Monitoring Game Species Communities in the Chiquibul Forest

September 2019

Funded by:

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CITATION

Arevalo, B. 2019. Monitoring Game Species Communities in the Chiquibul Forest. Friends for Conservation and Development. San Jose Succotz. Belize.

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Abstract

Unsustainable hunting can be more detrimental to targeted populations than habitat loss and fragmentation. Even small-scale subsistence hunting results in marked population declines in large-bodied animals. Line transects, surveyed on three occasions (2012-2013, 2015-2016, and 2018-2019) and camera traps were used to collect wildlife species data in the Chiquibul Forest. Line transect data revealed a decreasing trend in the overall mean encounter rates but not statistically significant compared to previous assessments. A similar trend was observed when encounter rates were analyzed by body size and conservation value classes. Camera trapping data shows that jaguars, pumas, and ocelots were among the most frequent encountered species, which are indications that the Chiquibul Forest supports healthy populations of prey species. Based on the hunting pressure stratification, no significant difference was recorded, this may be an indication that game species distribute evenly throughout the Chiquibul Forest, making it very difficult to isolate the true impact of illegal hunting of game species. Areas closer to the western border, where higher hunting pressure occurs may best be described as 'sinks' while areas with low hunting pressure act as the 'source'. It becomes important to continue with long term monitoring of wildlife species abundance especially using camera traps since this method results in higher encounter rates for species of conservation value, which are usually indicators of the overall ecosystem health.

INTRODUCTION

Unsustainable hunting of terrestrial vertebrates in tropical forests is the most widespread form of non-timber forest product resource extraction (Peres, 2000; 2001) and detrimental to targeted populations (Mittermeier, 1987). Mittermeier (1987) indicates that hunting can be more detrimental than habitat destruction, as it may cause local to regional population extinctions. Thiollay (1986) and Peres (1990) indicate that even small-scale subsistence hunting can result in marked population declines in large-bodied birds and mammals; altering trophic levels, eventually affecting forest dynamics. Large terrestrial vertebrates play an important role in seed dispersal, predation (Peres & van Roosmalen, 1996), and herbivory (Dirzo & Miranda, 1991), factors impacting tree species distribution and forest structure modification.

Unlike other anthropogenic disturbance including deforestation, fragmentation, and forest degradation, over-hunted areas are impossible to be detected and mapped using conventional remote-sensing technology, thus its quantification remains a challenge. The presence of large trees and forest canopy does not guarantee the presence of native fauna (Redford, 1992). It is only possible to speculate on the observable decrease in densities (or relative abundance) of large-bodied terrestrial vertebrates (Peres 2001). Yet the effects of many anthropogenic disturbances operate synergistically; for example, in the Chiquibul Forest, hunting is an opportunistic activity undertaken by individuals involved in illegal logging and non-timber forest (xate) extraction. These activities alone may contribute significantly to a reduction of large-bodied terrestrial vertebrate densities due to habitat disturbance. The objectives of this study were to i) document and describe the diversity of terrestrial games species, ii) calculate encounter rates by species for each game species recorded, and iii) compare game species encounter rates with 2012 - 2013, and 2015-2016 survey.

METHODOLOGY

Study site

The study occurred in the Chiquibul Forest (CF), which comprises of 176,999 ha of public lands dominated by tropical broadleaf forests (Meerman and Sabido 2001). The CF is an integral part of the Greater Maya Mountain Massif Key Biodiversity Area (Meerman and Wilson 2005, Salas and Meerman 2008, Walker et al. 2008), known as one of the largest contiguous blocks of forest in Central America (Bridgewater 2012). It is comprised of three protected areas, namely, the Chiquibul National Park (CNP), Chiquibul Forest Reserve (CFR), and the Caracol Archeological Reserve (CAR). The CNP is 106,838 ha and is comanaged by the Belize Forest Department (BFD) and Friends for Conservation and Development (FCD). The park was primarily established in 1991 for biodiversity and watershed protection. The CFR is 59,822 ha and is comanaged by BFD and Bull Ridge Ltd. through a long-term, low-density selective logging license primarily for extraction of mahogany (*Swietenia macrophylla*), Spanish cedar (*Cedrela odorata*), nargusta (*Terminalia amazonia*), and chicle (*Manilkara chicle*). The 10,339-ha CAR was established for archaeological and cultural tourism, and is managed by the National Institute of Culture and History. The region has a subtropical climate with marked dry (Feb-May) and rainy seasons (Salas and Meerman 2008), with an average daily temperature of 26ºC and 2000 mm/yr of rainfall (Dubbin et al. 2006). Elevation ranges from 300 m in the river valleys to 1,124 m on the highest peaks (Bateson and Hall 1977, Penn et al. 2004), with topography varying from rolling hills to moderate and steep slopes. Much of the CF is underlaid with Cretaceous limestone, leading to a vast array of caves and sinkholes, and a subterranean hydrology. However, Permian meta-sediments dominate the eastern regions (Bateson and Hall 1977, Cornec 2003), where most of the rivers and streams are found. Soil types vary, and are typically alkaline and relatively fertile compared to other tropical areas (Penn et al. 2003, Bridgewater 2012). On the steeper limestone slopes, Wright et al. (1959) classified soils as skeletal, leading to a semi-deciduous nature of forests in the northern half of the Chiquibul Forest.

