# A Comparative Analysis of Chamaedorea (Xate) Populations In the Chiquibul Forest

## 2012 to 2018

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***ABSTRACT***

*As a non-timber forest product (NTFP), xate (Chamaedorea spp.) has gained economic importance in Central America where annual xate exports from Guatemala are estimated at USD 4 million. Illegal xate harvesting in the Chiquibul Forest has been reported since the early 1970's but peaked in 2005-2010. The results indicate a significant decrease in the density of illegally extracted xate leaves from 2012 to 2018 for both C. ernesti-augustii and C. oblongata. In 2012, an estimated total of 16,337,332 leaves of C. ernesti-augustii had been illegally extracted from the Chiquibul Forest, compared to 1,650,496 leaves in 2018, this is a 89.9% decrease. The decrease in illegal harvesting also translates to a decrease in the economical value from $ US 724,288.40 in 2012 to $ US 73,171.99 in 2018. Although there is evidence of C. oblongata harvesting it appears not to be at a commercial scale. Some factors or the combination of such that may have attributed to the reduction in the illegal extraction of xate leaves include: Increase in the number and efficiency of law enforcement patrols within the area of influence; changes in international market price for xate; changes in certified NTFP exportation policies which makes it more difficult for illegal harvesters to "laundry" their product into the certified market base; promotion of alternative livelihood projects in poor, rural communities in Peten, and maintenance of a robust binational conservation effort.*

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# A Comparative Analysis of Chamaedorea (Xate) Populations In the Chiquibul Forest: 2012 to 2018

## INTRODUCTION

The genus, *Chamaedorea* (locally referred to as xate) is the largest palm genus in Central America (Henderson *et al.* 1995) with an estimated 75% of the species being threatened. In Belize, there are 12 reported species, including the three most favored species in the floral industry (*Chamaedorea elegans, C. ernesti-augustii* and *C. oblongata)* and harvested from the forests of Mexico, Guatemala and Belize. The latter two species are known to be of high relative abundance in the Chiquibul Forest. Annual xate exports from Guatemala are estimated at USD 4 million (Bridgewater et al. 2006), representing an important income source for many Guatemalan communities in the Department of Petén.

As a non-timber forest product (NTFP), xate (*Chamaedorea spp*.) has gained economic importance in Central America (Bridgewater *et al.* 2006). 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 the target species local extinction. Wicks (2004) and Morgan (2005) reported that wild xate plants produce 1 to 2 new leaves per year, these findings are also in accordance with those of Endress *et al*. (2006, 2004a), thus suggesting that harvesting frequency and intensity need to be regulated, giving time for harvested plants to recuperate. Porter-Morgan (2007), suggest that overharvesting of plants severely reduce their reproductive capacity, while others 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: a reduction in plant growth, reduction in the reproductive capacity and high plant mortality, (Endress *et al.* 2006).

The Chiquibul Forest shares 45 kilometers of an international border with Petén, Guatemala. Satellite imagery shows that forest cover in Guatemala is highly fragmented while in Belize the Chiquibul Forest appears highly intact. As a result, it is estimated that over 1,000 individuals from these communities, have at one time been engaged in illegally harvesting xate leaves from the Chiquibul (Williams et al. 2012), which has the greatest potential economic value for xate in Belize (Bridgewater *et al*. 2006). Illegal xate harvesting in the Chiquibul Forest has been reported since the early 1970's. Since then "xatero" (individuals that harvest xate leaves) activity kept increasing, leading to an evident dense trail network under the forest canopy. As a result, illegal xate extraction has been documented as a threat to the Chiquibul's biodiversity, thus the objectives of the study were to: i) determine xate population abundance and density within the Chiquibul Forest, ii) estimate the gross economic value of illegally harvested xate and iii) calculate the productive capacity of xate populations (by species) within the Chiquibul Forest, and iv) compare mean results of the 2012, 2015 and 2018 field surveys.

## METHODOLOGY

### Study site

The study was carried out in the Chiquibul Forest (CF), which comprises 176,999 ha of protected lands dominated by tropical broadleaf forests (Meerman and Sabido 2001). The CF is an integral part of the Greater Maya Mountains Massif Key Biodiversity Area (Meerman and Wilson 2005, Salas and Meerman 2008, Walker et al. 2008), representing one of the largest contiguous blocks of forest in Central America (Bridgewater 2012). It is composed of 3 protected areas, the Chiquibul National Park (CNP), Chiquibul Forest Reserve (CFR), and Caracol Archaeological Reserve (CAR). The CNP is 106,838 ha, comanaged by the Belize Forest Department (BFD) and Friends for Conservation and Development (FCD); established for biodiversity and cultural conservation. The CFR is 59,822 ha and comanaged by BFD and Bull Ridge Ltd. through a long-term, low-density selective logging license primarily for 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 average daily temperatures of 26°C 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 steeper limestone slopes, Wright et al. (1959) classified soils as skeletal, leading to the semi-deciduous nature of forests in the northern half of the CF.

