Illegal Logging In The Chiquibul Forest

An Economic and Ecological Valuation Assessment

Mitigating and Controlling Illegal Logging in the Chiquibul Forest

From: Friends for Conservation and Development (FCD)

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ABSTRACT

The Chiquibul Forest is the largest single block of protected forest in Belize and is part of the Chiquibul-Maya Mountains Key Biodiversity Area. Like many protected areas within Belize and with no exception to the Mesoamerican region it is faced with increasing anthropogenic threats, such as illegal logging. The main objectives of this study were to i) calculate the volume and economical value of timber illegally extracted and ii) quantify the ecological impact being caused by illegal logging. The Smalian's formula was used to calculate timber volume, from illegally logged trees along 300m wide transects, ranging from 1 to 4.6 km in length. The results indicate that primarily Mahogany *(Swietenia macrophylla King)* and Cedar *(Cedrela odorata L)* were targeted, having mean diameter at cut height of 0.57 m (± 0.13). The data shows that an average of 627.42 and 909.15 board feet of mahogany and cedar respectively has been extracted from each logged tree. This means that within the Chiquibul Forest an estimated 5,803,538 board feet of lumber with an aggregated value of US$9,448,144.00 have been extracted illegally within a zone of influence of 34,188.74 ha. The practice is extremely wasteful, given that 34.5% and 30.5% of the commercial bole length of Cedar and Mahogany trees, respectively, is not harvested by illegal loggers; translating to an aggregated economical value of US$3,058,075.00. In addition to the negative economical impacts that illegal logging is having on Belize, it has a myriad of ecological impacts since a total area of 393.17 ha. (92,316 damaged trees) have been deforested directly by this activity. The results indicate that illegal logging in the Chiquibul Forest is a well organized activity that needs to be addressed by corresponding authorities before targeted populations are further depleted.

INTRODUCTION

Belize has the greatest percentage (62.7%) of forest cover in the Mesoamerican Region (Cherrington et al. 2010); where 36% of its terrestrial component is under some form of legal protection. The Chiquibul Forest (CF) composed of the Chiquibul Forest Reserve, Chiquibul National Park and the Caracol Archeological Reserve is the largest single block of protected forest in Belize and is part of the Chiquibul-Maya Mountains Key Biodiversity Area. Like many protected areas within Belize and with no exception to the Mesoamerican

region it is faced with increasing anthropogenic threats which are altering natural processes. Presently illegal logging, mainly by Guatemalans, is considered as the most important source of stress for biodiversity conservation. Presently there are no human settlements within the CF but along the 54 km international border shared with Guatemala there are about 68 Guatemalan settlements, mostly poor and highly dependent on the immediate forests of the Chiquibul. Satellite imagery clearly shows a high degree of deforestation in Guatemalan territory, unlike Belize (Bridgewater et al. 2006). This adds pressure to the forest resources of the CF.

Illegal logging has become an issue of global concern, causing governmental revenue loss in the billions and a contributing factor to low timber prices. It is estimated that 80% of the timber harvested in Bolivia is illegal, while in Brazil 80% and in Columbia 42% of all timber has an illegal origin (Guertin 2003). For Central American countries such as Honduras and Nicaragua, the Forest Integrity Network (2003) reports an annual net loss of US$12-18 and US$8-12 million respectively, as a consequence of illegal logging. While the LMB Daily (2003) states that Indonesia is losing an estimated US$600 million annually to illegal logging. In the US, illegal logging in national forests represents a loss of at least US$1 billion (FIN 2003).

In late 2010, Friends for Conservation and Development (FCD), the co-managing institution for the Chiquibul National Park, identified an illegal logging "zone of Influence," with an estimated area of 22,000 ha. running parallel to the Belize-Guatemala Western Border. In order to quantify the magnitude of the problem, an assessment was conducted between the period 2010 – 2012, with the following objectives: i) calculate the volume of timber illegally extracted, ii) calculate the economic value of the illegally extracted timber iii) calculate the volume of timber left as waste by illegal loggers; iv) calculate the area being deforested by the felling of timber trees; v) calculate the number of damaged trees by the illegal felling of timber trees and vi) conduct a diagnosis of the severity of illegal logging by estimating the "illegal logging zone of influence."

Background

Illegal logging within the CF was first detected by FCD in 2006, but appeared to be a single and isolated case in the area of Rio Blanco (on the extreme south-west of the CNP). In March of 2008, a multi-agency patrol in the area documented that illegal logging was escalating and an evident logging trail network was observed. In late 2009, aerial flights conducted by FCD recorded numerous illegal logging clusters with flitches observed awaiting transportation. By 2010, the Belize Defense Force patrols reported relentless illegal logging. Observing the magnitude of the problem FCD started to document the activity but lacked necessary data to calculate volume of lumber illegally logged in the CF.

