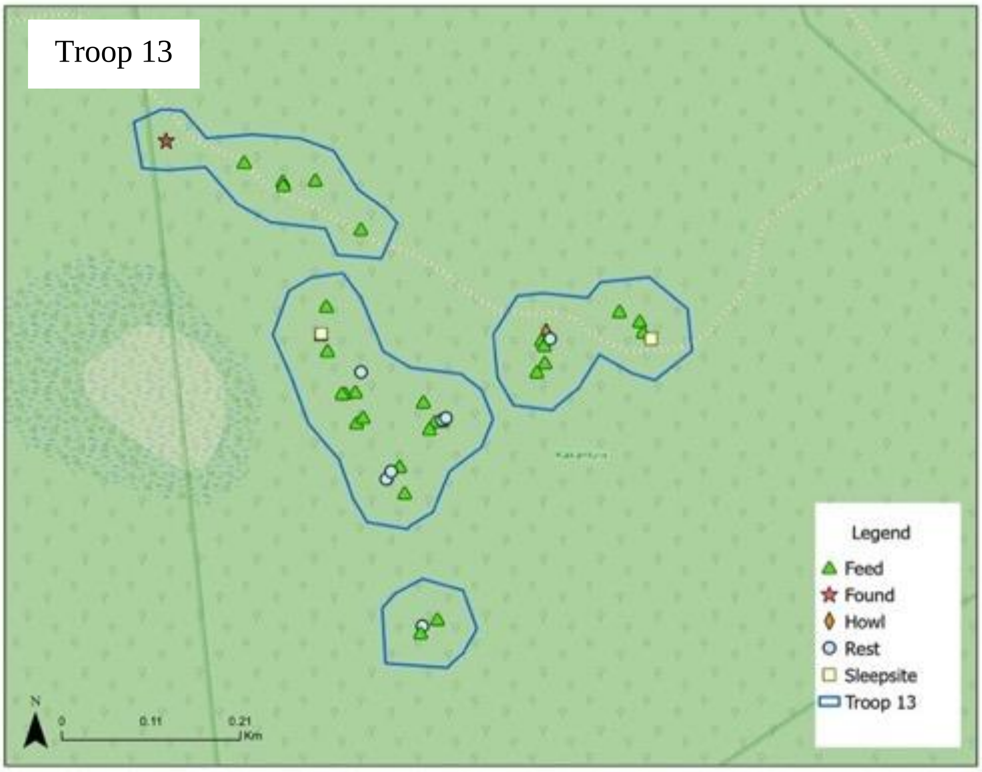

Figure 29 - Polygons developed to display the 3-day range for Troop 13, highlighting points of key behaviours presented over the study period.

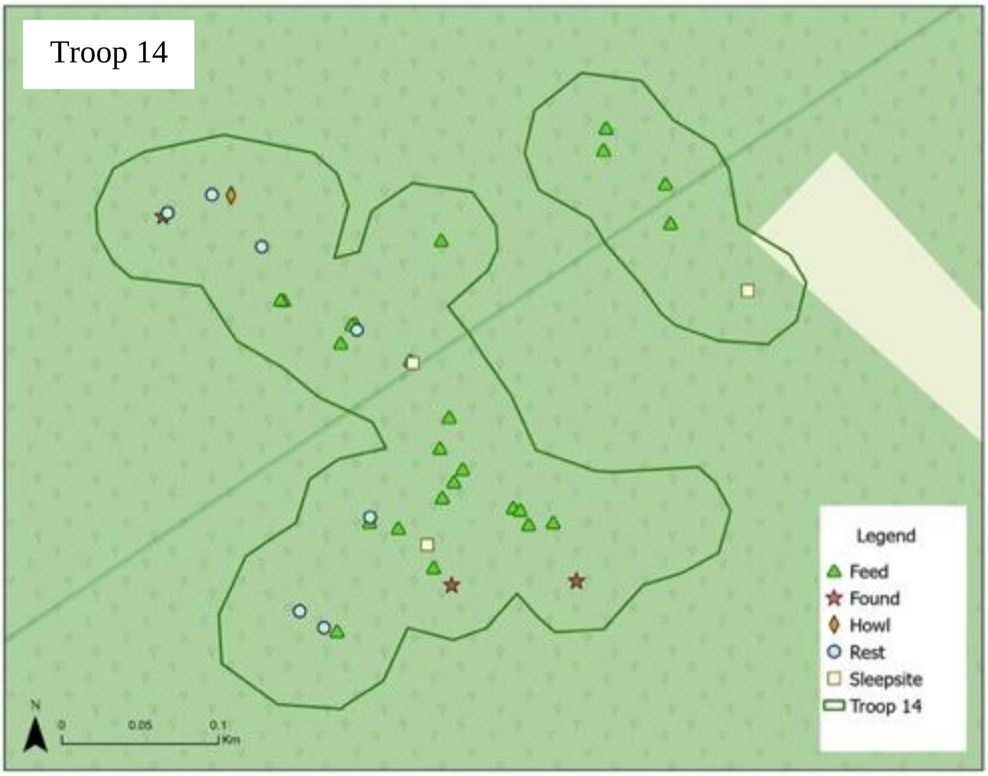

Figure 30 - Polygons developed to display the 3-day range for Troop 14, highlighting points of key behaviours presented over the study period.

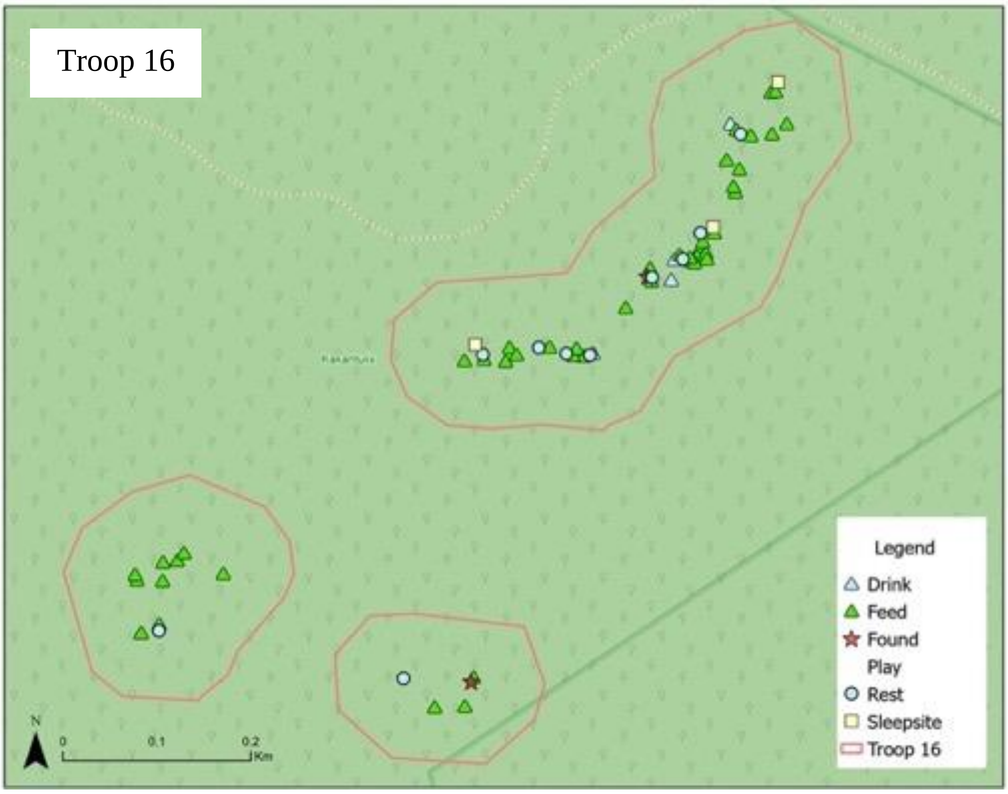

Figure 31- Polygons developed to display the 3-day range for Troop 16, highlighting points of key behaviours presented over the study period.