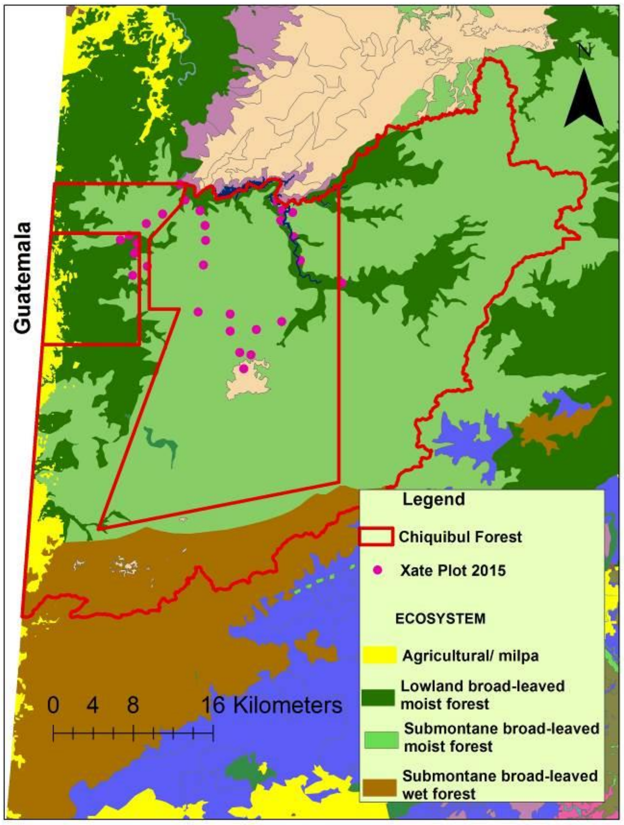


**Figure 1***: Ecosystem map of the Chiquibul Forest and spatial distribution of xate sampling plots within the study area.*

**Xate stock assessment**

A total of 30 plots were surveyed, each having an area of 0.4 ha. Plots followed a systematic sampling design distributed throughout the study area, while covering dominant ecosystems (Figure 1). Plots were established following Manzanero *et al*. (2009); Manzanero & Guzman (2003) and Bridgewater *et al*. (2006) methodology; each located at least 1 km apart. The central point of each plot was located at least 300 m away from any access point (roads, logging tracks, xatero trails, rivers), 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 access point. Once distancing at least 150 m from the trail, a 300 m transect was established North to South, at the mid-point of this transect another 300 m transect was demarcated going 150 m East and 150 m West. Each sampling plot was composed of 8 sub-parcels measuring 10 × 50 m ( Figure 2: Xate sampling plot designed (adapted from Manzanero et al. (2009). The first sub-plots were located 25 m from the central point of the transect.

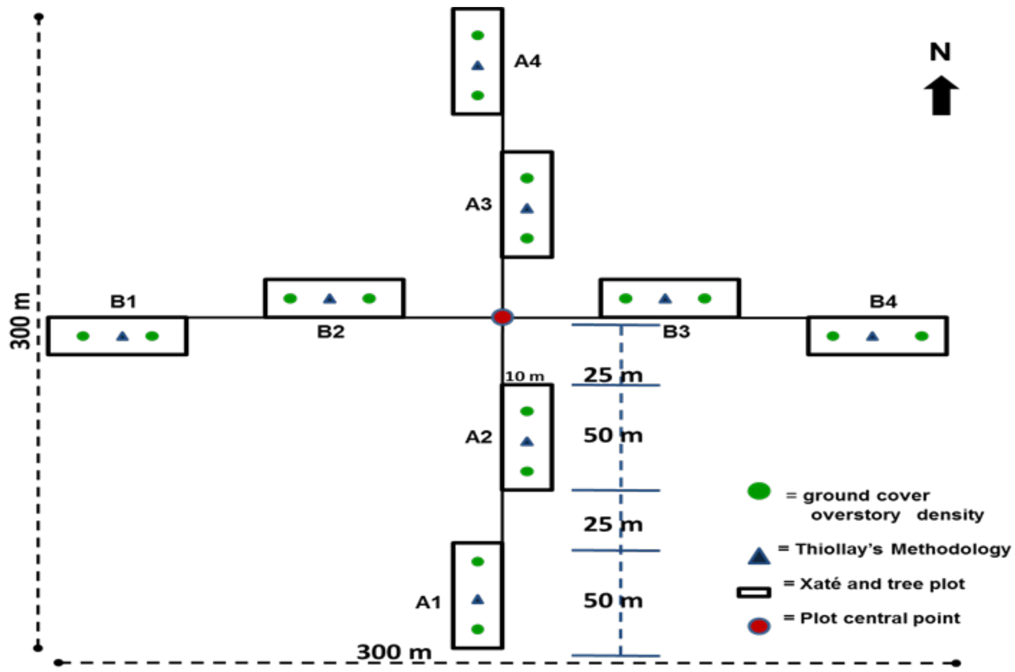


**Figure 2: Xate sampling plot designed (adapted from Manzanero et al. (2009)**

Within each of the sub-plots, all xate plants were identified at 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: 1. productive plants (plants that had reached maturity [have produced at least 1 commercial leaf], plants not having commercial leaves but with evidence that leaves had been harvested were considered as productive); 2. regeneration plants (plants that had not reached a productivity stage, meaning that these did not have 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 the reproductive state.

**Economic Assessment**

The economic assessment of the xate resources in the Chiquibul Forest were carried out at two levels; one based on the already extracted amount of xate leaves and the other based on potential xate harvest under a sustainable regime. The used market price for Xate (*C. ernesti-augustii* and *C. oblongata*) were based on historical market prices. Rainforest Alliance in Guatemala states that under a non-certified marketing scheme a bundle of 600 *C. ernesti augustii* 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 xate abundance in the Chiquibul Forest Reserve (CRF) and the entire Chiquibul Forest (CF) – which includes the Chiquibul National Park, Chiquibul Forest Reserve and the Caracol Archaeological Reserve, it was necessary to calculate the total area within these two zones that are suitable for xate. Based on the ecosystems map, the total area suitable for xate in the entire CF is 154,734 ha; while suitable xate ecosystems in the CFR includes an area of 59,022 ha.