Data collection

Line Transects

Three hundred and eighty-four km (128 km per stratification) of standard line transects were surveyed between September 2012 to March 2013, September 2015 to March 2016, and September 2018 to March 2019. This is an efficient and reliable method for the rapid assessment of species richness and abundance (Peres 1999), and an important foundation for determining conservation priorities (Silveira *et al*. 2003). Transects were established following a stratified-systematic sampling design. Categories were described as: high hunting pressure in the Caracol Area, medium in the Millonario to San Pastor Area and low in the Macal and Raspaculo River. Stratification was based on a hunting pressure gradient; assuming that closer to the Belize-Guatemala Border the higher the hunting pressure occurred and reduces in intensity as one moves deeper into Belizean territory (Figure 1). Four line-transects, each measuring two kilometers (distance measured with a GPS unit) oriented East-West were established in each strata, located 2 km apart. All transects were cleared no more than 1 m in width, for access only. Each was allowed a "rest period" (left alone by observer) of 15 days after opening and at least 5 days after each survey. Rest period allowed disturbances created during trail preparation and post survey to normalize allowing wildlife to redistribute themselves in space along the transect area in a total absence of observer disturbance (Peres, 1999). Transects were quietly surveyed at an average speed of 1 km/hour by an observer and a recorder, initiating at 0600 to 1100 hours; avoiding the survey of transects during heavy rainy days. Observers briefly stopped at very 100m in order to scan the forest for potential sightings and listened to sound cues. Data collected from each animal sighting included: species, abundance, transect bearing, animal bearing, animal sighting distance and mode of detection.

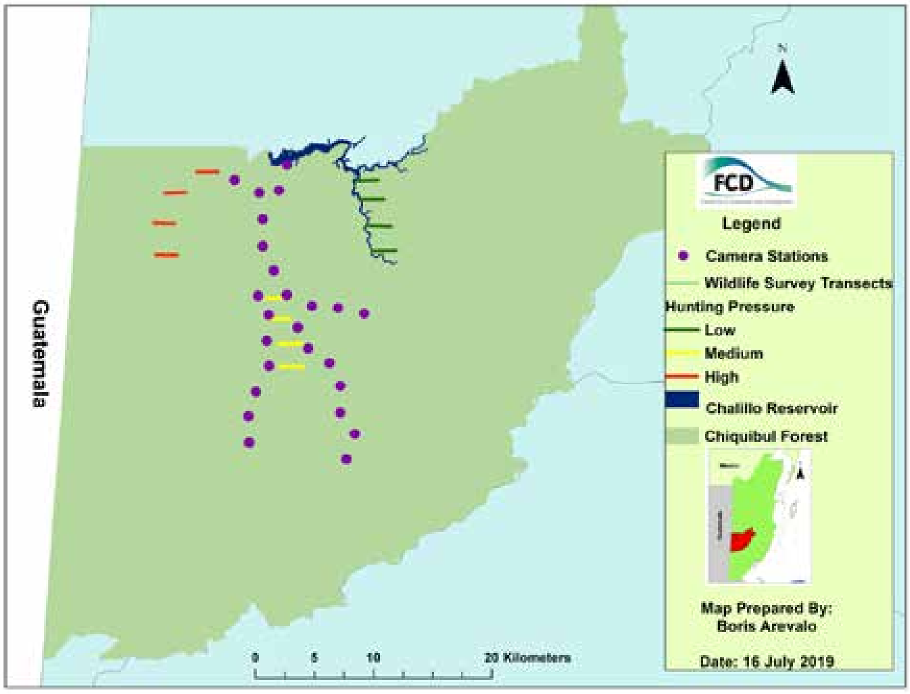

Figure 1: *Distribution of line-transects and camera trap stations during the study*

Camera Trapping

Twenty-five double camera (Moultrie M-50i series) stations were deployed within the Chiquibul Forest from May to June 2019, totaling 987 trapping nights. Each station was 2 km apart along access trails (Figure 1). Camera units were programmed to have a 30 second delay between triggers and take 3 pictures over a 6-second period each time triggered. Cameras were placed on average, 25 cm from ground level. Remote triggered cameras have a fairly wide heat/ motion sensor horizontally, but not vertically and placing cameras 20-30 cm high likely would increase photographic rates of small species while not compromising photographic rates of larger species (Kelly 2008).

Data analysis

Line Transect data summaries (means and 95% confidence intervals) was analyzed by survey and hunting pressure. Detection/ Encounter rates standardized to 100 km were used for analysis, since recorded species abundance was much variable (some species move in groups while others are solitary). Following Peres (2000) species were grouped into three body size classes: 1) small species (< 1 kg); 2) medium species (1 – 5 kg); 3) large species (> 5 kg). Game species were also grouped based on their conservation priority following the IUCN classification system but because of low encounter rates, Data Deficient and Least Concern species were reclassified as Least Concern, while Threatened, Endangered and Critically Endangered into species of Conservation Value.

Encounter rates standardized to 100 trapping nights were used to analyze camera trapping data. Activity patterns were compared between the most common detected species using package overlap (Ridout and Linkie 2009) in R (R Core Team 2017).

RESULTS

Line Transect Data

Wildlife encounter rates were statistically similar across the three surveys but a slight decreasing trend was observed (Figure 2) on this latter study. Encounters were represented by 10 bird and 21 mammal species, with varying encounter rates across survey years (Figure 3 and 4). For birds, the Keel-billed Toucan was frequently encountered followed by the Crested Guan, while the other species varied greatly in encounter rates during the surveys (Figure 3). Mean encounter rates of Crested Guans was statistically greater during the 2012-2013 survey compared to 2015-2016 and 2018-2019 surveys, while for the Keel-billed Toucan, a reversed pattern was observed (Figure 3). Deppe's Squirrel, Red-brocket Deer, and Baird's Tapir encounter rates were most common but vary in means across the three surveys. Deppe's Squirrel encounter rates were significantly higher during 2012-2013 than during 2015-2016 and 2018-2019 while mean Baird's Tapir encounters were significantly lower during the 2012-2013 compared to the other two surveys (Figure 4).

