Xaté Stocks in the Chiquibul Forest

An Economic and Ecological Valuation Assessment

2015

An Assessment of Xate Populations In the Chiquibul Forest

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Prepared by: ** Boris Arevalo

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** Corresponding Author: borisarevalo2008@yahoo.com

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INTRODUCTION

Chamaedorea is the largest palm genus in the Central American Region (Henderson *et al.* 1995) and according to the IUCN, an estimated 75% of the species are threatened. In Belize, there are 12 reported species of which three are the most favored in the floral industry being *Chamaedorea elegans, C. ernesti-augustii* and *C. oblongata*; of which the latter two species are known to be of high relative abundance in the Chiquibul Forest.

As a non-timber forest product (NTFP), Xaté *(Chamaedorea spp.)* has gained economic importance in Central America (Bridgewater *et al.* 2006). The leaves of these species *(C. elegans, C. ernesti-augusti, C. oblongata),* are harvested and exported for the international floral industry. The combination of over-harvesting and habitat loss have led to populations in this region becoming progressively vulnerable (Garwood *et al.* 2006; Porter-Morgan 2005). Unsustainable harvesting may lead to target species local extinction. Wicks (2004) and Morgan (2005) indicate that wild xaté plants produce 1 to 2 new leaves per year. These findings are also in accord with those of Endress *et al.* (2006, 2004a), suggesting that harvesting frequency and intensity need to be regulated giving time for harvested plants to recuperate. Porter-Morgan (2007), suggests that overharvesting of plants drastically reduce their reproductive capacity, while others may argue that cutting leaves from plants may create stress, inducing plants to increase leaf production (Endress *et al.* 2004a, b), but if leaf extraction is frequent and intense it may lead to high plant mortality, reduce plant growth and reduce its reproductive capacity (Endress *et al.* 2006).

The Chiquibul Forest shares 45 kilometers of international border with Petén, Guatemala. Satellite imagery shows that forest cover in Guatemala is highly fragmented while in Belize the Chiquibul Forest appears intact. As a result many Guatemalans have been illegally harvesting xaté leaves form the area which has the greatest potential economic value for xaté in Belize (Bridgewater *et al.* 2006). Illegal xaté harvesting in the Chiquibul Forest has been reported since the early 1970s. Since then "xatero" (individuals that harvest xaté leaves) activity has increased, leading to an evident dense trail network specifically for the activity. As a result illegal xate extraction is a threat to the Chiquibul biodiversity, thus the objectives of the study were: i) to determine xaté population abundance and density within the Chiquibul forest, ii) to estimate the gross economic value of illegally harvested Xaté and iii) to calculate the productive capacity of xaté populations (by species) within the Chiquibul Forest.

METHODOLOGY

Study Site

The Chiquibul Forest, located within the Cayo District, covers an area of 176,999 ha (437,376 acres) comprised of three protected areas, namely the Chiquibul National Park (106,838 ha), Chiquibul Forest Reserve (59,822 ha) and the Caracol Archeological Reserve (10,339 ha.). Meerman and Sabido (2001) identified 17 different ecosystems within the area, all being variants of Tropical Broadleaf Forests, except for a pine forest and non-mechanized agriculture category (Figure 1,). The region has a subtropical climate with a marked dry season between February to June and a rainy season coinciding with the hurricane season which starts from July to November (Salas & Meerman 2008). Cretaceous limestone forms the parent rocks found in the western half of the Chiquibul, while Permian meta-sediments are dominant on the east (Cornec 2003). On the extreme southern region of the Main Divide there are volcanic deposits. The soils are generally derived from limestone and are regarded fertile in comparison to other tropical areas but on the steeper limestone slopes Wright *et al.* (1959) classifies the soils as skeletal where the bedrock tends to protrude out as a consequence of the soil layer being a few centimeters thick.