An important factor considered when estimating the economical value of available commercial grade xate leaves was estimating xate population's productive capacity: This was calculated based on the amount of harvestable/ commercial grade leaves (by species) by hectare using the following equation:

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

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

Analysis of Variance (ANOVA) was conducted to investigate if there had been changes in mean abundance of xate from one survey to the other. The data used was from 2012, 2015 and 2018. If ANOVA showed statistical significance at p-value ≤ 0.05, then pair-wise mean comparisons were carried out to investigate which survey data were different. The results presented in this document are concentrated around *C. ernesti-augustii, C. oblongata*, (harvested species in the CF) and *C. neurochlamys* (has harvesting potential).

**RESULTS**

The 2018 survey showed that a total of 18,750 Chamaedorea plants were measured, representing 5 species: C. *oblongata, C. tepejilote, C. ernesti-augustii, C. schippi,* and *C. neurochlamys*. Dominant species was *C. oblongata* representing 53% of recorded abundance, followed by *C. tepejilote* (17%), while the least dominants species were *C. ernesti-augustii* (10%) and *C. neurochlamys* (7%). Of the recorded species, *C. ernesti-augustii* is targeted by harvesters, *C. oblongata* is not being harvested within the Chiquibul Forest at a commercial scale but it is harvested in the Petén Department of Guatemala; *C. neurochlamys* has harvesting potential but not targeted. The inflorescence of *C. tepejilote* are harvested and not the foliage, while no evidence was found that *C. schippi* is being harvested.

Results showed that *C. ernesti-augustii* and *C. oblongata* had an increase in abundance from 2012 to 2018, while *C. neurochlamys* increased in abundance from 2012 to 2015 but had a slight decrease from 2015 to 2018 (*Figure 2*). During 2012 a total of 1,588 *C. ernesti-augustii* plants were recorded while in 2018, abundance increased to 1,883 individual plants. For *C. oblongata* total recorded abundance increased from 7,588 plants in 2012 to 9,954 plants in 2015 and 2018.

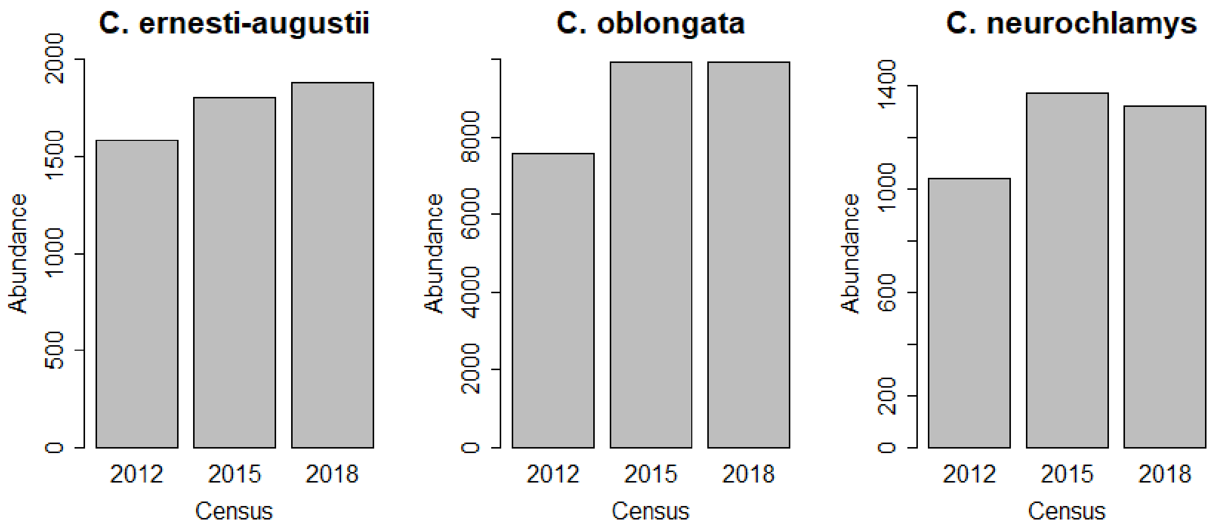


**Figure 2***: Recorded abundance of the three most important Chamaedorea species by census year in the Chiquibul Forest.*

### *Mean Comparisons*

ANOVA results show that the mean productive (F-statistics = 0.801, p-value =0.4522) and regeneration (F-statistics = 0.9458, p-value =0.3923) abundance of *C. ernesti-augustii* was not statistically significant from one survey to the other (*Figure 3*). Similar results were found for the mean abundance of productive (F-statistics = 0.5702, p-value = 0.5675) and regeneration (F-statistic = 1.099, p-value = 0.3377) of *C. oblongata* and *C. neurochlamys* (productive: F-statistics = 0.193, p-value = 0.8248; regeneration: F-statistics = 0.7789, p-value = 0.4621) (*Figure 3*).