Illegal logging is conducted using chain saws. Loggers first hunt for trees of interest, then return on a further date to fell these, cut logs and process these into flitches. Flitches are mostly 4 inches in height by 8 feet in length with varying widths. Flitches are usually left standing to sundry in order to facilitate transportation, which is primarily conducted by using horses. Illegal loggers conduct their activities during the day and or night depending on the location and evidence of patrol activities; making law enforcement difficult.

Definition of illegal logging

Presently there is no universal definition for illegal logging (Rosander 2008). Definition differ from country to country due to differences in the use of the term within a country's laws overseeing the harvesting and extraction of timber and non-timber forest products (NTFP). Although there is the existence of no universal definition all available definitions share common elements, namely that of harvesting forest products in violation of national legislation, ratified international conventions and treaties (World Bank 2006).

The European Union Action Plan for Forest Law Enforcement, Governance and Trade (EU/FLEGT), defines illegal logging when timber is harvested in violation of national laws (European Commission 2003); while Brack and Hayman (2001) state that illegal logging not only includes the harvesting of timber but also when it is transported, bought or sold in violation of national laws. Contreras-Hermosilla (2002) provides

a more detailed definition of illegal logging, which includes "unauthorized occupation of public and private forest lands, logging in protected or environmentally sensitive areas, harvesting protected tree species, woodland arson, wildlife poaching, unlawful transport of wood and other forest products, smuggling, transfer pricing and other fraudulent accounting practices, unauthorized processing of forest products, violation of environmental regulations and bribing government officials.

Management and harvesting of timber and NTFP in Belize is regulated by the Forest Act Chapter 213 of the Laws of Belize and its Subsidiary Instruments and The Private Forest Conservation Act, Chapter 217 of the Laws of Belize. The Forest Act notes that: *no person except by virtue of and subject to the conditions of any license a.) cut, girdle, burn or injure any tree, b) collect, prepare, use or remove any forest produce; in any forest reserve (protected area) or in national and private lands to which the provisions of the Act have been applied.* It is clear that the harvesting of timber or other NTFP is legal only with due permit or license. Part V, Section 28 of the Subsidiary Laws indicates that *"No person shall transport, or allow to transport any timber (other than sawn lumber) by any public road except if the timber is accompanied by a waybill." In addition, the Subsidiary Laws indicate that "No person shall export or attempt to export wild animals, products of wild animals, plants (other than cultivated plants), spices or seeds unless an application has been made by him to the Minister and his permit obtained authorizing the export."*

Therefore, according to the Belizean legislation, illegal logging involves the harvesting of timber, its transport and financial transaction in violation of national legislation; similar to that of Brack and Hayman (2001) and Contreras-Hermosilla (2002).

Impacts of illegal logging

Rosander (2008), states that illegal logging is related to corruption and organized crime; it fuels poverty and widens the gap between the powerful and the powerless and restricts access to natural resources. Coupled with the above, illegal logging has economical, social and ecological impacts (Lawson & MacFaul 2010; Li et al. 2008; Rosander 2008; Sheikh 2008; World Bank 2008). The World Bank (2006) estimates that in developing countries illegal logging causes an annual loss of more than US$ 15 billion and is responsible for lowering the price of wood products (up to 16% on certain products) globally (Lawson 2007) and constitutes 10% of the global timber trade (RIIA 2003). It is sometimes argued that weak law enforcement benefits the poor as they can make use of the forestry resources without paying due taxes (World Bank 2006). On the other hand many rich and powerful individuals are involved in illegal logging activities and usually employ the rural poor who gain marginal benefits (World Bank 2006) and are usually the ones processed by law enforcement units.

Illegal logging causes a wide array of ecological impacts (Lawson & MacFaul 2010; Sheikh 2008). Some direct impacts include the loss of biodiversity (in many cases depletion of wild animal populations that depend on ecosystems being logged) and if this occurs within protected areas, as in the case of the Chiquibul Forest, important biological and ecological functions are altered (Lawson & MacFaul 2010). Since illegal logging is carried with no regards of protecting the ecological integrity of the system, it leads to many collateral damages including damage to other tree species, decreases the amount of standing seed trees (reducing seed banks, which is directly linked to reduction of targeted species natural regeneration ability), deforestation (Rosander 2008), increase the risk of forest fires and lowers the potential for sustainable harvesting of timber species (Lawson & MacFaul 2010), which may also lead to soil erosion and sedimentation, causing water pollution.