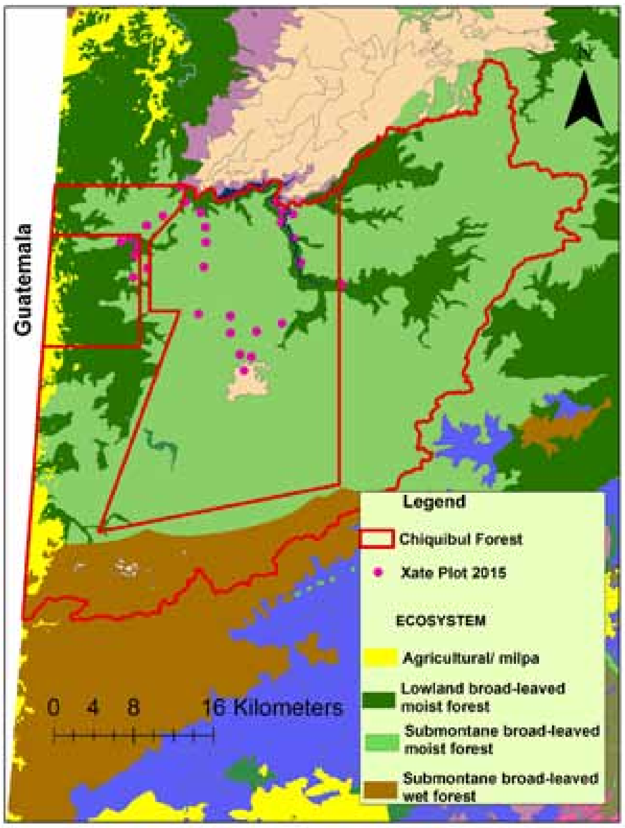

Figure 1: *Ecosystem map of the Chiquibul Forest and spatial distribution of Xaté sampling plots within the study area.*

Xaté Stock Assessment

A total of 30 plots were randomly selected from the 60 plots established in 2012, each having an area of 0.4 ha. Plots established in 2012 followed a systematic sampling design distributed throughout the study area, while covering dominant ecosystems (Figure 1). Plots were established based on the methodology provided by Manzanero *et al.* (2009); Manzanero & Guzman 2003 and Bridgewater *et al.* (2006); each located at least 1 km apart. Existing access routes such as logging roads, tracks, rivers and major xatero trails were employed as transects. The central point of each plot was located at least 300 m away from the transect, distance measured using a GPS and following a cardinal direction; making sure that the closest corner of the plot was located at least 100 m from the transect. Once distancing at least 150 m from the trail, a 300 m transect was established north to south. Each sampling plot was composed of 8 sub-parcels measuring 10 × 50 m. The first sub-plots were located 25 m from the central point of the transect (Figure 2).

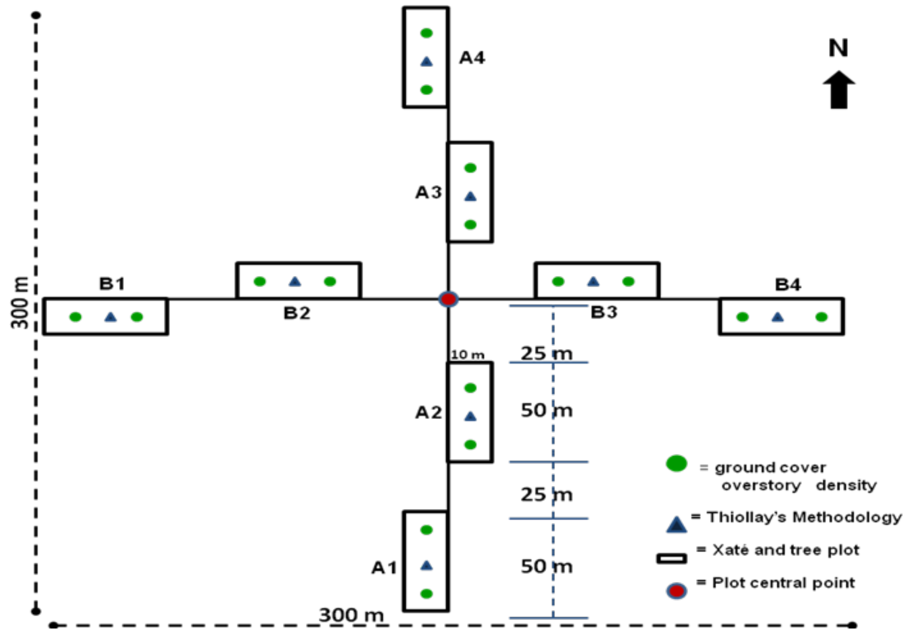

Figure 2: *Xaté sampling plot designed (adapted from Manzanero et al. (2009)).*

Within each of the sub-plots all xaté plants greater than 10 cm in height were identified to the species level and the following data was collected: height (measured to the base of the meristematic leaf); diameter (measured at 10 cm from ground level); development stage (productive plants: plants that had reached maturity meaning those plants that have produced at least 1 commercial leaf [plants not having commercial leaves but with evidence that leaves had been harvested were considered as productive]; regeneration plants: plants that had not reached a productivity stage, meaning that these did not had leaves of harvestable size [for such individuals only the species was recorded]); number of leaves; number of harvested leaves (ascertained by the amount of cut petioles left on the plant); number of commercial grade leaves; number of leaves with signs of herbivory and reproductive state.