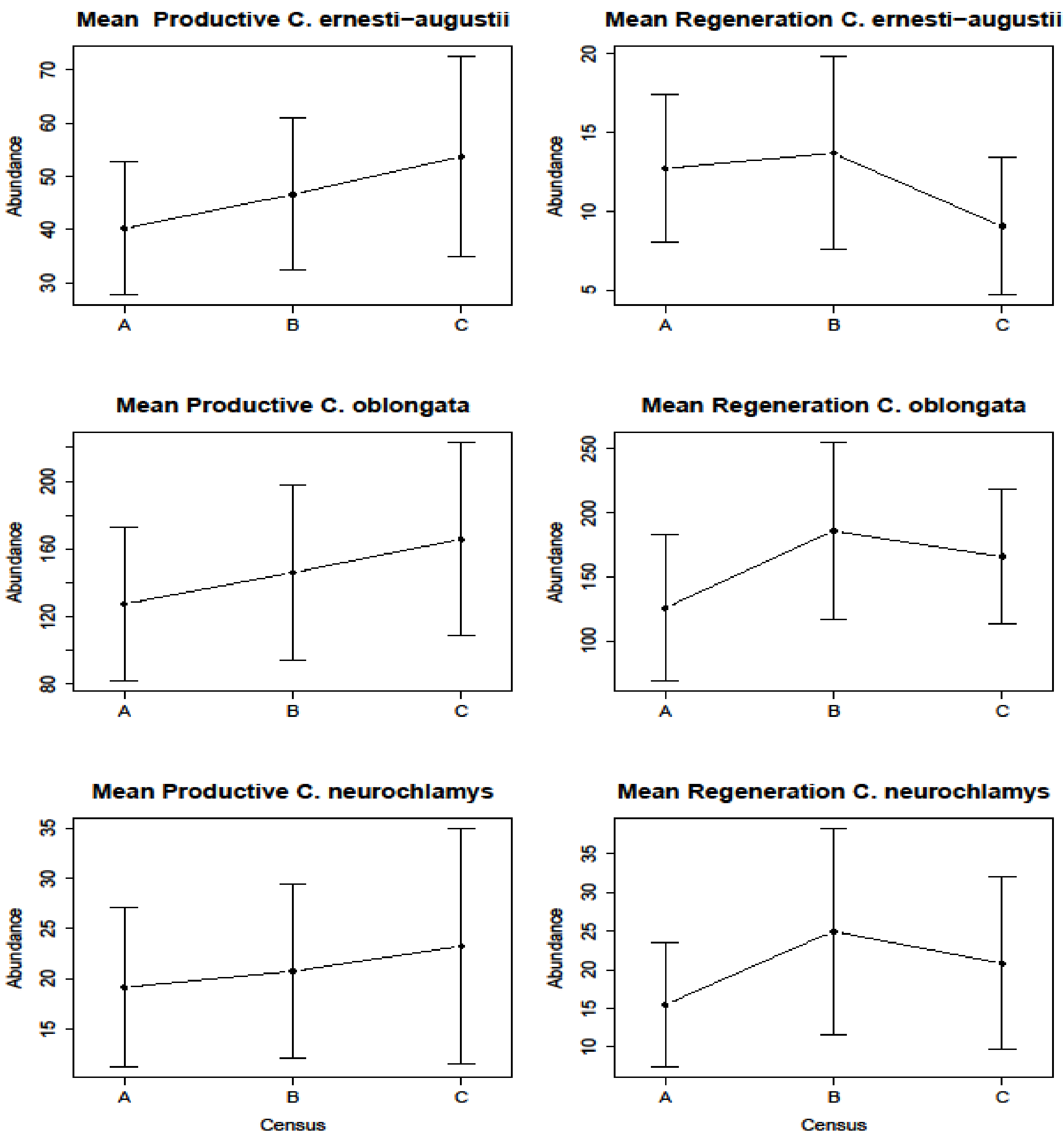


***Figure 3:*** *ANOVA for productive and regeneration plants of C. ernesti-augustii, C. oblongata and C. neurochlamys. A = 2012 survey, B = 2015 survey, C = 2018 survey.*

Mean abundance of total available leaves for *C. ernesti-augustii* was statistically significant different from one survey year to the other (F-statistics = 4.37, p-value = 0.01554, *Figure 4*). A pair-wise mean comparison showed that mean leaf abundance was significantly greater in survey 2018 compared to survey 2012 (t-value = 2.944, p-value = 0.0114). On the other hand mean available leaf abundance of *C. oblongata* (F-statistic = 0.8941, p-value = 0.4127) and *C. neurochlamys* (F-statistic = 0.2427, p-value = 0.785) were not statistical, significantly different from one survey year to the other (*Figure 4*).