METHODOLOGY

Site Description

The Chiquibul Forest, located within the Cayo District, covers an area of 176,999 ha (437,376 acres) and is 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), with central UTM coordinates 1,878,200 – 1,871,800 North and 265,600 – 322,600 East. 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 south of the Main Divide there are volcanic deposits. According to Wright et al. (1959) the soils are generally derived from limestone and are regarded fertile in comparison to other tropical areas but on the steeper limestone slopes the soils are skeletal.

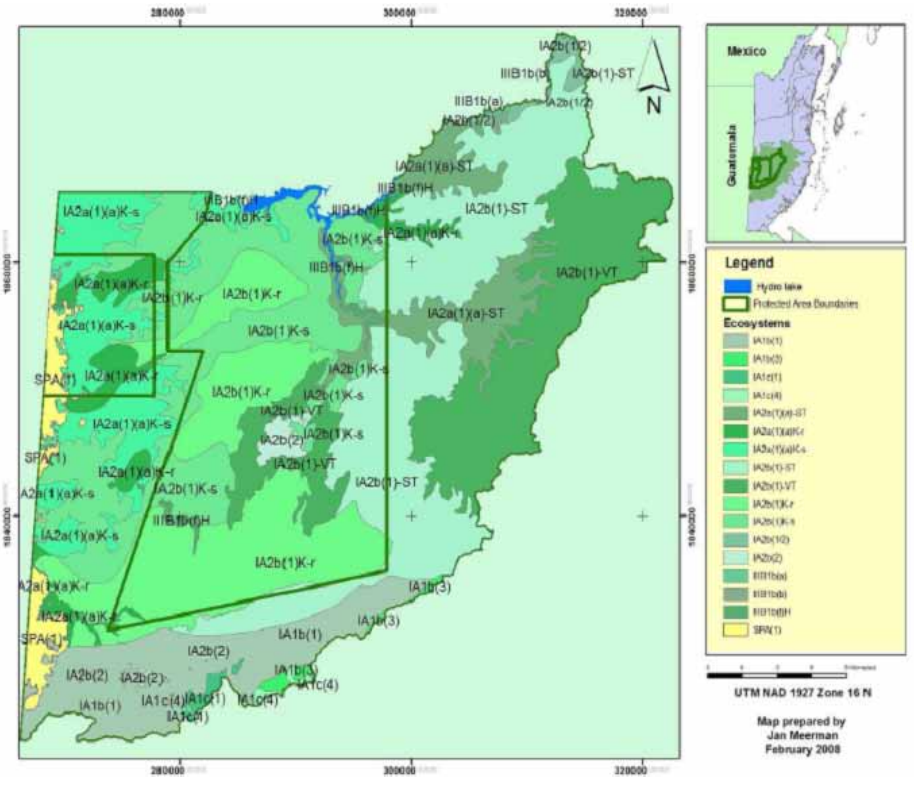

Figure 1: *Ecosystem map of the Chiquibul Forest.*

Data collection

Data was collected from 2011 to mid 2012, along major xatero trails which were regarded as transects (Figure 2). Transects vary in length (from 1 to 4.6 km). This type of transects were used over stratified random rectangular plots mainly as a consequence of security issues. It became very dangerous to be for more than half an hour in one location and above all causing noise as a consequence of opening plot boundaries, as illegal loggers were frequent around the working site. The use of transects allowed to move fast from one location to the next and prevented most associated noise. The use of trails as transects also allowed to cover greater area accounting for more variability. All logged trees that were within a perpendicular distance of 150 m from either sides of the trail were identified and measured.