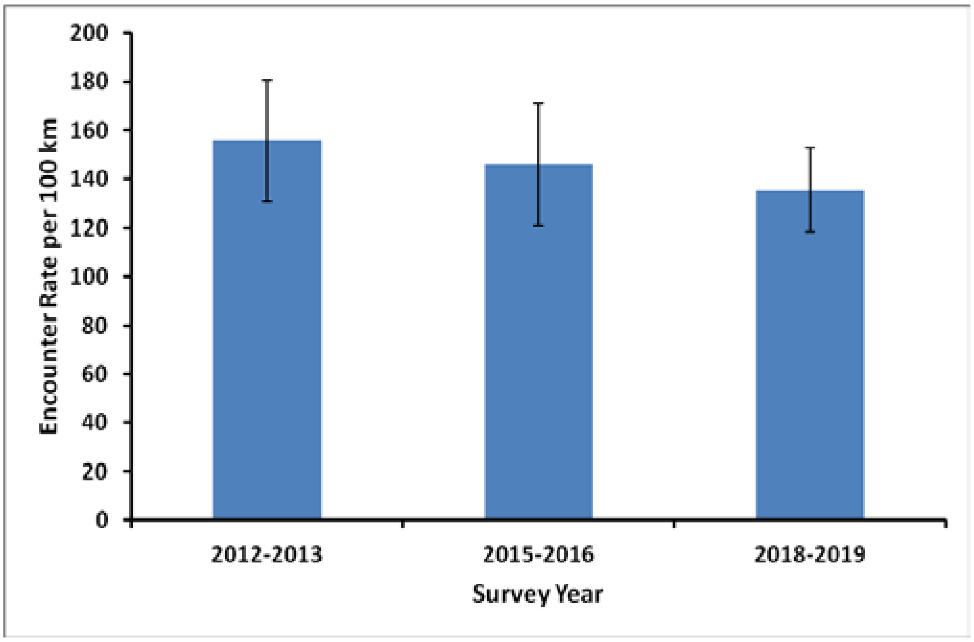

***Figure 2**: Mean animal encounter rates per 100 km of line transect surveyed in the Chiquibul Forest with 95% confidence intervals.*

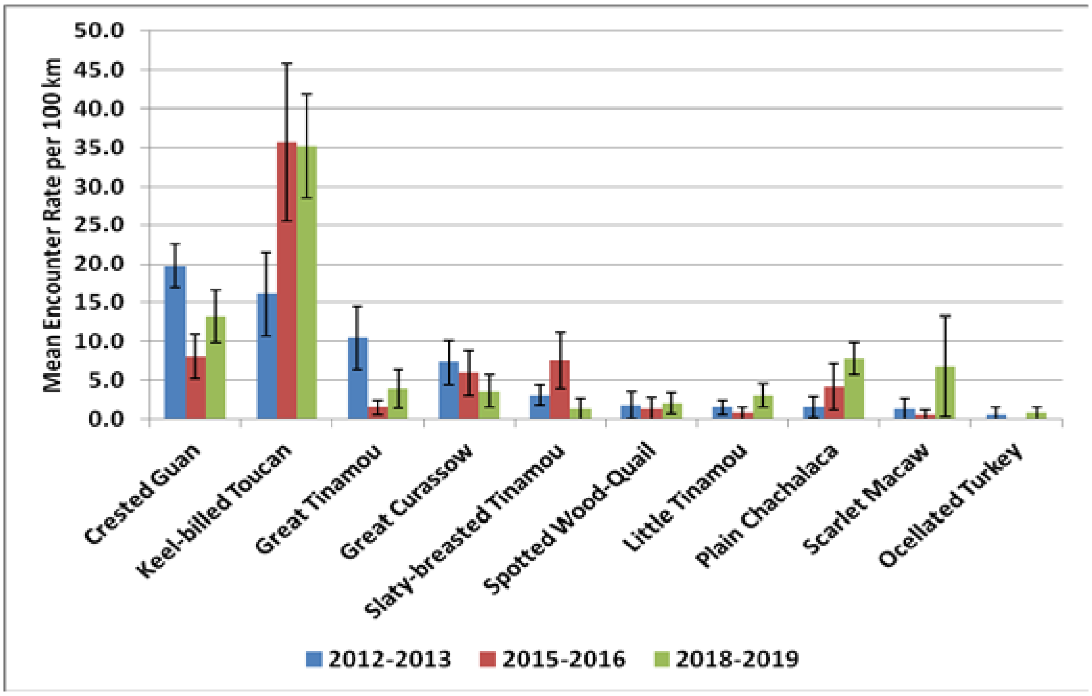

Figure 3: *Mean encounter rates per 100 km and 95% confidence intervals for mammals surveyed on line transects in the Chiquibul Forest.*