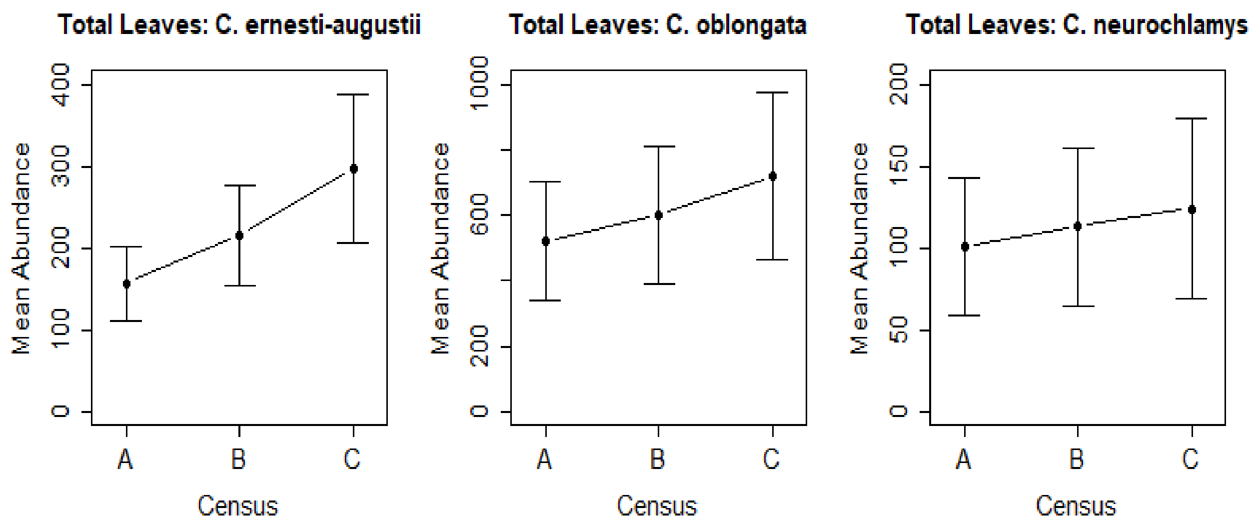


***Figure 4:*** *ANOVA for the mean abundance of available leaves of C. ernesti-augustii, C. oblongata and C. neurochlamys. A = 2012 survey, B = 2015 survey, C = 2018 survey.*

Analysis of variance for the mean abundance of *C. enersti-augustii* leaves damaged by herbivores showed to be statistical, significantly different (F-statistic = 6.919, p-value = 0.001627) from one survey year to the other ( *Figure 5*). Pair-wise mean comparisons showed that the mean abundance of *C. ernesti-augustii* leaves with herbivory were significantly greater during 2018 than in 2012 (t-value = 3.68, p-value = 0.00119) and significantly greater in 2015 than in 2012 (t-value = 2.31, p-value = 0.05). The mean abundance of *C. oblongata* leaves with herbivory were not significantly different (F-statistic = 2.281, p-value = 0.1082) from one survey year to the other (*Figure 5*).

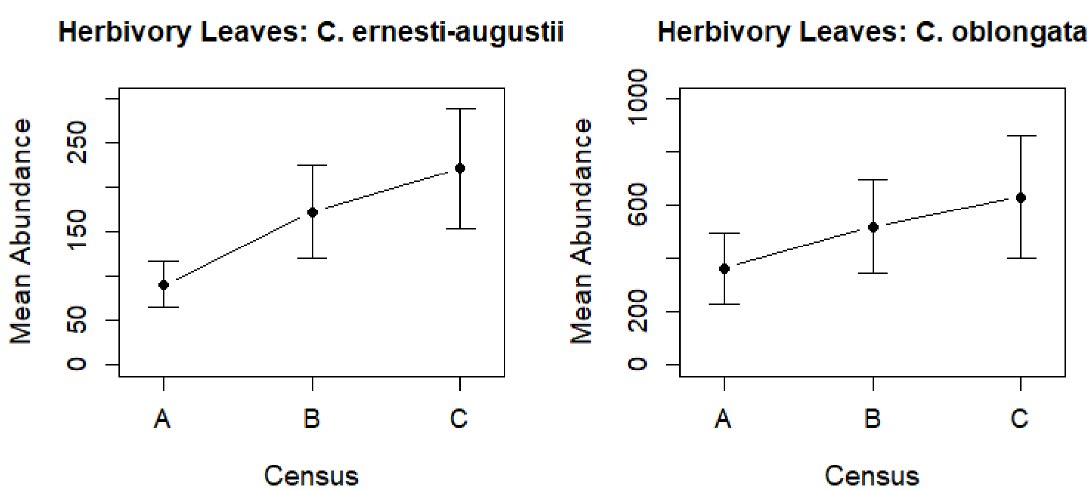


***Figure 5:*** *ANOVA for the mean abundance of leaves damaged by herbivory for C. ernesti-augustii and C. oblongata in the Chiquibul Forest. A = 2012 survey, B = 2015 survey, C =2018 survey.*

ANOVA results showed that the mean abundance of cut or illegally harvested leaves of *C. ernesti-augustii* were statistical, significantly different (F-statistic = 11.84, p-value = 2.836e-05) from one survey to the other (*Figure 6*). Pair-wise mean comparison showed that mean abundance of cut leaves in survey 2018 was statistical, significantly less than in 2012 and 2015 (2012 and 2018: t-value = 4.813, p-value = 1e-04, 2015 and 2018: t-value = 3.026, p-value = 0.00902). There was no statistical, significant difference in mean abundance of cut leaves for *C. oblongata* from 2012 to 2018 (F-statistics = 0.4798, p-value = 0.6205, *Figure 6*).