Figure 32 - Polygons developed to display the 3-day range for Troop 17, highlighting points of key behaviours presented over the study period.

Figure 33 - Polygons developed to display the 3-day range for Troop 18, highlighting points of key behaviours presented over the study period.

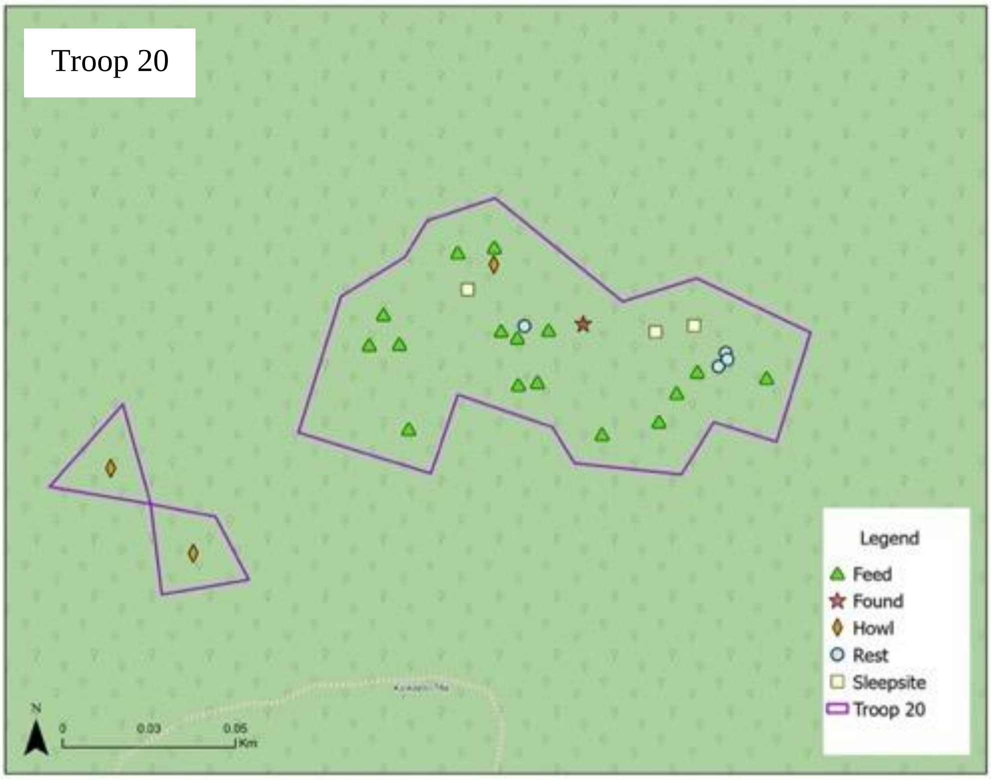

Figure 34- Polygons developed to display the 3-day range for Troop 20, highlighting points of key behaviours presented over the study period.

Figure 35 - Polygons developed to display the 3-day range for Troop 22, highlighting points of key behaviours presented over the study period.

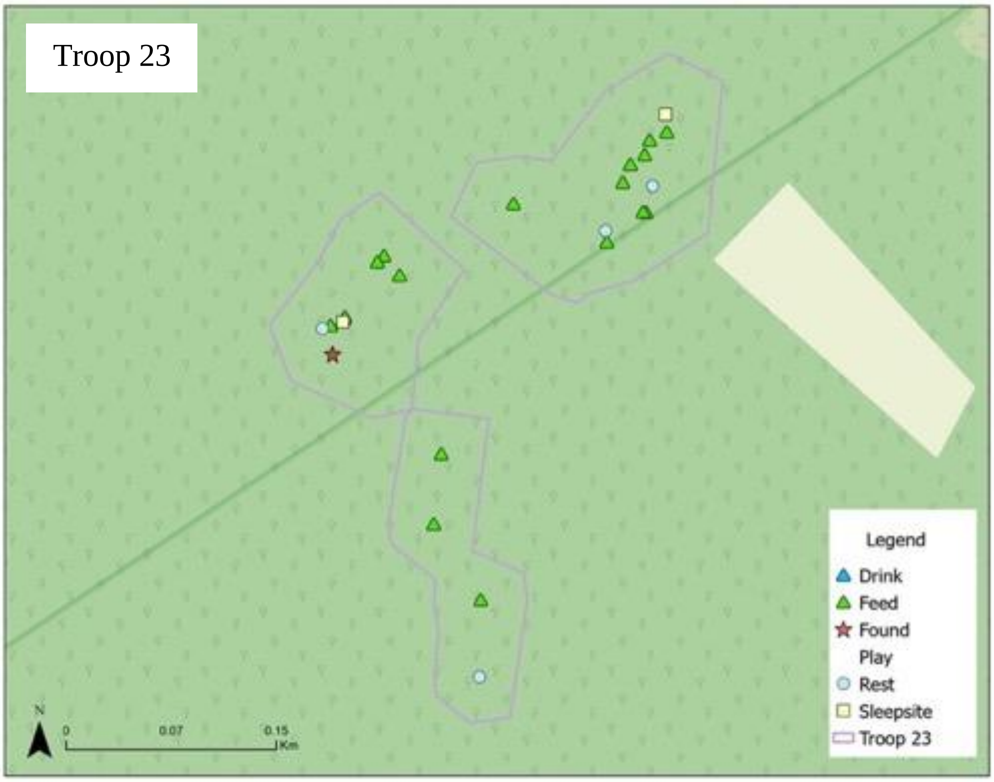

Figure 36 - Polygons developed to display the 3-day range for Troop 23, highlighting points of key behaviours presented over the study period.

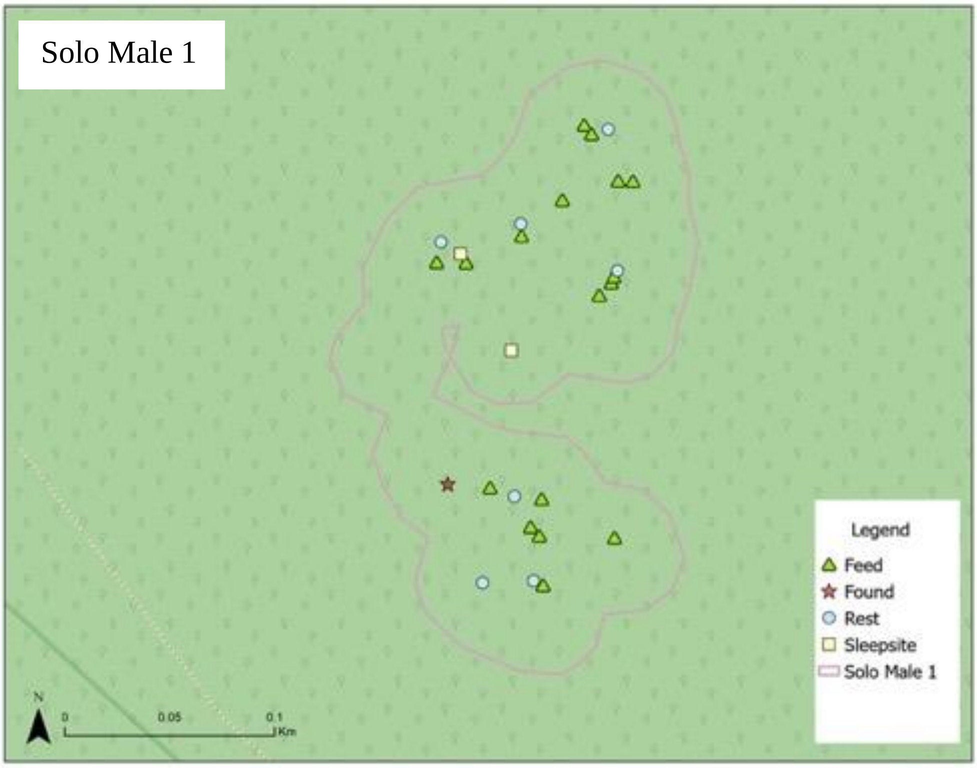

Figure 37 - Polygons developed to display the 3-day range for Solo Male 1, highlighting points of key behaviours presented over the study period.