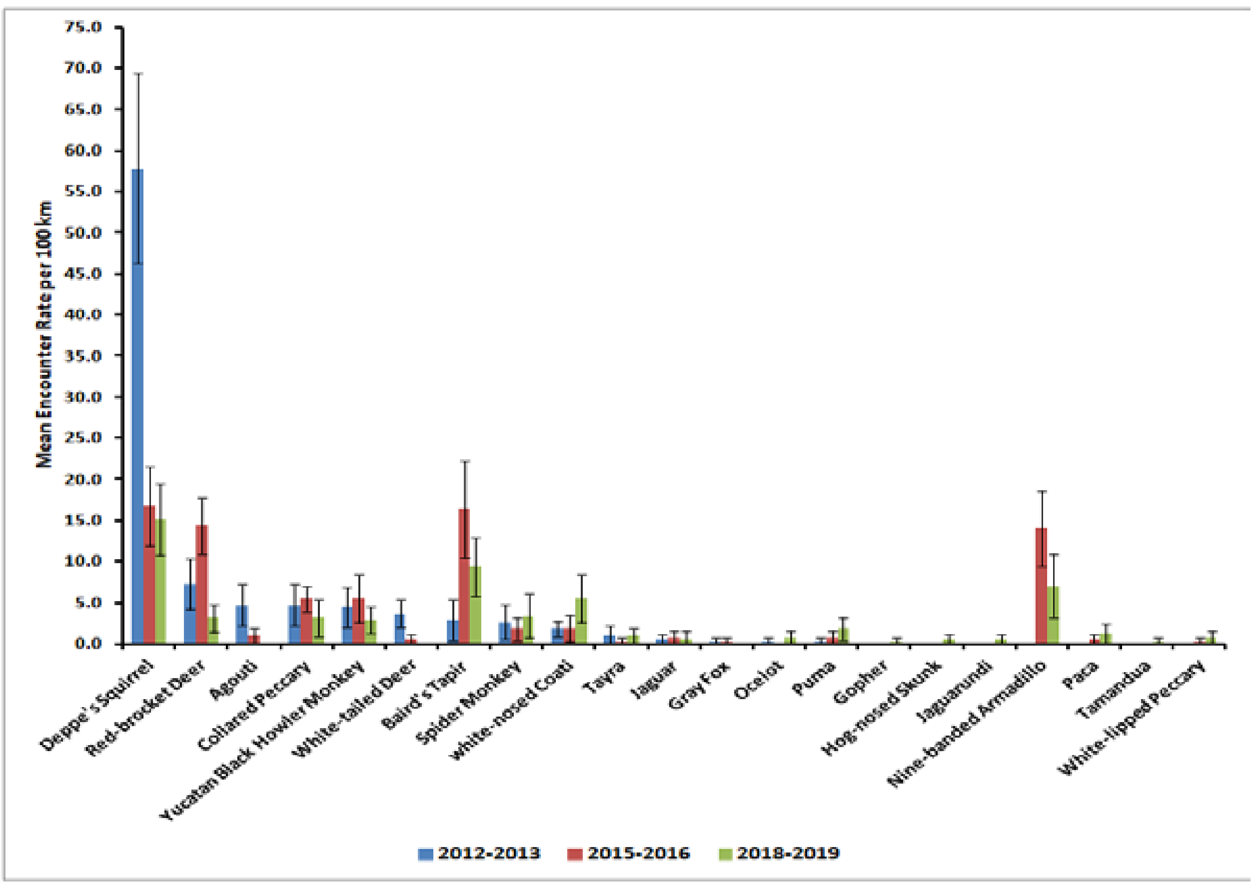

Figure 4: *Mean encounter rates per 100 km and 95% confidence intervals for mammals surveyed on line transects in the Chiquibul Forest.*

Overall, small bodied animals had a significantly higher mean encounter rate than medium and large bodied species (Figure 5). Mean encounter rates of Large animals was significantly higher during the 2015-2016 surveys compared to the 2012-2013 and 2018-2019 surveys, while mean encounter rates for medium and small animals were not significantly different (Figure 5).

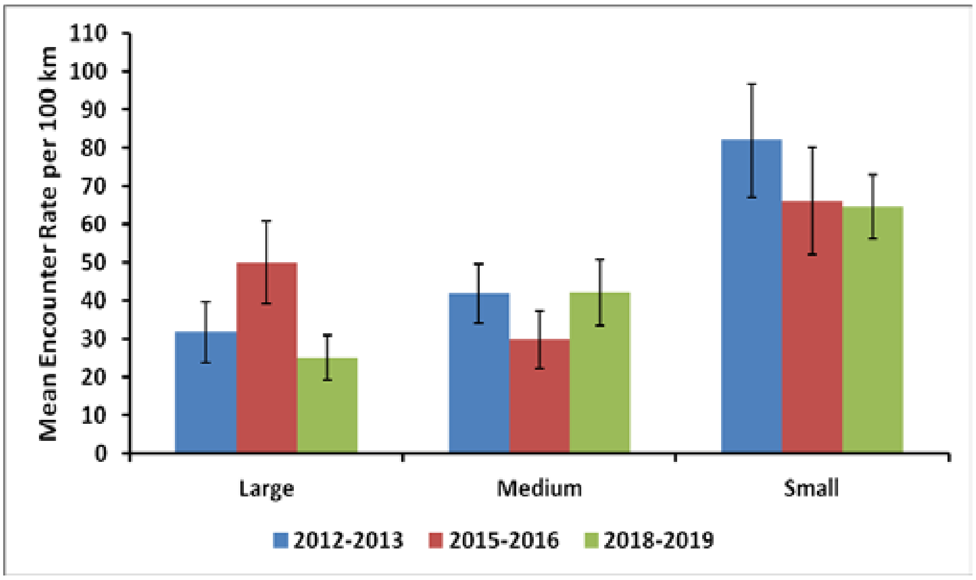

Figure 5: *Mean encounter rates per 100 km and 95% confidence intervals base on animal body size encouner within the Chiquibul Forest.*

At low hunting pressure strata, a statistically significant mean difference was observed in small bodied animals where encounter rates were lower during the 2018-2019 survey, while no difference was observed for large and medium size body animals (Figure 6). Large body animal encounter rates were significantly greater during the 2015-2016 surveys at the medium hunting pressure strata, while the other body animal classes showed no statistical difference across surveys but overall small bodied animals were encountered more frequently than large and medium animals at the medium hunting pressure strata (Figure 6). At the high hunting pressure strata there were no significant differences for all body classes among surveys (Figure 6).