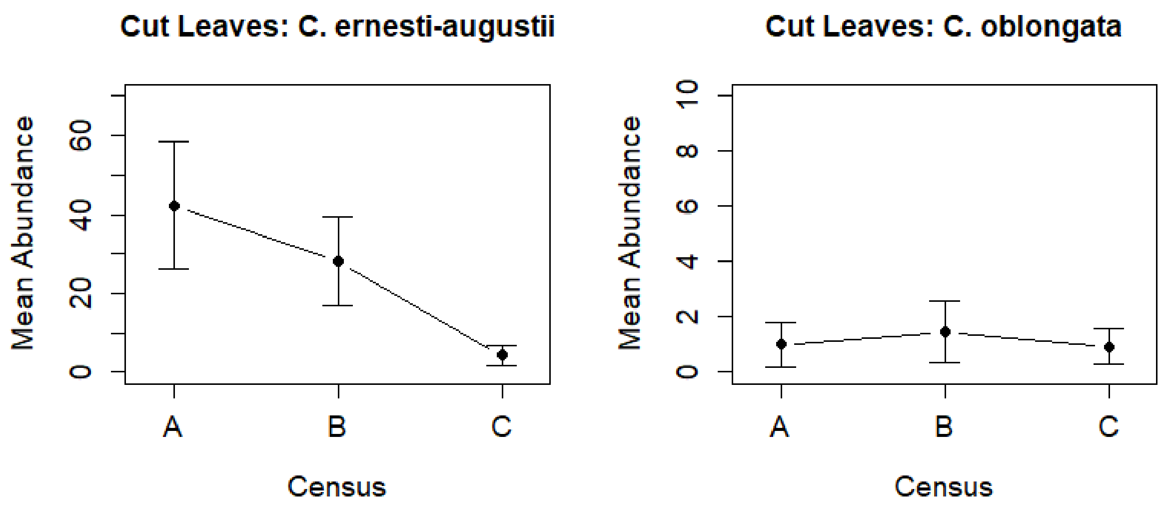


***Figure 6:*** *ANOVA for the mean abundance of cut/ illegally harvested leaves for C. ernesti-augustii, and C. oblongata in the Chiquibul Forest. A = 2012 survey, B = 2015 survey, C = 2018 survey.*

Mean abundance of commercial grade leaves was not statistical, significantly different from one survey to the other for both *C. ernesti-augustii* (F-statistic = 0.7888, p-value = 0.4576) and *C. oblongata* (F-statistic = 0.9268, p-value = 0.3997) [*Figure 7*].

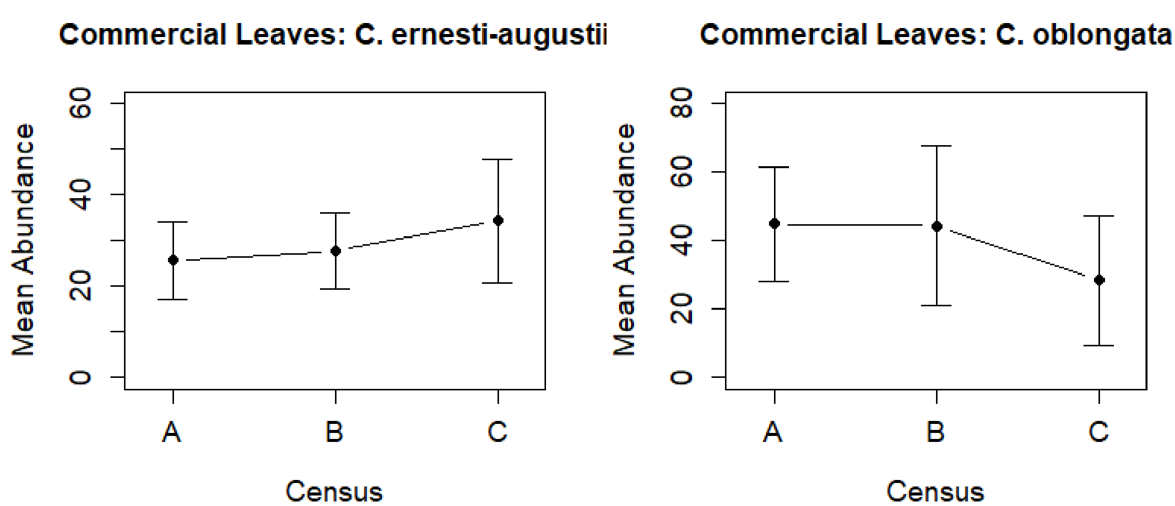


***Figure 7:*** *ANOVA for the mean abundance of commercial grade leaves of C. ernesti-augustii, and C. oblongata within the Chiquibul Forest. A = 2012 survey, B = 2015 survey, C = 2018 survey.*

***Density***

There was an increase in the density (individuals/ha) of productive *C. ernesti-augustii* and *C. oblongata* from 2012 to 2018 but for the regeneration class an increase was observed only from 2012 to 2015 and a decrease in density from 2015 to 2018 (*Figure 8*).