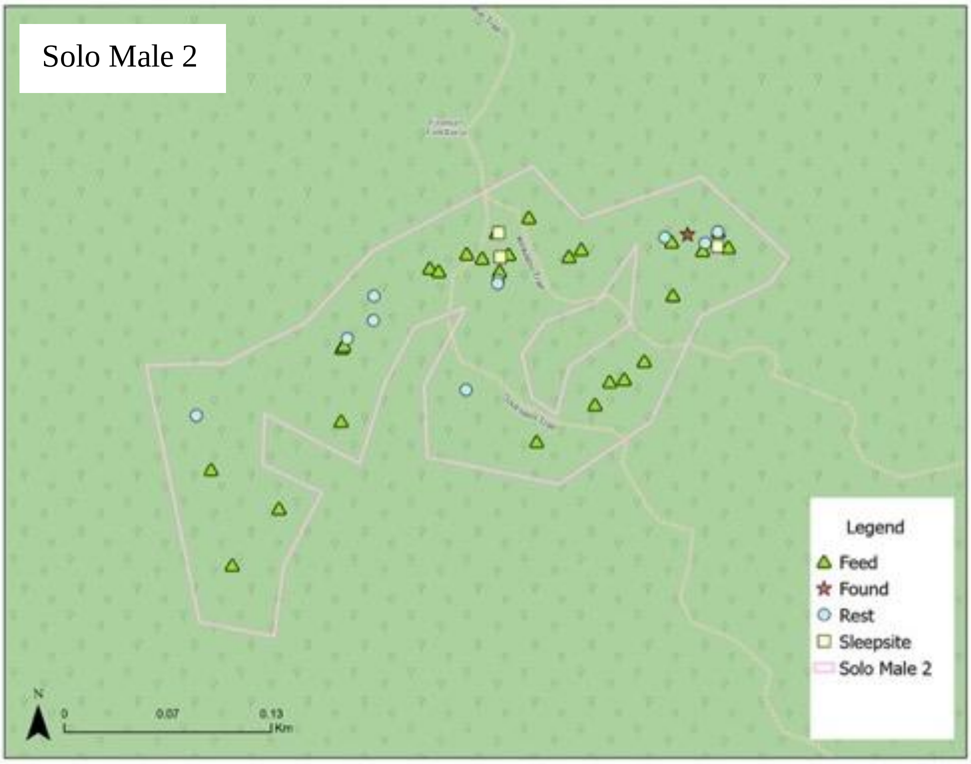

Figure 38- Polygons developed to display the 3-day range for Solo Male 2, highlighting points of key behaviours presented over the study period

Appendix F: *Identification Key for the Howler Monkeys Located During the Study Period (See the page below)*

HOWLER MONKEYS RECORDED AND PHOTOGRAPHED IN THE NORTHEASTERN BIOLOGICAL CORRIDOR

NOVEMBER 2022 - OCTOBER 2023

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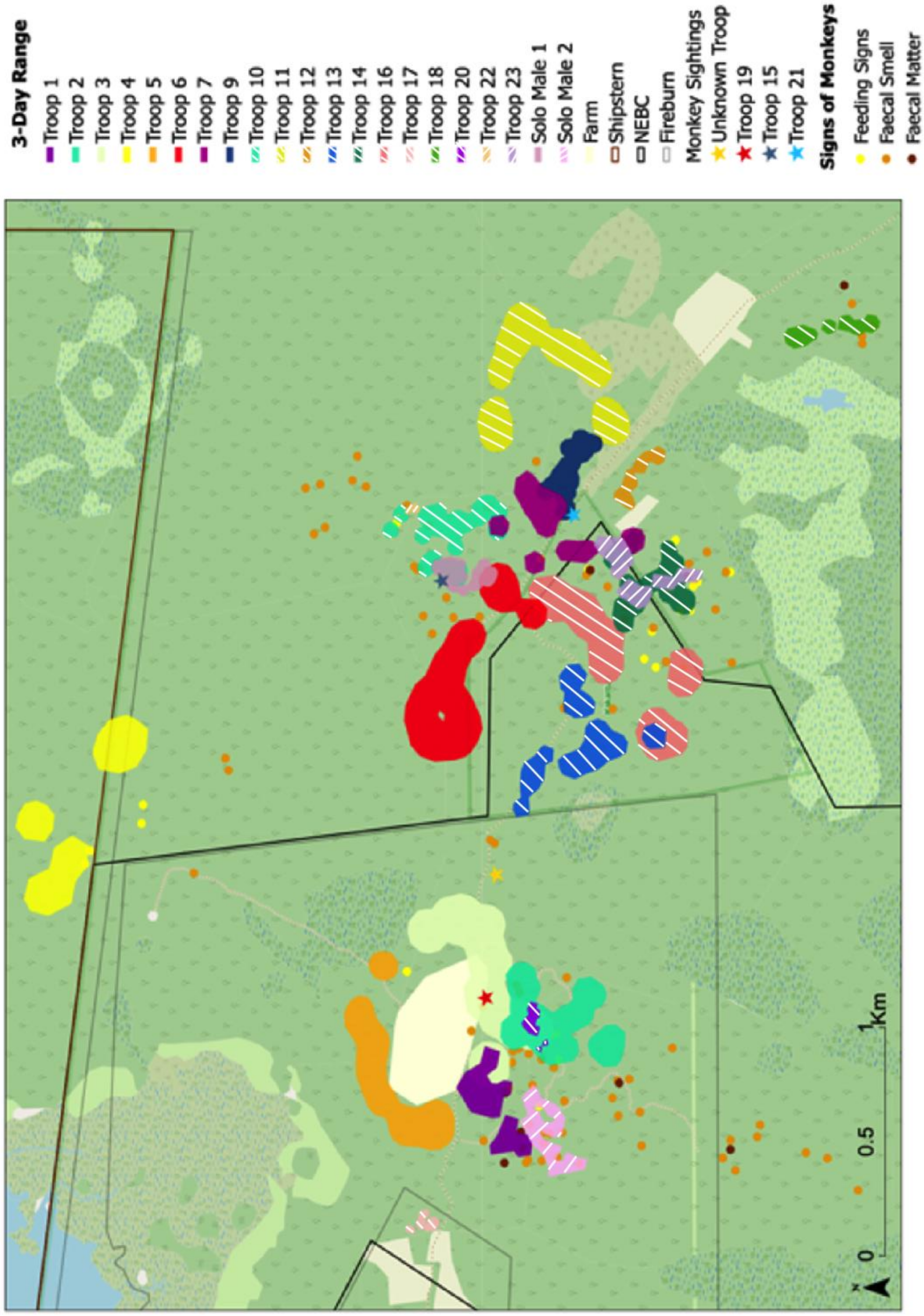
MAP OF HOWLER MONKEYS FOUND:



DESCRIPTIONS FOR AGE CATEGORY:

CATEGORY	STAGE	AGE	DESCRIPTION
INFANT	1	0-3 months	• Carried ventrally by mother. • Attempts to explore surroundings but will not let go of mother. • Only nursing, no solid foods
	2	3-9 months	• Carried dorsally by mother. • Explores nearby surrounding when the mother is resting but remains close. • Mainly nursing, but will eat some solid foods
	3	9-12 months	• Carried dorsally by mother for long or difficult distances, follows mother independently for shorter periods. • Rests with mother • Still nurses but increasingly eating more solid foods
JUVENILE	1	1 -1.5 years	• Males sex organs are small, females have long thin clitoris and thin vulvar lips • Significantly smaller body size than adults • Rests with mother • Independent movements but still follows mother. • Some suckling still seen
	2	1.5 -2 years	• No longer nursing. • Larger than stage 1 juveniles • Independent movements • May rest near mother
	3	2-2.5 years	• Typical emigration stage • Slightly smaller than sub-adults • Independent • Mother not obvious
SUB ADULT		2.5-5 years	**Male:** • Younger-looking faces than adult males but their beard is starting to develop. • Similar size to adult females **Female:** • Body size is slightly smaller than adult female. • Clitoris is shorter than juveniles, vulvar lips thin
ADULT		5+ years	**Male** • Larger than females • beard • Typically, only one per troop **Female** • clitoris hardly noticeable, larger vulvar lips • Signs of nursing/pregnancy/with infant