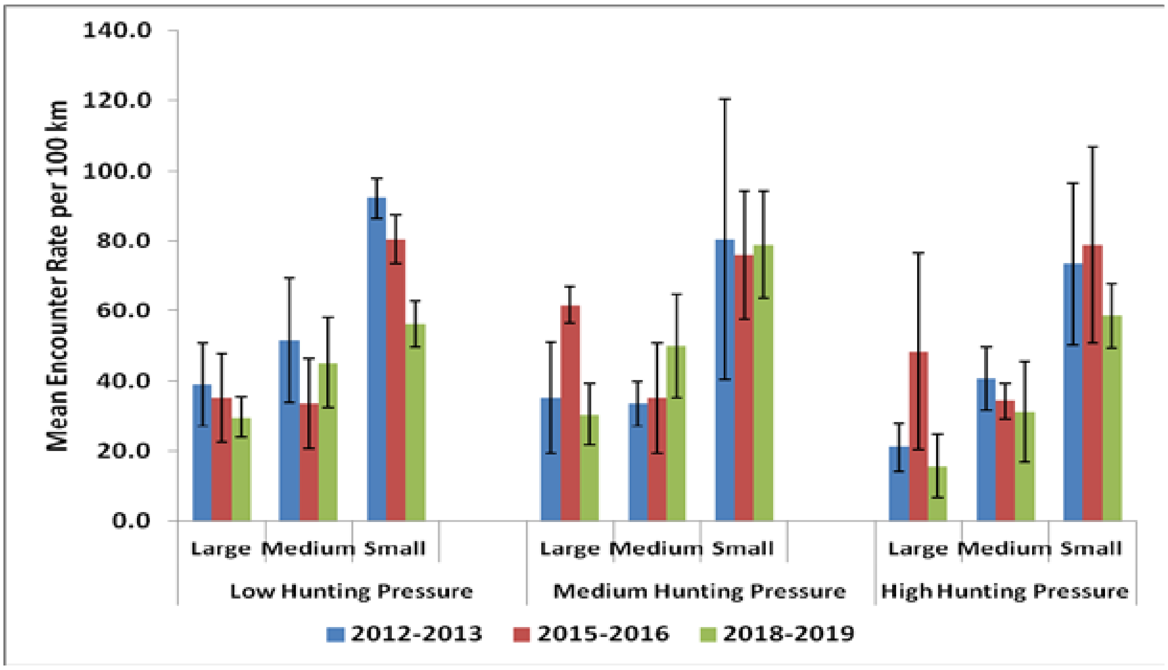

Figure 6: Mean encounter rates per 100 km and 95% confidence intervals base on animal body size recorded by hunting pressure strata in the Chiquibul Forest.

Mean encounter rates for species of least conservation concern and of conservation value were not significantly different between survey (Figure 7) but the mean encounter rates for species of conservation consern was significantly lower than that of least concern speices (Figure 7) as were base on hunting pressure (Figure 8).

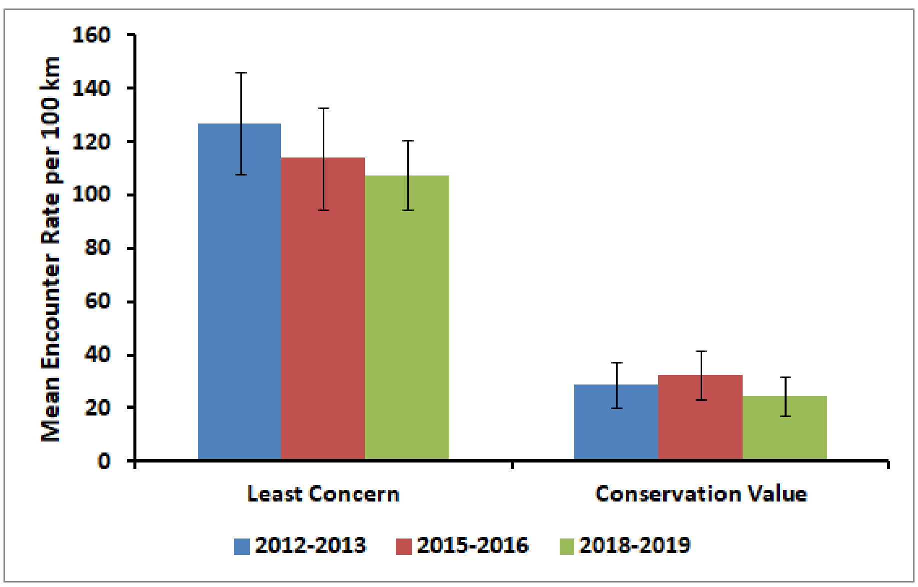

Figure 7: Mean encounter rates per 100 km and 95% confidence intervals base on species conseration value encouner within the Chiquibul Forest.

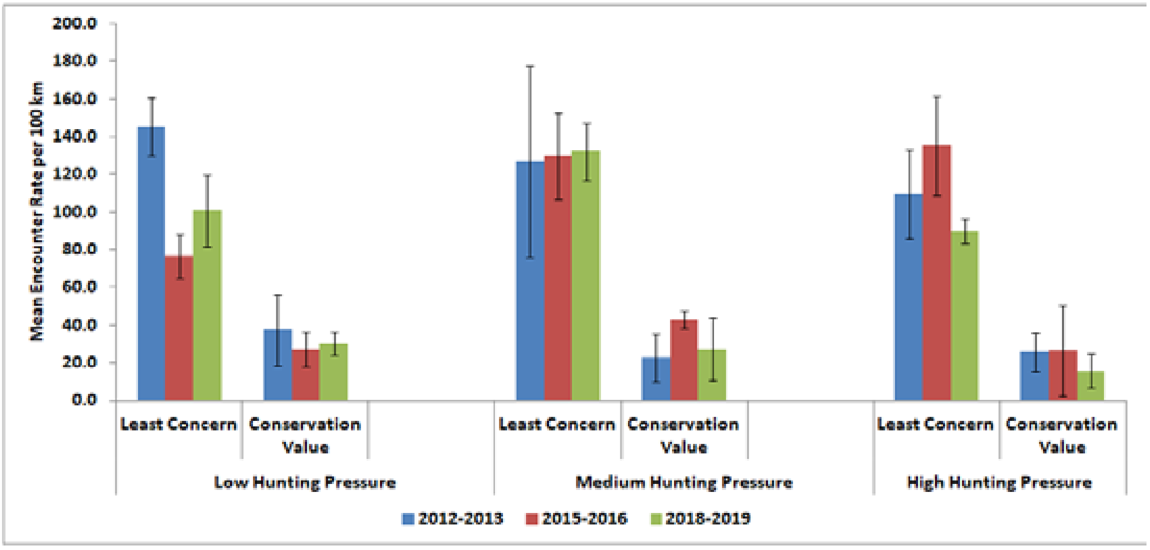

Figure 8: Mean encounter rates per 100 km and 95% confidence intervals base on conservation value recorded by hunting pressure strata in the Chiquibul Forest.