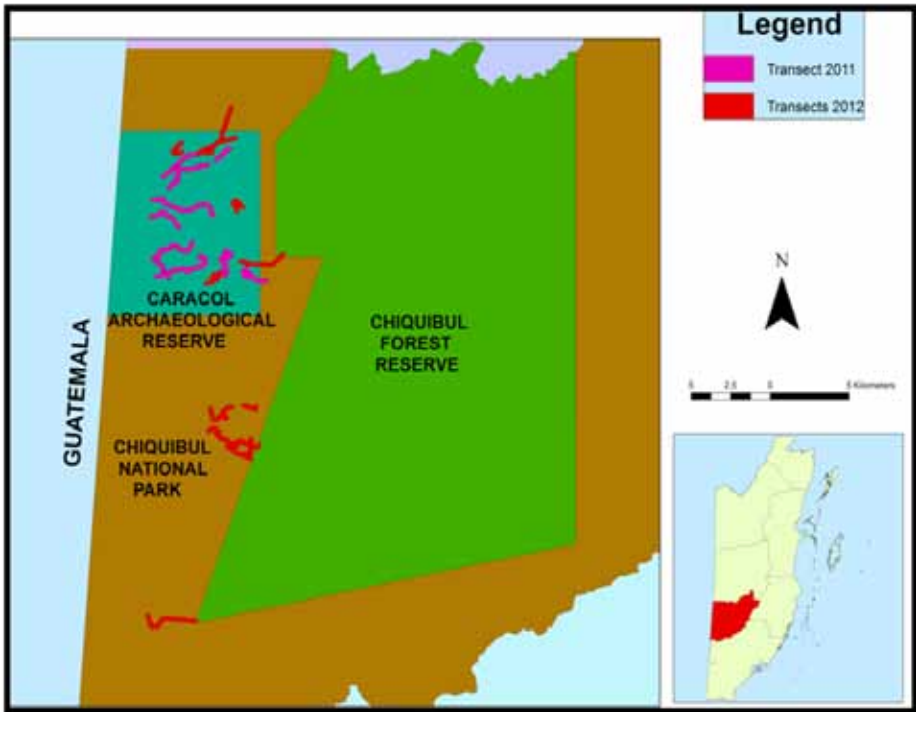

Figure 2: *Distribution of transects within Chiquibul Forest*

The variables that were recorded from each logged tree included: species, perpendicular distance to trail (m), diameter at cut height (cm), diameter at cut end (cm) and commercial bole length (m). In addition, to the above variables, the geographic coordinates were taken for each tree. The diameter of logged trees was measured using a carpenters tape where possible (excluding the trees' bark) or a diametric tape. The commercial bole length (refers to the length of the tree from which lumber can be obtained)

of the trees was regarded as the bole length of the same to the first major fork but if above branches were of suitable diameter and more than or equal to 3 m in length these were also measured both for diameter and length. The commercial bole length was estimated based on field evidence left behind by loggers. This was achieved by estimating a distance between the logged tree stump and the cut end (usually at first major tree branching). Great care was taken to avoid over estimating the length due to log displacement during the felling process; this was achieved by carefully analyzing the area where the tree was sawn.

Timber wastage was calculated by measuring the length and diameter (at both ends) of commercial quality logs left behind by illegal loggers.

In order to quantify the amount of deforestation being caused by felling of tree, the circumference of the area deforested by the felling of each tree was measured using a tape.

Data analysis

Data collected in the field was analyzed using the following software: Microsoft Excel, InfoStat and ArcGIS. In order to calculate the commercial volume of logged trees, the variables diameter at cut height, diameter at cut end and commercial bole length were utilized. The commercial volume of the trees was estimated using the Smalian's Formula (See Formula 1); this formula is based on calculating the volume for the frustum of a paraboloid (Figure 3). Although this formula tends to slightly over estimate the real volume of a tree it was the most accurate in this case as it was only possible to measure the above mentioned diameters as most to all of the commercial length of the trees had been sawn, preventing the measurement of intermediate log diameters. Once the volume of the tree was calculated, it was proceeded to calculate the quantity of board feet. This calculation was conducted following the conversion factor of CONADEH (2009), where it states that 1 m3 of timber in logs will yield 262 board feet if it was to be sawn in a saw mill. The economic value of the timber was calculated based on the current national prices for a board foot of mahogany and cedar. Research on national timber prices indicates that a board foot of mahogany is valued at US $ 1.75, and cedar at US $ 1.50 (US $ 1= Bz $ 2).

Formula 1: Smalian's Formula: $$V = \frac{h}{2}(A_b + A_u)$$

Where:
V = volume
h = commercial bole length of tree
A_b = cross sectional area of tree at cut height
A_u = cross sectional area of tree at cut end

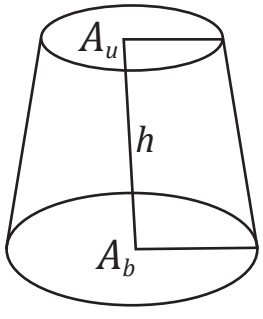

Figure 3: *Diagram showing necessary measurements to calculate tree's commercial volume using Smalian's Formula.*

Zone of Influence

Since illegal logging is not occurring throughout the entire Chiquibul Forest, a zone of influence was identified. The zone of influence refers to the territory within the Chiquibul Forest that has been impacted by illegal logging. The identification of this zone was made possible by projecting the geographic coordinates of catalogued logged trees within the Chiquibul Forest; this data was mainly collected during routine ranger patrols over the last two years (2010 to mid 2012). Once the coordinates were projected using ArcGIS, it was proceeded to draw a polygon by connecting the far extreme points (logged trees with greatest distance into Belizean territory). The "Zone of Influence" was used as a proxy to estimate the severity of illegal logging occurring within the Chiquibul Forest.