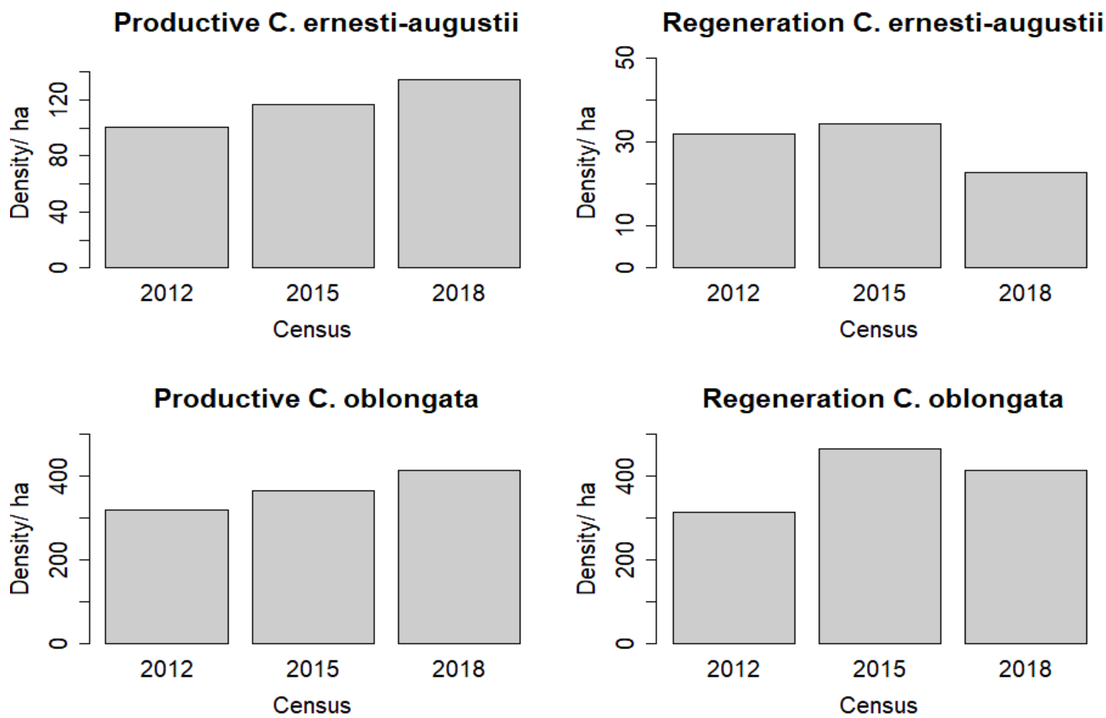


***Figure 8:*** *Density per hectare of productive and regenerating C. ernesti-augustii and C. oblongata per census in the Chiquibul Forest.*

A significant decrease in the density of illegally extracted xate leaves was observed from 2012 to 2018 for both *C. ernesti-augustii* and *C. oblongata* (*Figure 9*). In 2012, an estimated total of 16,337,332 leaves had been illegally extracted from the Chiquibul Forest, compared to 1,650,496 leaves in 2018. The decrease of illegal harvesting also translates to a decrease in the economic value (*Table 1*). Although there is evidence of *C. oblongata* harvesting (*Figure 9*) it appears not to be for a commercial nature as indicated in the economic analysis. This pattern is similar to the ANOVA results for the mean abundance of cut/ illegally harvested leaves.

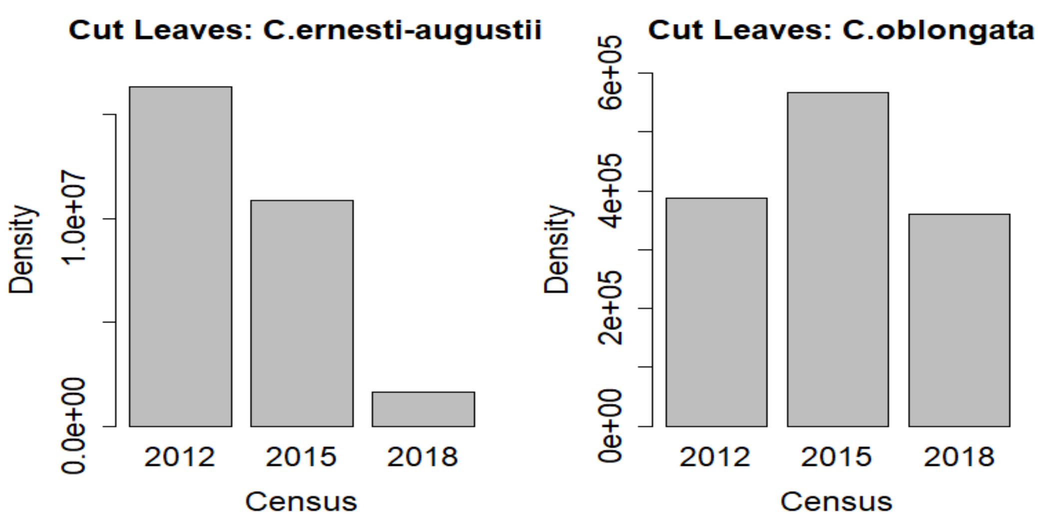


***Figure 9****: Density of cut/ illegally harvested C. ernesti-augustii and C. oblongata leaves in the Chiquibul Forest from 2012 to 2018.*

***Table 1:*** *Economical value of illegally cut xate leaves in the Chiquibul Forest from 2012 to 2018.*

| Species | Year (Census) | Economic value (US $) |
|---|---|---|
| ***C. ernesti-augustii*** | 2012 | 724,288.40 |
| | 2015 | 482,477.80 |
| | 2018 | 73,171.99 |
| ***C. oblongata*** | 2012 | 4,513.08 |
| | 2015 | 6,619.18 |
| | 2018 | 4,212.20 |

Results showed an increase in the density of commercial grade leaves of *C. ernesti-augustii* from 8,298,384 leaves in 2012 to 10,665,815 leaves in 2018, with an increase in economic value from $ US 525,564.30 to $ US 675,501.60 in the same time period (Table 2).
A decrease in the density of commercial grade leaves was recorded for *C. oblongata* from 2012 to 2018 (Table 2).