Camera Trap Data

Sixteen birds, twenty-three mammals, and 1 reptile (Green Iguana) species were recorded by camera traps. Ocellated Turkey and Great Curassow had significantly higher mean encounter rates per 100 trap nights than other bird species (Figure 9). For mammals, Gray Fox, Ocelot, Baird's Tapir, Common Opossum, Jaguar, Puma, and the Brocket Deer had all greater encounter rates but not significantly different from each other (Figure 10).

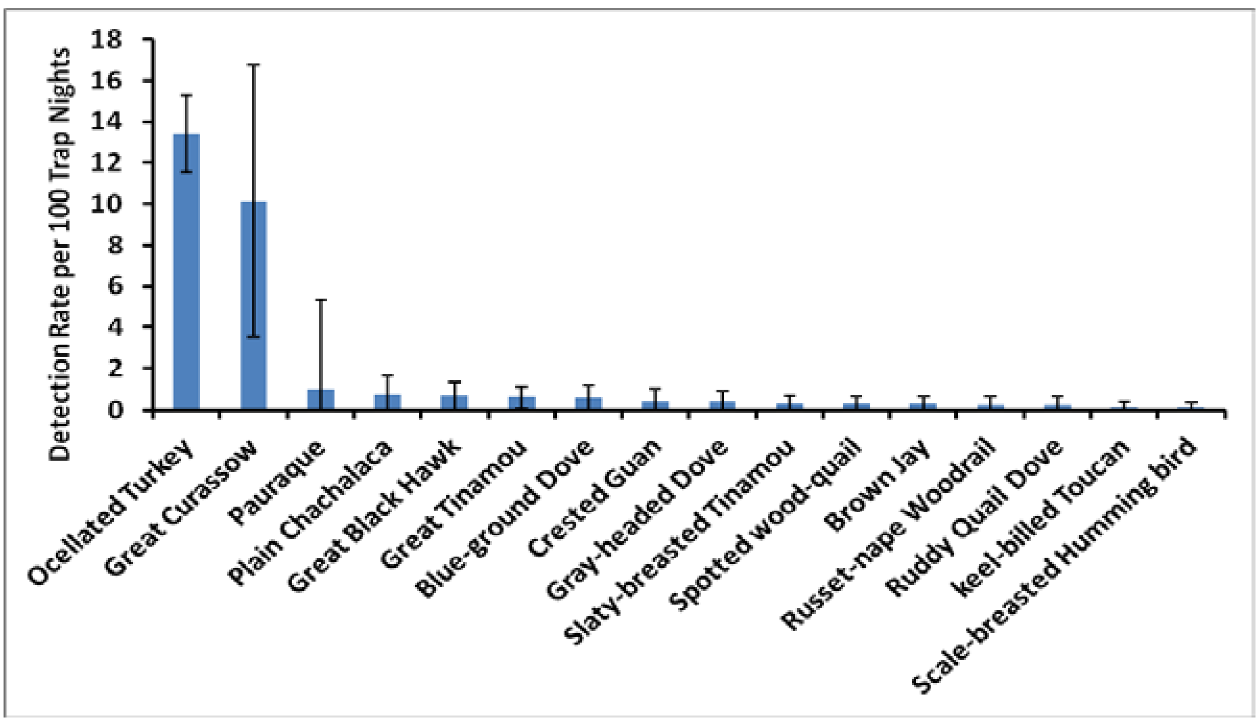

Figure 9: Mean encounter/ detection rates per 100 trap nights and 95% confidence intervals for bird species recorded in the Chiquibul Forest.

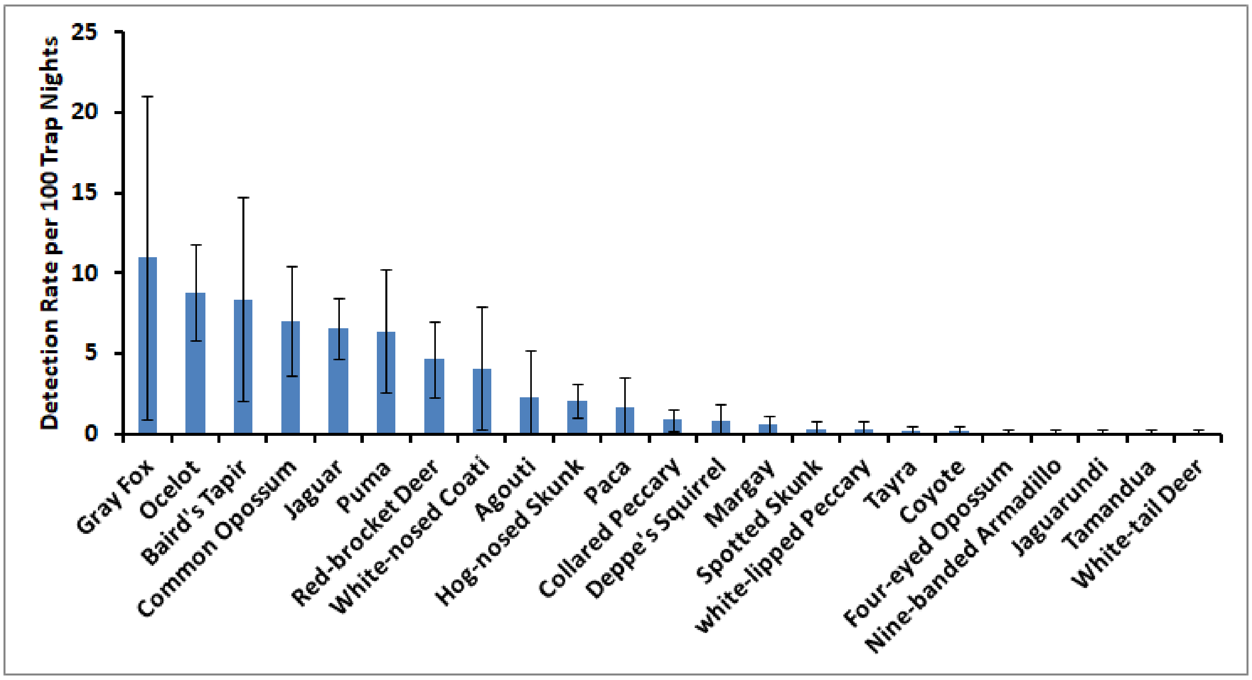

Figure 10: Mean encounter/ detection rates per 100 trap nights and 95% confidence intervals for mammal species recorded in the Chiquibul Forest.