Projection of timber extracted and its economic value

In order to do an estimate of the amount of timber extracted within the Chiquibul Forest, 150 m radii buffers were constructed along surveyed transects using the software ArcGIS. Once the buffers were constructed these were clipped and respective areas were calculated. Total surveyed area was calculated as a summation of all transects' area. Once the total surveyed area was calculated, the volume and amount of board feet by species was calculated per hectare. Once calculated the amount of lumber being extracted per hectare, it was proceeded to multiply the amount of board feet per hectare by the total amount of hectare calculated within the illegal logging zone of influence. In order to make projections more realistic to the current situation the amount of deforested area resulting from agricultural incursions was calculated based on 2010 land use change maps of the Chiquibul Forest. Once the deforested area was calculated, this was subtracted from the total area of the zone of influence, in order to obtain area presently under mature forest cover. Having estimated the amount of lumber in board feet that had been illegally logged it was proceeded to multiply this value with the national price for board foot of mahogany and cedar in order to estimate the economical value.

RESULTS

Data indicates that there has been a drastic increase in total areas of forest being impacted by illegal logging (Figure 4 and 5). From 2010 to 2011, there was an increase in area of 46.6%, while from 2011 to 2012, the illegal logging zone of influence increased by 28.3%, translating to an illegal logging zone of influence totaling 34,189 ha.