TOTAL MONKEYS IN EACH TROOP:

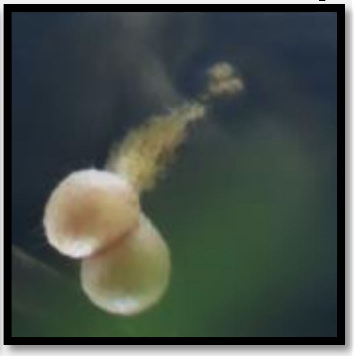
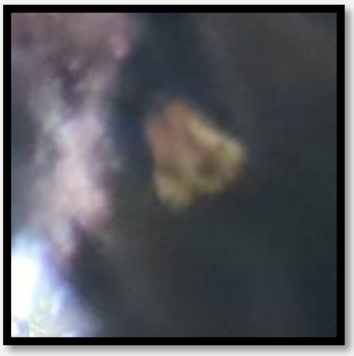
Age	Adult		Sub Adult		Juvenile							Infant							Troop Size
					Stage 3			Stage 2		Stage 1		Stage 3		Stage 2		Stage 1			
Sex	**M**	**F**	**M**	**F**	**M**	**F**	**UN**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**UN**	
Troop ID																			
T1	1	3							2		2						1	1	10
T2	1	2							2	1				1					7
T3/T19*	2	3	3			1			1		1				1				12
T4	1	1																	2
T5	1	2											1						4
T6	1	2									1	1							5
T7	1	2											2						5
T9	1	2				1			1	1				1					7
T10	1	2	1													1			5
T11	1	3				1									2				7
T12	1	2			1										1	1			6
T13	1	1		1															3
T14/T23*	1	2	1				1	2	2					2					11
SM1	1																		1
T16	1	2			1								1						5
T17	1	1	1																3
T18	1	1			1			1				1							5
T20	2	2				2		1				1							8
T21	1	3						1				2							7
SM2	1																		1
T22	1	2										1							4
Total Sex	23	38	6	1	3	5	1	5	8	2	4	6	4	4	4	2	1	1	
Total Age	**61**		**7**		**9**			**13**		**6**		**10**		**8**		**4**			
Total	**118**																		

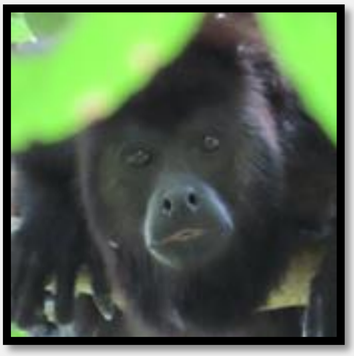
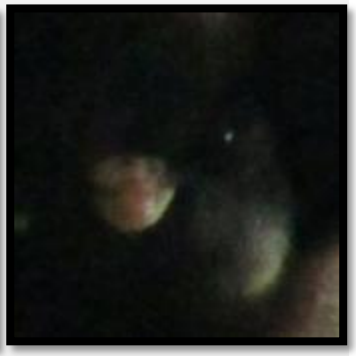
* Have overlapping troop members

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES

FIREBURN AREA:

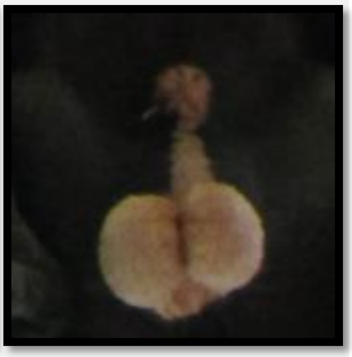
TROOP 1

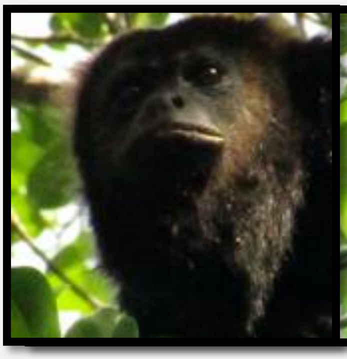
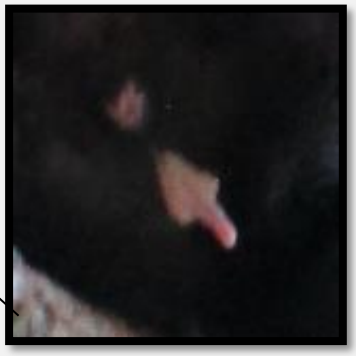
1	Male	Adult	13/11/22	No	Use same area as the Original Nicki Troop
					
2	Female	Adult	13/11/22	No	
					
3	Female	Adult	13/11/23	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
4	Female	Adult	13/11/23	No	
					
5	Female	Juvenile Stage 2	13/11/23	No	
					
6	Female	Juvenile Stage 2	13/11/23	No	
					
7	Female	Juvenile Stage 1	13/11/23	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
8	Female	Juvenile Stage 1	13/11/23	No	
					
9	Female	Infant Stage 1	?/09/23	No	Only brielfly Seen
10	Unknown	Infant Stage 1	?/09/23	No	Mother is 2 Only briefly seen

TROOP 2

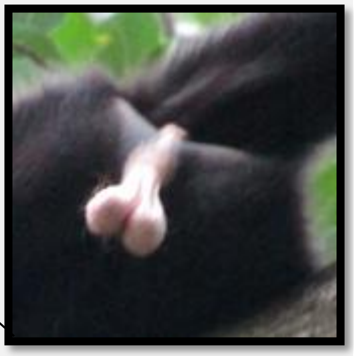
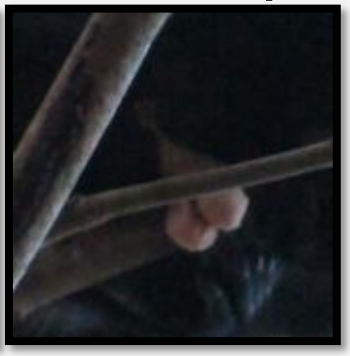
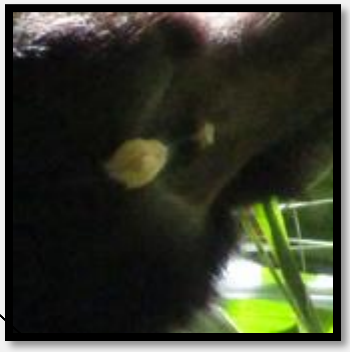
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	14/11/2022	No	
					

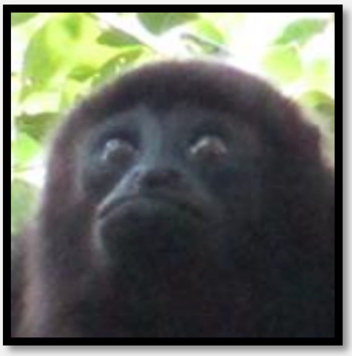
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
2	Female	Adult	14/11/2022	Maybe Richie?	
					