Economic Assessment

The economic assessment of the xaté resources in the Chiquibul Forest was carried out at two levels; one based on the already extracted amount of xaté leaves and the other based on potential xaté harvests under a sustainable regime. The used market price for xaté *(C. ernesti-augusti* and *C. oblongata)* was based on the historical market price, where Rainforest Alliance (Guatemala) states that under a non certified marketing scheme a bundle of 600 *C. ernesti augusti* will sell at an average of US $ 38.00; while *C. oblongata* will sell at US $ 10.00 per 600 leaves. It is estimated that on average, 30% of uncertified harvest leaves are rejected (Manzanero 2012, pers. comm.). This factor was used when estimating the gross economical value of illegal extracted leaves but not used for the economical assessment of potential harvested leaves under a sustainable regime because in the field leaves regarded as being of commercial grade satisfied international market standards. In order to extrapolate xaté abundance in the Chiquibul Forest Reserve (CRF) and the entire Chiquibul Forest (CF) it was necessary to calculate the total area within these two zones that are suitable for xaté. Based on the ecosystems map, the total area suitable for xaté in the entire CF is 154,734 ha; while suitable xaté ecosystems in the CFR have an area of 59,022 ha. It should be remembered that forest reserves does permit sustainable harvest of forest products under an appropriate permit issued by the Forest Department.

An important factor to consider when estimating the economical value of available commercial grade xaté leaves was to estimate the xaté population's productive capacity: This was calculated based on the amount of harvestable leaves (by specie) by hectare using the following equation:

$$\textit{Productive Capacity} = IL + (X - IL) / 2$$

Where: IL = inferior limit at a 95% confidence interval
X = mean

RESULTS

A total 19,881 individual plants were measured during the 2015 surveys, translating to a 32.6% increase in abundance compared to the 2012 surveys (Table 1). Regenerating individuals were more abundant in 2015 but not more in productive individuals for the same period. From 2012 to 2015 there was a recorded mortality of 4.3% of which 60.4% were productive individuals. A recruitment rate of 18.18% was recorded with *C. neurochlamys* reporting the highest change of 44.45%, followed by *C. oblongata* (Table 1).

Table 1: *Abundance of individuals, proportional contribution and % change by species of all Chamaedorea spp. measured during 2012 and 2015 surveys.*

Species	Year	Abundance			Proportion (%)	% Change 2012 - 2015
		Productive	Regeneration	Total		
C. oblongata	2012	3769	3819	7588	50.58	---
C. tepejilote	2012	512	2181	2693	17.95	---
C. schippi	2012	1825	261	2086	13.91	---
C. ernesti-augustii	2012	382	1206	1588	10.59	---
C. neurochlamys	2012	464	573	1037	6.91	---
C. oblongata	2015	6022	4761	10783	54.21	42
C. tepejilote	2015	843	2433	3276	16.47	21.6
C. schippi	2015	1764	645	2409	12.11	15.48
C. ernesti-augustii	2015	454	1461	1915	9.63	20.6
C. neurochlamys	2015	823	675	1498	7.53	44.45

C. oblongata recorded greatest density of the five recorded species, while *C. neurochlamys* had the least (Figure 3). Density patterns were maintained for both surveys but *C. oblongata* recorded an increase density change of 42.2% from 2012 to 2015. Development stage patterns were similar for both surveys (greater productive individual densities), except for *C. oblongata* and *C. neurochlamys* whereby regeneration individual densities were higher during the 2015 survey (Figure 4). *C. ernesti-augustii* recorded the least density for regenerating individuals.