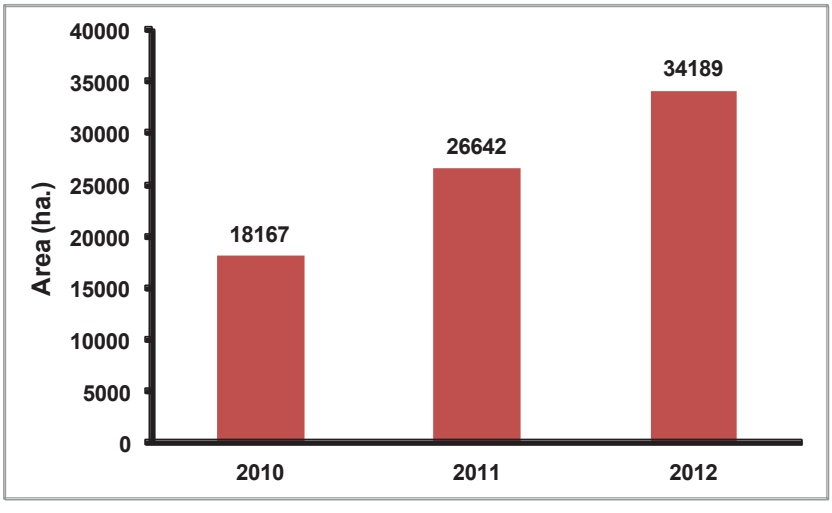

Figure 4: *Area of the Chiquibul Forest being impacted by illegal logging.*

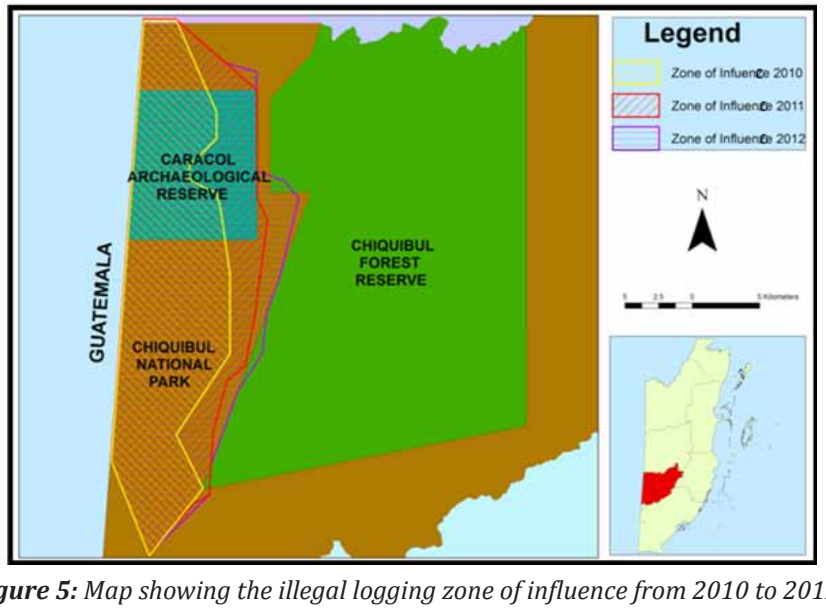

Figure 5: *Map showing the illegal logging zone of influence from 2010 to 2012.*

A total of 439 illegally logged trees were measured within a surveyed area of 1,898.57 ha. The majority of the logged trees were either Mahogany *(Swietenia macrophylla King)* representing 59.9% or Cedar *(Cedrela odorata L)* representing 39.4%, while only two Samwoods *(Cordia alliodora)* and one Santa Maria *(Calophyllum brasilense)* tree were recorded. All logged trees had a mean diameter at cut height of 0.57 m with a commercial bole length of 13.05 m (Table 1). The mean diameter for Cedar trees was 0.63 m, while Mahogany showed a mean diameter of 0.53 m with a bole length of 12.9 m (Table 1).

Table 1: *Mean plus Standard Deviation (SD) for the diameter at cut height and commercial bole length of illegally logged trees in the Chiquibul Forest.* (** = absolute value)

Species	n	Variable	Mean +SD	Minimum	Maximum
All Trees	439	Diameter at Cut height (m)	0.57 ±0.13	0.31	1.5
		Bole length (m)	13.05 ± 2.97	6.2	24.3
Cedar	173	Diameter at Cut height (m)	0.63 ± 0.13	0.39	1.5
		Bole length (m)	13.24 ± 3.03	6.2	22
Mahogany	263	Diameter at Cut height (m)	0.53 ± 0.11	0.31	0.97
		Bole length (m)	12.9 ± 2.93	6.6	24.3
Samwood	2	Diameter at Cut height (m)	0.38 ± 0.03	0.35	0.4
		Bole length (m)	15.5 ± 2.12	14	17
Santa Maria	1	Diameter at Cut height (m)	0.5**	----	----
		Bole length (m)	12.7**	----	----

The relative frequency distribution classes show that 0.42 of all logged Cedar trees had a diameter between 0.58 m and 0.76 m while trees greater than 0.95 m in diameter had a relative frequency of only 0.03 (Figure 6 A). Mahogany trees with a diameter at cut height between 0.42 and 0.53 had a relative frequency of 0.42, making it the most dominant class followed by tree in the diametric class of 0.53 m and 0.64 m, while mahogany trees with a diameter greater than 0.75 m showed a relative frequency of 0.04 (Figure 6 B).

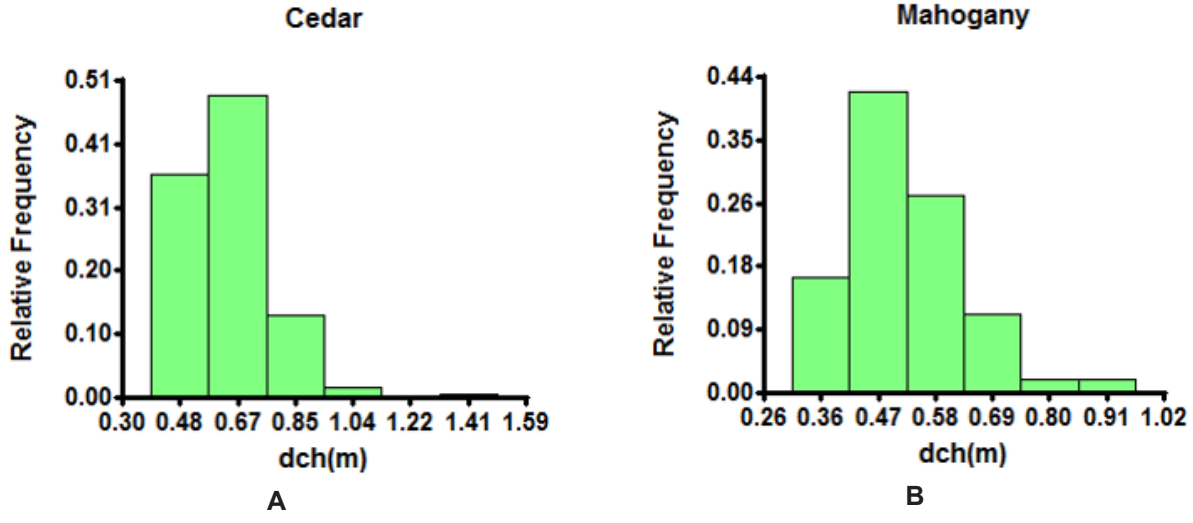

Figure 6: *Relative frequency of illegally logged Cedar (A) and Mahogany (B) trees within the Chiquibul Forest.*