3	Female	Adult	14/11/2022	Maybe Fern?	
					
4	Female	Juvenile Stage 2	14/11/2022	No	
					
5	Female	Juvenile Stage 2	14/11/2022	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
6	Male	Juvenile Stage 1	14/11/2022	No	Mother Is 3
					
7	Male	Infant Stage 2	14/11/2022 2	No	Mother is 2
					

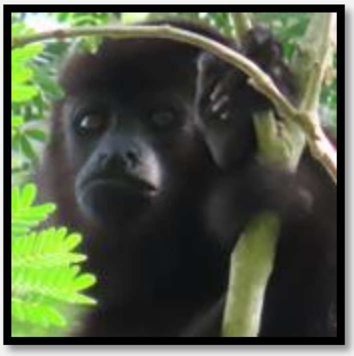
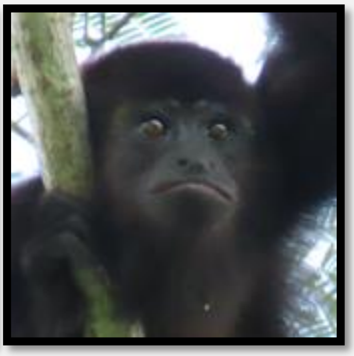
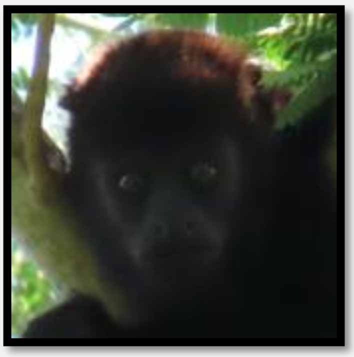
TROOP 3

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	16/11/2022	Maybe Dudley?	
					
2	Male	Sub-Adult	16/11/2022	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
3	Male	Sub-Adult	16/11/2022	No	
					
4	Male	Sub-Adult	16/11/2022	No	Also recorded in Troop 19
					
5	Female	Adult	16/11/2022		
					
6	Female	Adult	16/11/2022	Maybe Livvy?	Also recorded in Troop 19
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
7	Female	Juvenile Stage 3	16/11/2022	No	
					
8	Female	Juvenile Stage 1	16/11/2022	No	Mother is 5. Also recorded in Troop 19
					
9	Female	Juvenile Stage 1	16/11/2022	No	Mother is 6. Also recorded in Troop 19
					

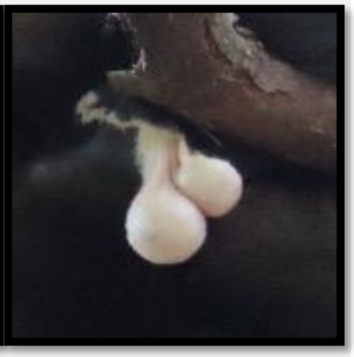
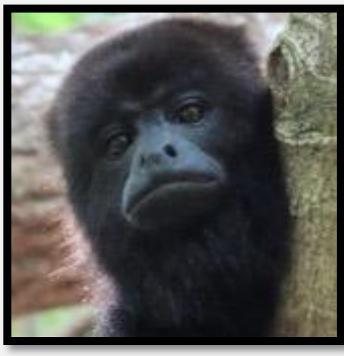
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 19					
10	Male	Adult	05/09/2023	Clyde	Found in Same area as Troop 3
					
6	Female	Adult	05/09/2023	Maybe Livvy?	As recorded in Troop 3
					
11	Female	Adult	05/09/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
4	Male	Sub-Adult	05/09/2023	No	Also Recorded In Troop 3
					
9	Female	Juvenile Stage 2	05/09/2023	No	Also recorded in Troop 3
					
8	Female	Juvenile Stage 1	05/09/2023	No	Also Recorded in Troop 3
					
12	Female	Infant Stage 2	05/09/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES

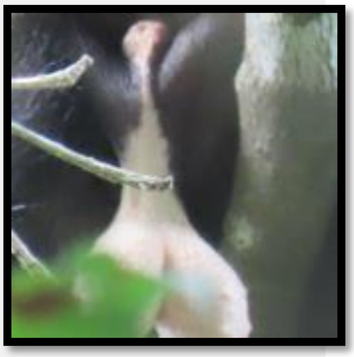
TROOP 5

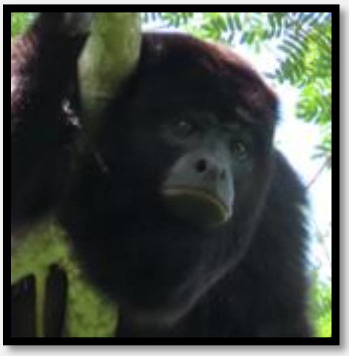
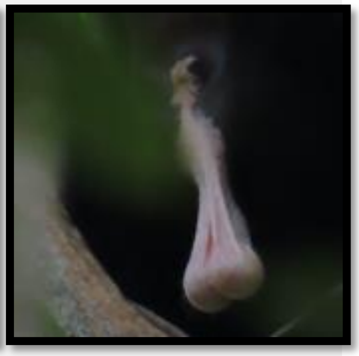
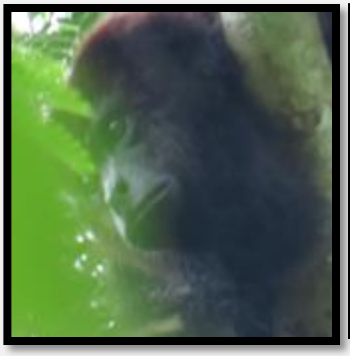
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	17/12/2022	Maybe Nicky?	
					
2	Female	Adult	17/12/2022	No	
					
3	Female	Adult	17/12/2022	No	
					
4	Female	Infant 3	17/12/2022	No	
					

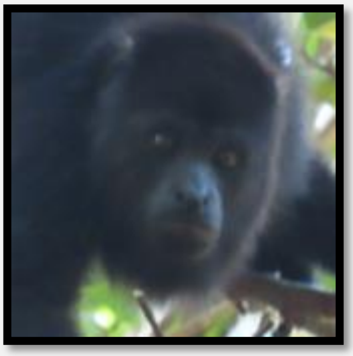
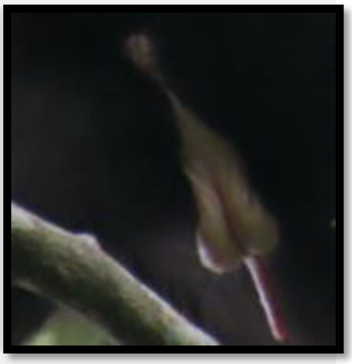
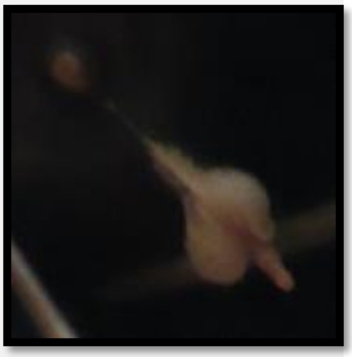
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 17					
1	**Male**	**Adult**	**24/6/23**		
	  				
2	**Female**	**Adult**	**24/6/23**		
	  				
3	**Male**	**Sub-Adult**	**24/6/23**		
	  				

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
SOLO MALE 2					
1	Male	Adult	14/09/2023	No	





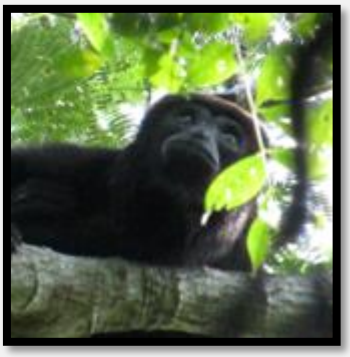
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 20					
1	Male	Adult	6/09/2023	No	
					
2	Male	Adult	06/09/2023	No	
					
3	Female	Adult	06/09/2023	No	
					
4	Female	Adult	06/09/2023	No	
					

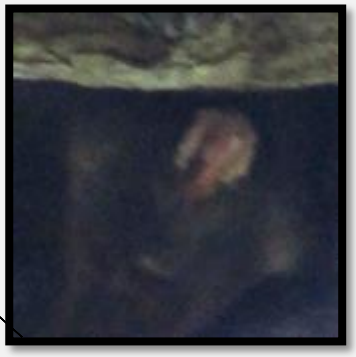
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
5	Female	Juvenile Stage 3	06/09/23	No	
					