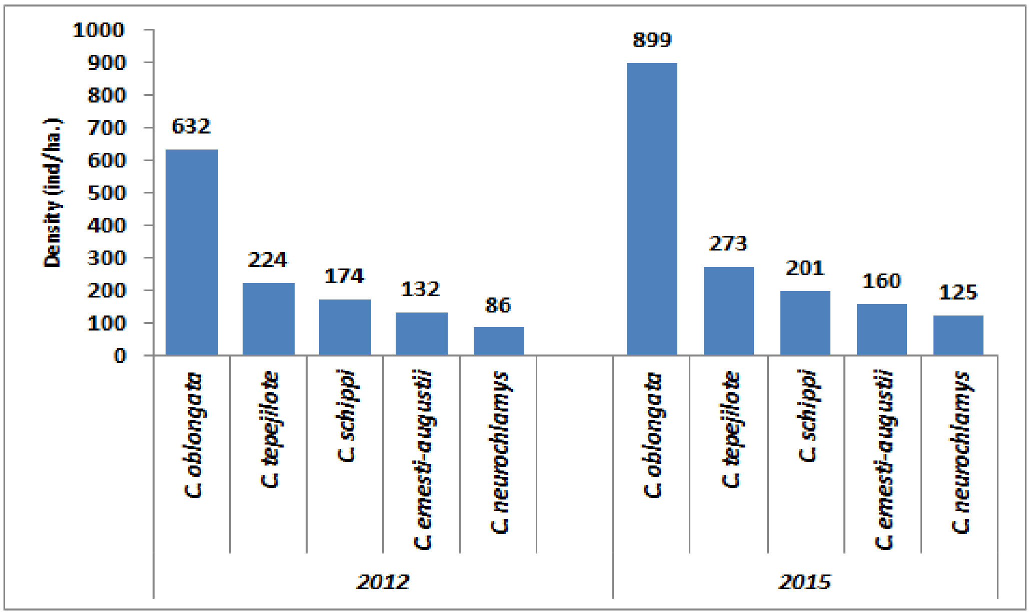

Figure 3: *Overall density of Chamaedorea species recorded during the 2012 and 2015 surveys*

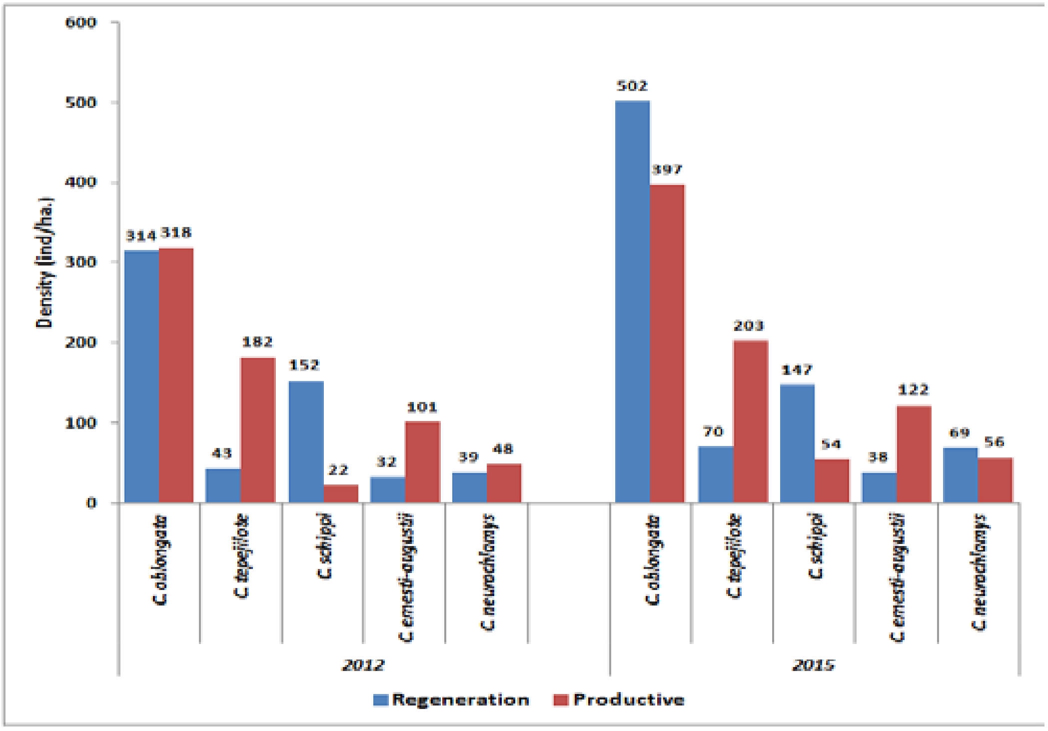

Figure 4: Density of Chamaedorea species recorded during the 2012 and 2015 surveys density by development category

In 2012, Chamaedorea leaves with herbivory represented 57.9 to 73.6 percent of all leaves while in 2015 more than 80% of the leaves by species had been affected by herbivores; significantly affecting commercial grade leave availability (Figure 5).