Mean detection rates of large bodied animals were significantly greater than medium and small animals (Figure 11). Species of conservation importance (near threatened, endangered and critically endangered) had greater mean detection rates than those of least conservation concern (Figure 12).

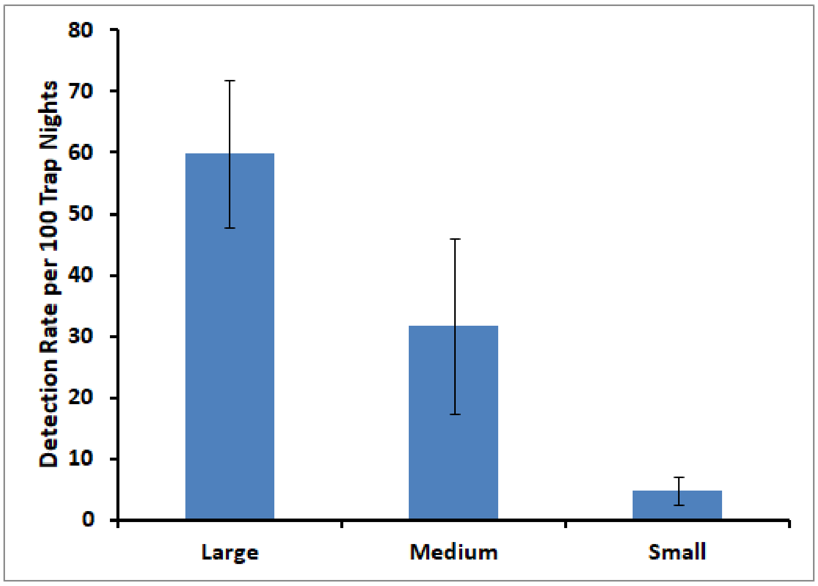

Figure 11: Mean detection rate and 95% confidence intervals per 100 trap nights for animals based on body size class

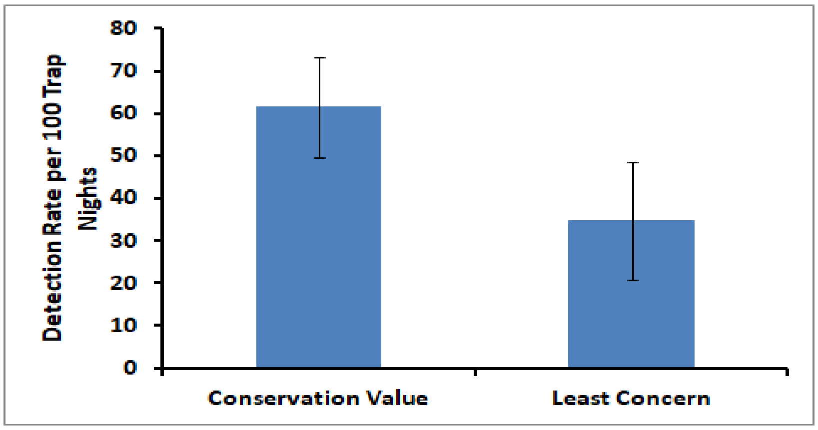

Figure 12: Mean detection rate and 95% confidence intervals per 100 trap nights based on conservation value.

Both Ocellated Turkey and Great Curassow were active throughout the day, but peaking activity during early daylight hours. Jaguars and Pumas were mostly active throughout the night hours but pumas extended their activities during early daylight hours while ocelots were mostly encountered during night hours peaking at midnight (Figure 13). Baird's Tapir showed a nocturnal activity with two peaks, one around 21:00 hrs and the other around 03:00 hrs. Gray fox activity peaked around 12:00 hrs and then a second peak of activity at 04:00 hrs while Common opossums peaked activity at 00:00 hrs (Figure 11).