Our results indicate that a mean volume of 3.47 m3 (909.15 board feet) of lumber was extracted from each Cedar tree, while Mahogany trees were able to yield a mean of 2.39 m3 of lumber (Table 2). Based on the projections made, it is estimated that a total of 10,940.4 Cedar and 11,282.28 Mahogany trees have been illegally harvested, translating to an extraction intensity of 0.32 m3 and 0.33 m3 per hectare of Cedar and Mahogany respectively. Within the Chiquibul Forest, an estimated total of 2,832,195.22 board feet of Cedar have been extracted with an economical value of US $4,248,293.00; while for Mahogany an estimated 2,971,343.39 board feet with an economical value of US $ 5,199,851.00 have been illegally extracted (Table 2).

Table 2: *Volume and economic value of illegally harvested timber in the Chiquibul Forest*

		No. Trees	Volume (m^3)	Board feet	Value (US $)
Cedar	Sum (sample)	173	600.32	157,284.2	
	Mean		3.47	909.15	
	Minimum		1.04	273.86	
	Maximum		22.5	5,895.3	
	Mean per hectare	0.091	0.32	82.84	
	Projected total: ILZI	3,115.32	10,940.4	2,832,195.22	
					4,248,293.00
Mahogany	Sum (sample)	263	629.82	165,012.3	
	Mean		2.39	627.42	
	Minimum		0.44	114.43	
	Maximum		14.68	3846.39	
	Mean per hectare	0.14	0.33	86.91	
	Projected total: ILZI	4,736	11,282.28	2,971,343.39	
					5,199,851.00
Grand Total					**9,448,144.00**

Not all of the commercial bole length of logged trees is harvested by illegal loggers, leaving commercial grade lumber as "waste." Our results indicate that 34.5% and 30.5% of all logged Cedar and Mahogany trees respectively is left in the jungle as "waste". The data indicates that a mean of 314.24 and 191.8 board feet per tree of Cedar and Mahogany respectively are left to rot in the Chiquibul Forest; with an aggregated economical value of US $ 3,058,075.00 (Table 3).

Table 3: *Volume and economic value of lumber left behind by illegal loggers operating within the Chiquibul Forest.*

		Bole Length (m)	Volume (m^3)	Board feet	Value (US $)
Cedar	Mean	4.84	1.2	314.24	
	Minimum	0	0	0	
	Maximum	13.24	13.18	3,453.1	
	Projected total: ILZI	-----	3738.38	978,958.15	
					1,468,437.00
Mahogany	Mean	5.5	0.73	191.8	
	Minimum	0	0	0	
	Maximum	16.1	7.31	1,914.73	
	Projected total: ILZI	----	3457.28	908,364.8	
					1,589,638.00
Grand Total					**3,058,075.00**

Illegal logging also leads to deforestation and forest degradation, the latter very difficult to quantify. The data reveals than on average 0.05 ha. are deforested by the felling of each illegally harvested Cedar or Mahogany tree, and damaging a mean of 11.74 trees (Table 4). Based on this results it was projected that a total of 393.17 ha. have been impacted by illegal logging within the Chiquibul Forest.

Table 4: *Area deforested in the Chiquibul Forest as a consequence of felling illegally logged trees*

		Area (ha.)	No. Trees damaged
All trees	Mean	0.05	11.74
	Minimum	0.008	2
	Maximum	0.25	40
	Projected total: ILZI	393.17	92,316

DISCUSSION

The results clearly indicate that illegal logging within the Chiquibul Forest is a well organized activity, showing no signs of a decrease. Even though the increase in area of the illegal logging zone of influence from 2011 to 2012 was 64.7% less than that observed during 2010 to 2011, it shows that loggers are penetrating deeper into the forest, where the furthest recorded illegal logging activity was located 11.5 km from the Belize-Guatemala Western border. It is estimated that the illegal logging zone of influence has not increased as drastically compared to previous years because the further an illegal logger venture into the Chiquibul Forest, the more difficult it becomes to them; as travelling time increases and the probability of being intersected by law enforcement agencies increases. Nonetheless, illegal loggers are able to evade law enforcement units by conducting their illicit activities in a random fashion and operating at night.

In the context of the Caracaol Archaeological Reserve (CAR), it was observed that illegal logging intensity has increased and illegal loggers have started to target smaller girth trees and salvaging what is possible from previously left timber; thereby allowing us to conclude that target populations are being depleted. A major barrier to the expansion of the illegal logging in this area is the Caracol Road as crossing lumber on a widely visible path increases the probability of being detected especially during milling the trees and or product transportation. Presently on the North of CAR, illegal logging is only 400 m away from the Caracol Road while at the southern section of CAR loggers have managed to go around the road as it ends at the Caracol epicenter and are making their way north but such venture is becoming more labor intensive.