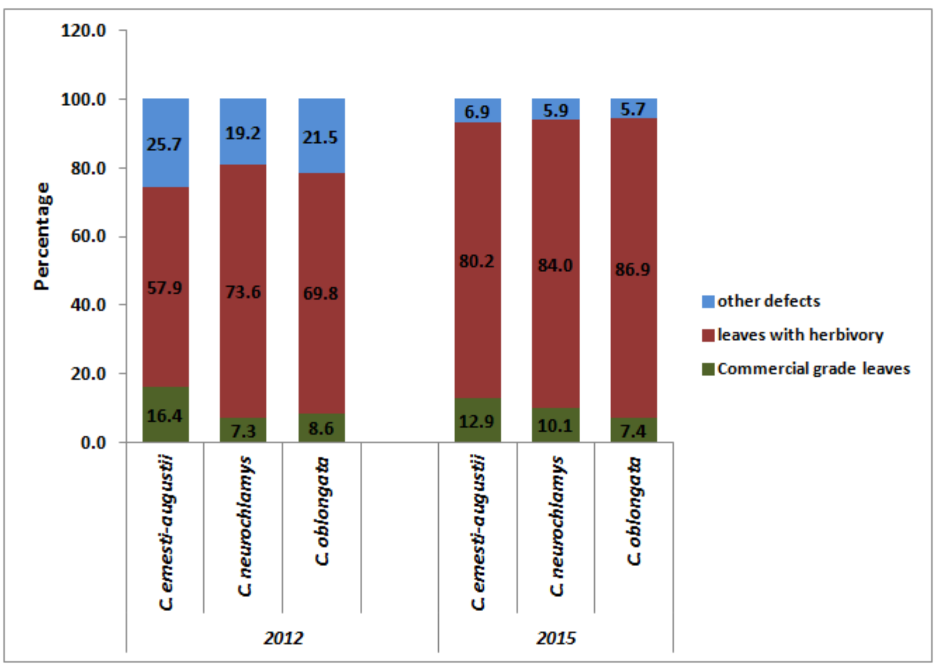

Figure 5: Percentage distribution of leaves by category for the Chamaedorea sp. recorded in the Chiquibul Forest during 2012 and 2015 surveys

Density of illegally harvested *C. ernesti-augustii* was slightly less in 2015 but density of leaves with herbivory increased by 1.9 times when compared to 2012. This pattern was also observed in the other two species but at various percentages. *C. oblongata* appears not to be harvested for commercial purposes as indicated by the density of extracted leaves. Based on mean densities per hectare in 2012 an estimated 16.3 million *C. ernesti-augustii* leaves had been extracted, this was found to have been reduced to 10.8 million in 2015 with an economical value of US$ 482,249.00. Extraction of *C. oblongata* has been minimal for both periods 2012 and 2015 (Table 2).

Table 2: *Density and economical value of illegaly extracted xate leaves in the Chiqubul Forest*

Species	Year	Illegal Extracted Leaves		US $$
		Mean/ ha	CF	
C. ernesti-augustii	2012	105.8	16,335,268	724,197.00
	2015	70.3	10,877,800	482,249.00
C. oblongata	2012	2.5	382,193	4,459.00
	2015	3.6	561,684	6,553.00

From 2012 to 2015 the productive capacity of *C. ernesti-augustii* had increased by 10%, with an estimated value of US$ 0.577 million. On the other hand *C. oblongata* recorded a decrease in its productive capacity by 11.7 % (Table 3).

Table 3: *Productive Capacity and economical value of available xate leaves in the Chiquibul Forest for 2012 and 2015*

Species	Year	Productive Capacity		
		Mean/ ha	CF	US $$
C. ernesti-augustii	2012	53.6	8,290,648	525,074.00
	2015	58.9	9,118,475	577,503.00
C. oblongata	2012	91.255	14,120,251	235,338.00
	2015	81.685	12,639,447	210,657.00

DISCUSSION

Chamaedorea species are widely distributed in the Chiquibul Forest but densities vary greatly across species, similar to the findings of Bridgewater *et al.* 2006. *C. oblongata* was dominant accounting for 50.58% and 54.21% of total abundance during 2012 and 2015 surveys, while *C. ernesti-augustii* (the species targeted for its foliage) was the second least common species, representing 10.58% and 9.62% of recorded abundance in 2012 and 2015 surveys, respectively. This is different from the findings of Bridgewater *et al.* (2006) who reported that *C. ernesti-augusti* accounted for 22% of the absolute abundance recorded. The results indicate a proportional decrease of 0.96% in *C. ernesti-augustii* from 2012 to 2015; as did *C. tepejilote* and *C. schippi* but all species reported an increase percentage change from 2012 to 2015.