6	Female	Juvenile Stage 3	06/09/2023		
					
7	Male	Juvenile Stage 2	06/09/23	No	
					
8	Male	Infant Stage 3	06/09/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES

SHIPSTERN AREA:

TROOP 4

1	Male	Adult	16/12/2022	Jaz	
					
2	Female	Adult	16/12/2022	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
KAKANTULIX AREA:					
TROOP 6					
1	Male	Adult	11/01/23	No	
					
2	Female	Adult	11/01/23	No	
					
3	Female	Adult	11/01/23	No	
					

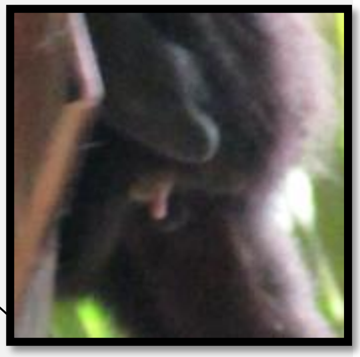
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
4	Female	Juvenile stage 1	11/01/23	No	
					
5	Male	Infant Stage 3	11/01/23	No	
					

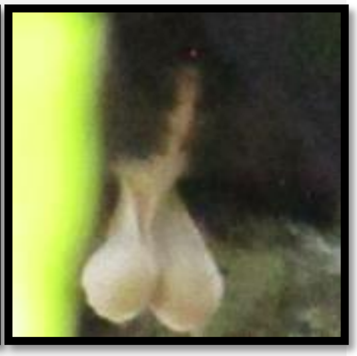
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 7					
1	Male	Adult	12/01/23	No	
					
2	Female	Adult	12/01/23	No	
					
3	Female	Adult	12/01/23	No	
					

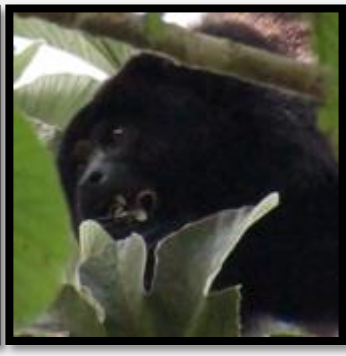
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
4	Female	Infant Stage 3	12/01/23	No	Mother Is 2
					
5	Female	Infant Stage 3	12/01/23	No	Mother is N.o 39
					

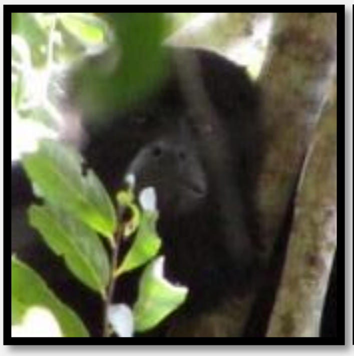
TROOP 9

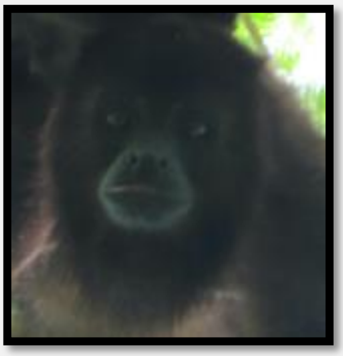
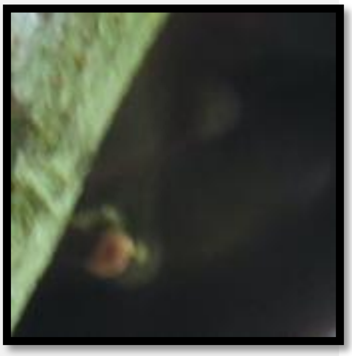
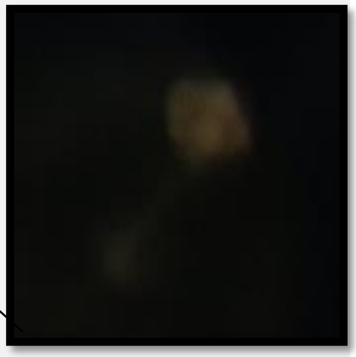
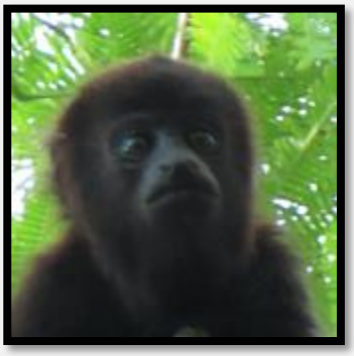
1	Male	Adult	24/01/2023	No	
					

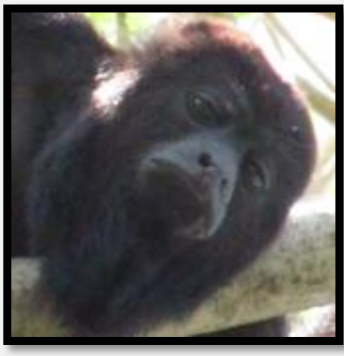
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
2	Female	Adult	24/01/23	No	
					
3	Female	Adult	24/01/23	No	
					
4	Female	Juvenile Stage 3	24/01/23	No	
					
5	Female	Juvenile Stage 2	24/01/23	No	
					

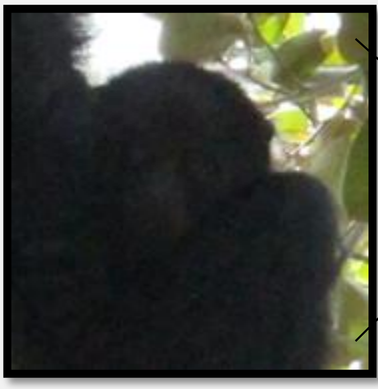
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
6	**Male**	**Juvenile Stage 1**	**24/01/23**	**No**	
					
7	Male	Infant Stage 2	?/04/2023	No	Only briefly seen
TROOP 10					
1	**Male**	**Adult**	**24/1/23**	**No**	
					
2	**Female**	**Adult**	**24/1/23**	**No**	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
3	Female	Adult	24/1/23	No	
					
4	Male	Sub-Adult	24/1/23	No	
					
5	Male	Infant 1	24/1/23	No	N.o 49 is Mother
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 11					
1	Male	Adult	26/02/2023	Maybe Tower Hill Male?	Tower Hill Area
					
2	Female	Adult	26/02/2023	No	
					
3	Female	Adult	26/02/2023	Tower Hill Female C	
					

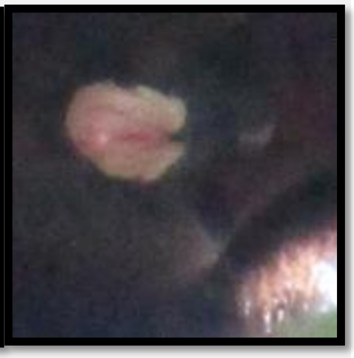
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
	Female	**Juvenile stage 3**	**26/02/2023**	**No**	
4					
	Female	**Adult**	**8/10/23**	**No**	**Found in October with the Troop**
5					
	Female	**Infant Stage 2**	**8/10/23**	**No**	
6					
	Female	**Infant Stage 2**	**8/10/23**	**No**	
7					

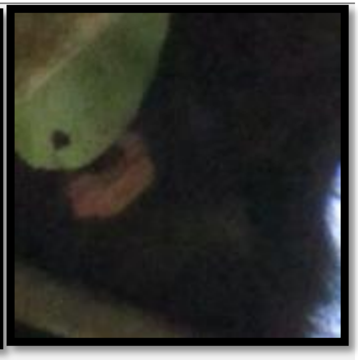
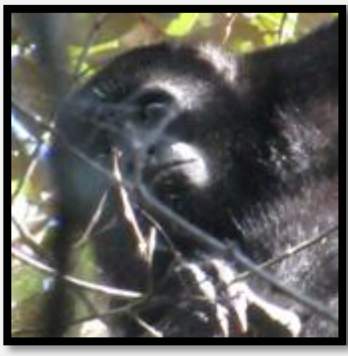
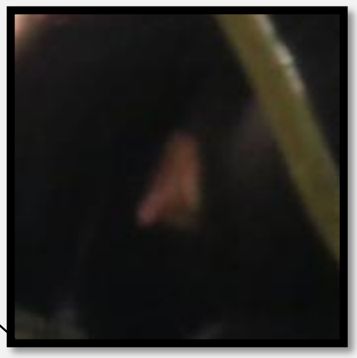
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 12					
1	Male	Adult	09/02/23	No	Area where Mowgli was found.
					