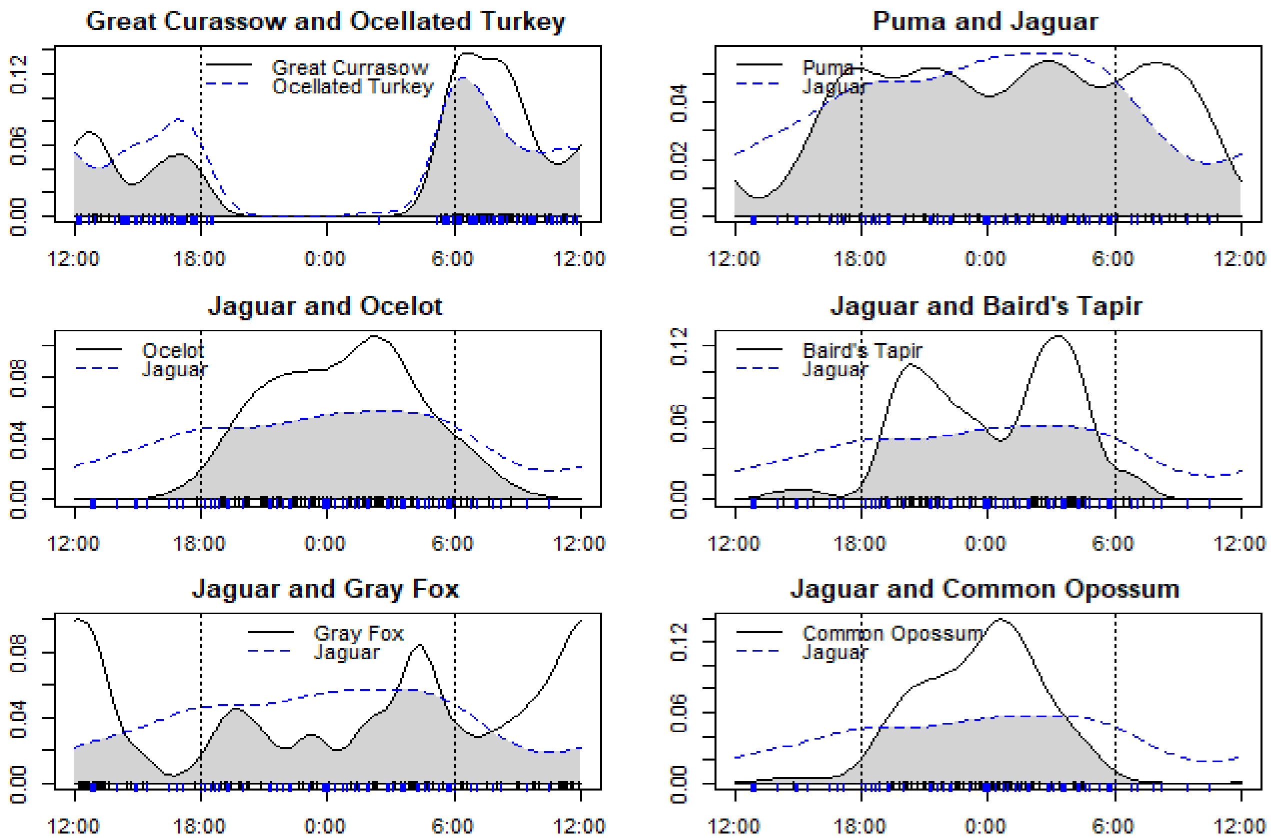

Figure 13: Daily activity patterns of the most frequently encountered birds and mammals in the Chiquibul Forest.

DISCUSSION AND CONCLUSION

A decreasing trend was observed in the overall mean encounter rates of animal species but not statistically significant. A similar trend was observed when encounter rates were analyzed by body size and conservation value classes with and without hunting pressure stratification. The failure to find significant differences is captured by the large confidence intervals (CI) representing the uncertainty in the estimates. The confidence intervals are sensitive to variability in the population (spread of values) and sample size. The former is difficult to address while an increase in number of transects and survey intensity of the same would help to address the latter source of variation. When used to compare the means of two or more treatment groups, a confidence interval shows the magnitude of a difference between groups; this is helpful in understanding both the statistical and biological significance.

Camera trapping data shows that jaguars, pumas, and ocelots were among the most frequently encountered species, which are indications that the Chiquibul Forest supports healthy populations of prey species. The endangered White-lipped Peccary was recorded using line transects and camera traps; a good indication that the species is re-establishing itself in the forest. The White-lipped Peccary is nomadic, moving with shifting patterns of food availability.

The pattern of statistically significant lower mean encounter rates of large compared to small bodied animals observed in the Chiquibul Forest has also been reported from other forests by Peres (1990) and Mena *et al.* (2000) using line transects. This phenomenon is commonly observed in natural ecosystems, since larger animals require more resources, thus an ecosystem can support less large animal abundance than small species. Hunting greatly affects the abundance of large animals as well. This may go in line with the conclusions presented by Peres & Nascimento (2006) and Jerozolimski & Peres (2003) that hunters prefer large bodied game species over smaller ones, which is explained better by the Optimal Foraging Theory but would target smaller bodied species as large game is depleted.

Based on hunting pressure stratification, no significant difference was recorded. This may serve as an indication that game species distribute evenly throughout the Chiquibul Forest, thus making it very difficult to isolate the true impact of illegal hunting on target species. It is only possible to infer that illegal hunting is occurring throughout the forest as evidence of this is frequently observed along trails and illegal camp sites. Even though results do not support the hypothesis that game species are less abundant closer to the Guatemala-Belize Western Border, it is believed that areas closer to farm clearings have less density of game species but these areas are impossible to survey due to security reasons. Areas that were categorized as having high hunting pressure are at least 6 kilometers away from the border and the impact of illegal hunting on game species densities and abundance may be diffused. Game species from further forested areas migrate to these areas due to available resource (food, shelter, breeding ground) indicating that areas closer to the border acting as ‘sinks’ while areas with low hunting pressure as the 'source'. It becomes important; therefore, to continue with a long-term monitoring of game species abundance to determine if abundance is changing.

Line transect surveys yield higher encounter rates for more active animals but tend to underestimate secretive and cryptic species, especially wild cats. Although encounter/ detection rates cannot directly be compared using line transects and camera trap, sampling methods yield opposite results for mean encounter rates of animals based on body size and conservation value. Camera traps yield greater encounter rates for larger animals than medium and small animals as it does for species of conservation concern. Camera traps capture mostly terrestrial birds and mammals but encounter rates have wider confidence intervals, an indication that sampling effort need to increase. The sampling effort can be increased by deploying more and keeping cameras active for extended time periods. Although both survey techniques complement each other, line transects requires more effort and resources compared to camera trapping.

Many game species play a critical role in tropical forests serving as seed dispersers and herbivores, their absence affects forest structure and composition (Stoner et al. 2007), through limited seed dispersal (Muller-Landau 2007), lowering germination success as seeds do not experience gut passage (Traveset & Verdu 2002), lowering seed predation (Corlett 2007) and finally, hunting alters the plant species composition and spatial distribution of the seedling and sapling layers (Nunez-Iturri & Howe 2007, Wright *et al.* 2007 & 2003). Andresen & Laurance (2007) conclude that hunting indirectly affects both diversity and abundance of dung beetles due to a decrease in dung availability. Dung beetles play an important role as seed dispersers as they bury seed with the dung protecting seeds from granivores (Vulinec 2000).

Gregarious species such as White-nose Coati, Ocellated Turkey, Spotted Wood Quail, Collared and White-lipped Peccary are more at risk of experiencing abundance declines than more solitary species like the Red-brocket deer, Crested Guan and Agouti, due to illegal hunting as hunters will take more than one individuals once a drove is encountered.

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