**Table 2:** *Density of available commercial grade leaves and economical value under a sustainable harvesting regime for C. ernesti-augustii and C. oblongata in the CF*

| Species | Year (Census) | Sustainable Productive Capacity | | Economic Value (US $) |
|---|---|---|---|---|
| | | Mean Density/ ha. | CF | |
| ***C. ernesti-augustii*** | 2012 | 53.63 | 8,298,384 | 525,564.30 |
| | 2015 | 59.09 | 9,143,232 | 579,071.40 |
| | 2018 | 68.93 | 10,665,815 | 675,501.60 |
| | | | | |
| ***C. oblongata*** | 2012 | 91.24 | 14,117,930 | 235,298.80 |
| | 2015 | 81.51 | 12,612,368 | 210,206.10 |
| | 2018 | 47.48 | 7,346,770 | 122,446.20 |

**DISCUSSION AND CONCLUSION**

Of the five recorded Chamaedorea (xate) species, only three show evidence of being harvested in the Chiquibul Forest, two species for the fronds (*C. ernesti-augustii, C. oblongata*) and one for the inflorescence (*C. tepejilote*). C. *schippi* and *C. neurochlamys* showed no evidence of being harvested but may have potential, especially *C. neurochlamys* as the fronds resemble those of *C. oblongata*. Of the harvested xate species *C. ernesti-augustii* is favoured by illegal harvesters and for this reason the species harvesting study focused on *C. ernesti-augustii*, *C. oblongata* and *C. neurochlamys* (harvesting of *C. tepejilote* was not considered since there is no mechanism of quantifying the rate of extraction by illegal harvesters, compared to the other harvested species in which the petiole base of the harvested frond stays attached to the plant).

For all Chamaedorea species, an increase in abundance was observed from 2012 to 2018. Although ANOVA results were not significant statistically, mean abundance of productive plants for targeted species showed an increasing trend that can be biologically significant to highly disturbed populations, which may indicate that harvested populations are in a state of early recovery. On the other hand, mean abundance of regenerating individuals show an increase from 2012 to 2015 but decreased from 2015 to 2018. These differences were not statistically significant but a biological trend can be observed. The decrease in mean abundance of regenerating plants may be attributed to the impacts of Hurricane Earl on August of 2016. Although a category one hurricane can severely impact canopy cover, in some plots a 50-100 forest canopy was destroyed, causing an increase in sunlight reaching the forest floor. Recorded Chamaedorea species are direct sunlight intolerant, as the species are strictly understorey plants.

The results indicate that there was a significant statistical decrease in the mean abundance of cut/ illegally harvested leaves of *C. ernesti-augustii* from 2012 to 2018, which also concurs with the statistically significant increase in mean abundance of total available but no significant mean difference was recorded for commercial grade leaves from 2012 to 2018. The main reason why the observed increase in commercial grade leaves was not statistically significant can be attributed to the statistically significant increase in mean abundance of leaves (for *C. ernesti-augustii* and *C. oblongata)* with herbivory damage from 2012 to 2018. Many xate leaves showed other blemishes that can be attributed to Hurricane Earl impacts, which also added to the reduction in mean abundance of commercial grade leaves by species.

A significant decrease in the density of illegally extracted xate leaves was observed from 2012 to 2018 for both *C. ernesti-augustii* and *C. oblongata*. In 2012, an estimated total of 16,337,332 leaves of *C. ernesti-augustii* had been illegally extracted from the Chiquibul Forest, compared to 1,650,496 leaves in 2018, this is a 89.9% decrease. The decrease in illegal harvesting also translates to a decrease in the economical value from $ US 724,288.40 in 2012 to $ US 73,171.99 in 2018. Although there is evidence of *C. oblongata* harvesting it appears not to be at a commercial scale, evident on mean abundance of cut leaves and density of extraction per hectare. 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 individuals involved in illegal Xate extraction is unknown. It is still unclear how illegal Xate extraction has affected target populations and can only be answered if long term monitoring continues. What the assessments have shown is that *C. ernesti-augustii* has the lowest ratio of regenerating individuals to productive plants and can only be assumed that illegal harvesting has been affecting the reproductive capacity of the species.

The productive capacity of *C. ernesti-augustii* increased by 28.3% from 2012 to 2018 and presently 10,665,815 leaves can be extracted under a sustainable regime with an economical value of US$675,501.60. On the other hand there was a decrease of 48% in available commercial grade leaves of *C. oblongata* from 2012 to 2018, which if harvested can have a monetary value of US$122,446.20. 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.

The results of the 2018 xate stock assessment in the Chiquibul Forest clearly indicate (statistical and biological significant) that the rate of illegal extraction of *C. ernesti-augustii* leaves has reduced by 89.9% compared to 2012. This finding is also supported by the 28.3% increase during the same time period, in the productive potential of targeted species. Some factors or the combination of such that may have contributed to the reduction in the illegal extraction of xate leaves include: 1. Increase in the number and efficiency of law enforcement patrols within the area of influence, 2. Changes in international market price for xate, 3. Changes in certified NTFP exportation policies which makes it more difficult for illegal harvesters to "laundry" their product into the certified market base, 4. Reduction in the availability of commercial grade leaves from 2012 to 2015, making it more difficult for harvesters to harvest at an economically viable rate, 5. Change in practice of financial generating activities within their communities, and 6. Constant bi-national work with Belize and Guatemalan NGO in public education and increase law enforcement patrol within and around identified hotspot communities in Guatemala.

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