2	Female	Adult	09/02/23	No	
					
3	Female	Adult	09/02/23	Tilly?	
					
4	Male	Juvenile Stage 3	09/02/23	No	
					

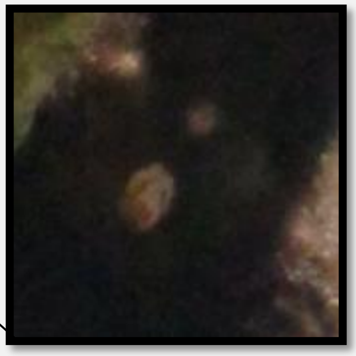
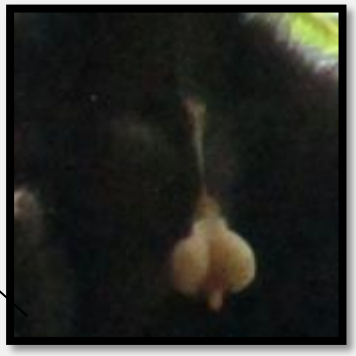
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
5	Female	Infant Stage 2	09/02/23	No	
					
6	Male	Infant Stage 1	09/02/23	No	
					

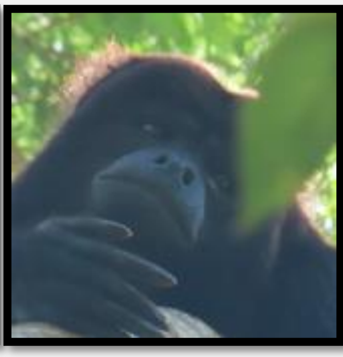
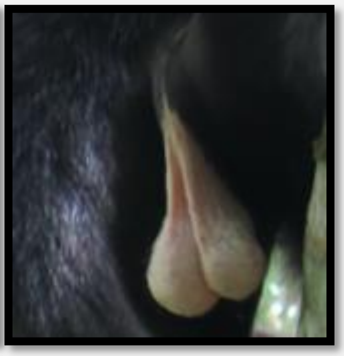
TROOP 13

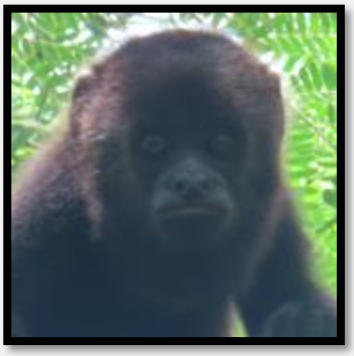
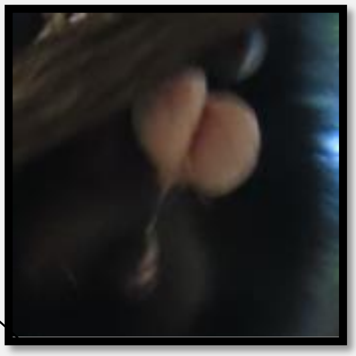
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	12/03/2023	No	
					

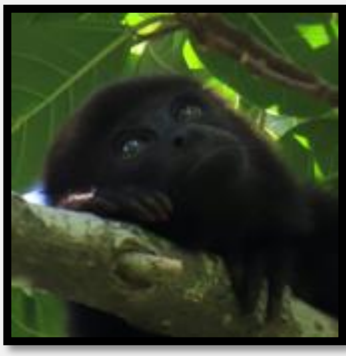
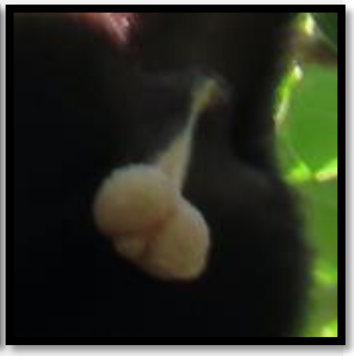
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
2	Female	Adult	12/03/2023	Maybe polly?	
					
3	Female	Sub-Adult	12/03/2023	No	
					
TROOP 14					
1	Male	Adult	22/03/2023	No	
					

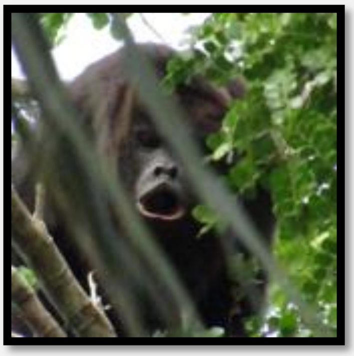
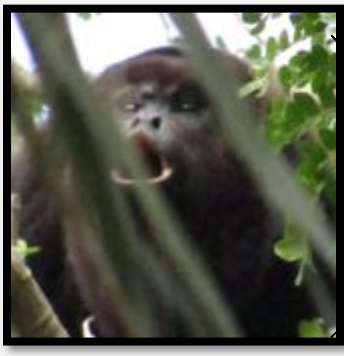
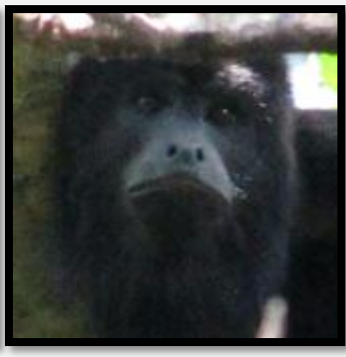
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
2	Female	Adult	22/03/23	No	
					
3	Female	Adult	22/03/23	No	
					
4	Male	Sub-Adult	22/03/2023	No	
					
5	Female	Juvenile Stage 2	22/03/2023	No	
					
6	Female	Juvenile Stage 2	22/03/2023	No	

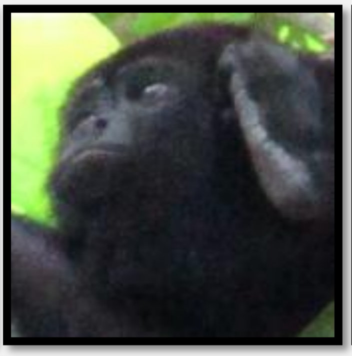
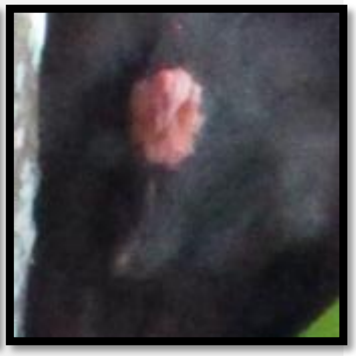
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
7					
	Male	Juvenile Stage 1	22/03/2023	No	
					
8	Male	Juvenile Stage 1	22/03/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 23					
1	Male	Adult	30/09/23	No	Same as Troop 14
					
2	Female	Adult	30/09/23	No	Same as Troop 14
					
3	Female	Adult	30/09/2023	No	Same as Troop 14
					
4	Male	Sub-Adult	30/09/2023	No	
					

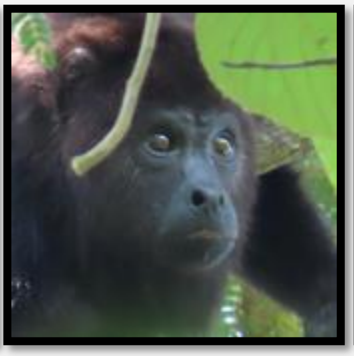
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
7	**Male**	**Juvenile Stage 2**	**30/09/2023**	**No**	
					