Results indicate that over the years, mainly *C. ernesti-augusti* has been targeted by illegal xaté harvesters. During the 2012 surveys, data indicated that 37.72% of all recorded productive plants had signs of leaf extraction, while in 2015 the percentage decreased to 31.2%. During both surveys illegal extraction has been much less than the 86% reported by Bridgewater *et al.* (2006), while the harvested *C. oblongata* plants represented less than 1%. Based on the minimal harvesting density (3.7 leaves/ ha.) compared to the productive capacity (81.685 leaves per ha. in 2015) for *C. oblongata* we may deduct that such leaves may have been cut for different purposes other than for commercialization. Even though this study did not found evidence of illegal extraction of *C. neruochlamys* leaves, abundance and density data of both plants and leaves were collected due to plant and leaf architecture similarity with *C. oblongata*, which may have a potential to be extracted; although at this moment there are no records that it is or has been commercialized.

A major limiting factor affecting the productive capacity of both *C. ernesti-augustii* and *C. oblongata* is the high occurrence of leaves with herbivory. Results indicate that leaves with herbivory for *C. ernesti-augustii* were 3.53 time greater in 2012 compared to the density of commercial grade leaves. In 2015 herbivore damaged leaves increased to 6.24 times more than commercial grade leaves. From a commercial stand point of view herbivory is a major limiting factor but may contribute to the conservation of targeted populations as less commercial grade leaves are available for harvesting, making it a very time consuming endeavor.

Illegal xate harvesting *(C. ernesti-augustii)* has decreased from a density of 105.8 to 70.3 leaves per hectare in 2015 with an estimated economical value of $US 0.724 and $US 0.482 million in 2012 and 2015 respectively. The economical benefits of the extracted NTFP is certainly contributing to improving the livelihoods of Guatemalans found in communities buffering the CF but the true economic impact at the family level is not clear as the number of persons involved in illegal xaté extraction is unknown. On the other hand productive capacity for *C. ernesti-augustii* has slightly increased from 53.6 to 58.9 leaves per hectare in 2015 but the productive capacity for *C. oblongata* has decreased from 91.255 to 81.685 leaves per hectare from 2012 to 2015. Overall the economical value for both *C. ernesti-augustii* and *C. oblongata* presently in the Chiquibul Forest if sustainably harvested is over $US 0.788 million. Although it appears to be an economically viable NTFP industry, the issue of herbivory and illegal extraction needs to be addressed in order to make the industry sustainable over time.

This study did not focus on the impacts of leaf extraction on the reproductive capacity of xate species. However, results indicate that *C. ernesti-augustii* for both 2012 and 2015 had the least density of regeneration individuals and was significantly less than productive individuals. Another species that has significantly less regeneration individuals compared to its productive capacity was *C. tepejilote*. This species is targeted for its inflorescence as it is a plant having a high demand in Guatemalan and Belizean markets.

CONCLUSION

From 2012 to 2015, a decrease change of 50.5% was recorded in the density of illegally harvested xaté leaves in the Chiquibul Forest. The decrease may be attributed to one or more of the following factors: Increase in law enforcement patrols in the Chiquibul Forest; changes in market price and demand for the product; an increase in the density of leaves with herbivory and/or the engagement of xateros in other illicit activities. The results also show that the productive capacity of *C. ernesti-augustii* had a positive change of 9%, also supporting the statement that illegal xaté harvesting has decreased.

Although only *C. ernesti-augusti* has been targeted in the Chiquibul Forest due to its high market value, it is possible that the scenario may shift to *C. oblongata* if demand and price for this species increase or if *C. ernesti-augustii* densities are depleted from the region. Illegally extracted xate had an economical value of $US 482,249.00 while present stocks of harvested sustainable xate will yield a monetary value of $ US 577,503.00 for *C. ernesti-augustii*, and an additional $ US 210,657.00 from *C. oblongata*. For the xate industry to be economically feasible, the issue of leaf herbivory and illegal extraction need to be addressed. Once this occurs, the productive capacity will most likely double.

It is still unclear how illegal extraction has affected the xate populations and can only be answered if the long term monitoring continues. The assessments, however, shows that *C. ernesti-augustii* has the lowest ratio of regenerating individuals and can only be assumed that illegal harvesting has been affecting the reproductive capacity of the species.

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For more information contact:

Friends for Conservation and Development
San José Succotz, Cayo District
Tel: 823-2657
Email: fcd@btl.net
website: www.fcdbelize.org