8	**Male**	**Juvenile Stage 2**	**30/09/23**	**No**	**Damaged Right Eye**
					
9	**Male**	**Infant Stage 2**	**30/09/23**	**No**	
					

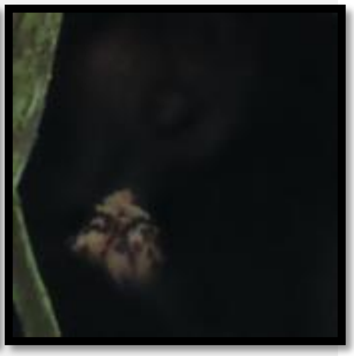
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
10	Male	Infant Stage 2	30/09/2023	Kaibill	Suspected Orphan, Adult Female Below
					
11	Unknown	Juvenile Stage 3	03/10/2023	No	
					
N/A	Female	Adult	1/10/2023	No	Remains. Assumed Kaibill's Mother
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
TROOP 15					
1	**Male**	**Adult**	**02/04/2023**	**No**	**Rest of troop unknown. Seen with 1 female, not photographed.**
					
TROOP 16					
1	**Male**	**Adult**	**23/04/2023**	**No**	**BC Territory**
					
2	**Female**	**Adult**	**23/04/2023**	**No**	
					

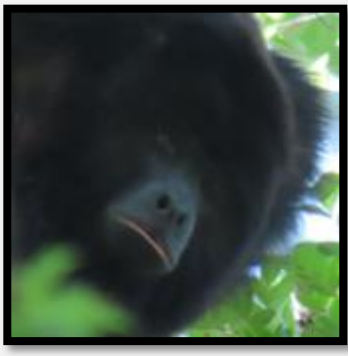
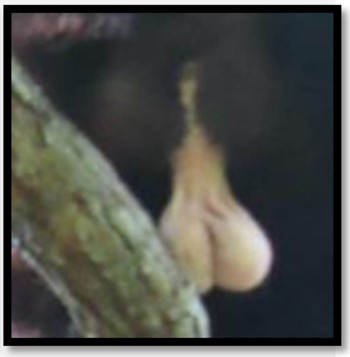
NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
3	Female	Adult	23/04/2023	No	
					
4	Male	Juvenile Stage 3	23/04/2023	No	
					
5	Female	Infant Stage 3	23/04/2023	No	
					

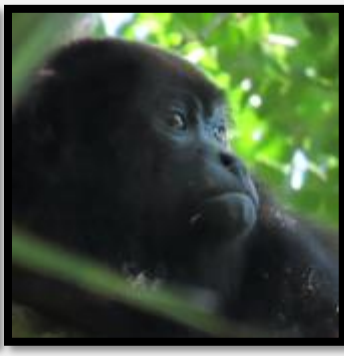
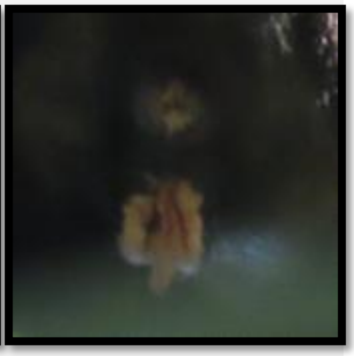
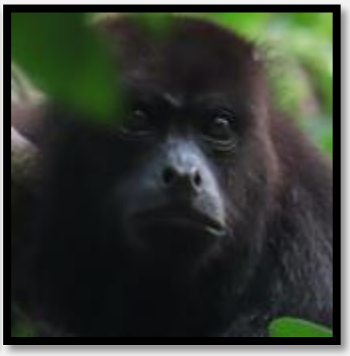
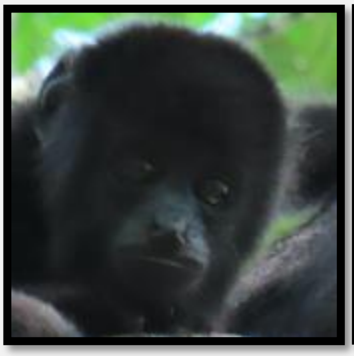
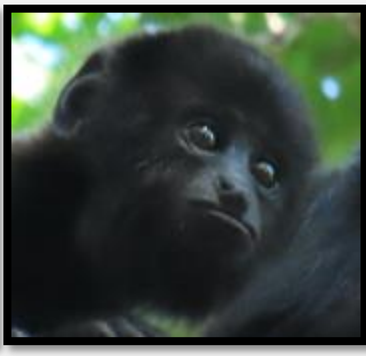
TROOP 21

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	24/09/23	No	
					
2	Feale	Adult	24/09/23	No	
					
3	Female	Adult	24/09/23	No	
					
4	Female	Adult	24/09/23	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
5	Male	Juvenile Stage 2	23/09/24		
					
6	Male	Infant Stage 3	24/09/24	No	
					
7	Male	Infant Stage 2	24/09/23	No	
					

TROOP 22

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
1	Male	Adult	25/09/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
2	Female	Adult	25/09/2023	No	
					
3	Female	Adult	25/09/2023	No	
					
4	Male	Infant Stage 3	25/09/2023	No	
					

NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
SOLO MALE 1					
1	Male	Sub-Adult	20/04/2023	No	

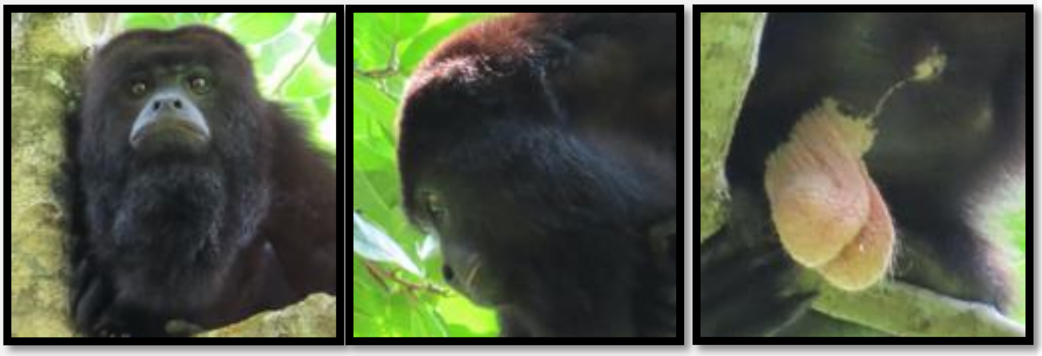


NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES

SPIDER RELEASE AREA:

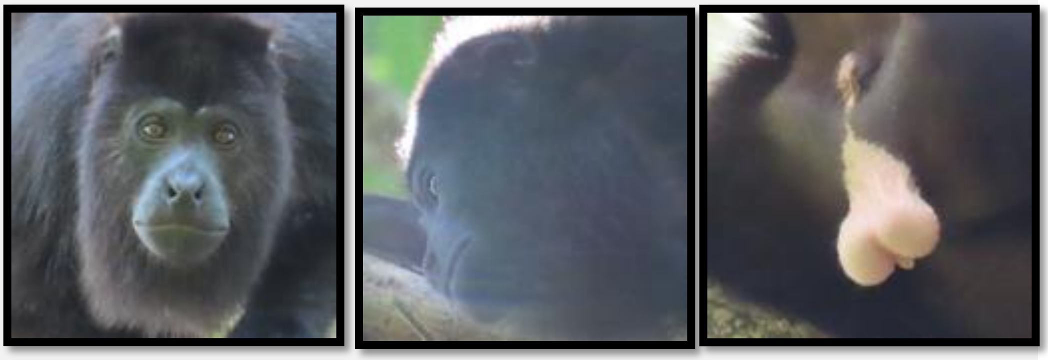
TROOP 18

1	Male	Adult	28/06/2023	No	



2	Female	Adult	28/06/2023	No	

3	Male	Sub-Adult	28/06/2023	No	



NUMBER IN TROOP	SEX	ESTIMATED AGE	DATE FOUND	IDENTIFIED AS A RELEASED MONKEY?	OTHER NOTES
4	Male	Juvenile Stage 2	28/06/2023	No	
					
5	Male	Infant Stage 3	28/06/2023	No