Belize has had an approximate economic loss of US$9,448,144.00, due to illegal logging, causing the Central Government an approximate loss of US$290,177.00 in royalties alone. Even though the figures may appear astounding, its true economical impact goes beyond the timber economical value, as there is the need to consider its ecological impacts. Based on work conducted by Cho et al. (2011), it is estimated that the Chiquibul Forest has an average of 160 metric tons of carbon in its above ground biomass, which is equivalent to 752 metric tons of CO2 per hectare. Assuming a conservative carbon credit value of US$ 7 per metric ton of CO2 equivalent, deforestation due to illegal logging has caused an approximate economic loss of US$ 2,068,752.00.

Illegal loggers are severely destroying the mahogany and cedar populations in the Chiquibul Forest, as indicated by the results, where a high percentage of logged trees fall below the minimum cutting diameter (62 cm) established by law. The data indicates that 48.5% and 15.9% of all logged cedar and mahogany trees respectively had a diameter equal or greater than the established minimum cutting diameter. This brings some ecological implications on the targeted species' populations such as loss of potential seed trees, which are necessary for the continued process of natural regeneration, reduction in the seed banks of wild population, necessary for regeneration after severe destructions such as hurricanes and fires, alteration of population age structure (great variability in age structure is required by a population, this assures population viability over time) and ultimately leading to severe genetic erosion as the few remaining standing trees will (if possible) produce the following generation.

The data also indicates that more than 30% of the commercial bole length of logged trees is left in the jungle by illegal loggers, with an aggregated economical value of US$3,058,075.00. It is important to consider the possibility of identifying methods for the extraction of this lumber in a timely manner as the funds generated from its sale can be directly invested to the conservation of the Chiquibul Forest. This potential financial mechanism can help alleviate the problem of limited funds to conduct patrols more frequently and to equip law enforcement agents with the required field equipment. In order to derive an economical benefit from the "waste" lumber it is important to take into consideration the legal protection status of each protected area and a means of a standard agreement must be established among all management institutions working in the area, namely the Forest Department, National Institute of Culture and History, and Friends for Conservation and Development. If such permit is granted, it is also important to set a formal Committee responsible for financial management and must be composed by representatives of the different management institutions and other relevant Departments in order to manage the funds with accountability and transparency.

Although illegal loggers are conducting the activity in a much artisanal manner, by employing chainsaws to fell and mill lumber, the intensity at which it is occurring has categorized the activity as one of the most critical threat to the area's biodiversity and cultural heritage. It is important to understand that this activity is not only targeting the harvested timber populations but brings other ecological, economical and cultural issues as well. Although no rigorous assessment exists on how illegal logging affects game species populations, it is evident that illegal hunting which is mainly conducted for subsistence is having a severe blow on game populations, as it was common to observe evidence of illegal hunting, mainly animal remains (feathers and bones) and expended shot gun shells along logging trails.

It is evident that illegal loggers are targeting only two "hardwood" species of high commercial value being Mahogany and Cedar. Both Belize and Guatemala have included Mahogany in Appendix II of CITES, meaning that the harvesting and trade of this specie is highly regulated by national and international standards. Nonetheless, it appears that in Guatemala there is no credible control as illegal loggers are able to commercialize the lumber being illegally extracted from the Chiquibul Forest. By the scale of the extraction it may be suspected that timber resulting from this activity is either exported to regional or international markets; another scenario may be that the timber is being used in the furniture industry, which are either sold in the local market or for export. With the existence of a well established market, illegal logging has become a highly lucrative activity which is leading to the destruction of the targeted populations within Belizean territory.

CONCLUSION AND RECOMMENDATIONS

Illegal logging within the Chiquibul Forest shows no signs of decrease, and it is clear that a well established market exists for the lumber being extracted. Illegal loggers have extracted approximately 2,832,195 and 2,971,343 board feet of Cedar and Mahogany respectively, within an area of 34,188.74 ha. The lumber extracted has an aggregated economical value of US $9,448,144.00.

This study also indicates that the activity is very wasteful as 34.5% and 30.5% of the commercial bole length of Cedar and Mahogany trees is not harvested. In addition, to having negative economical impact on Belize it is causing a myriad of ecological impacts that range from compromising the population viability of targeted species to deforestation and forest degradation. It is evident that the issue of illegal logging in the Chiquibul Forest is as a direct link between corrupt practices and the inability of the Belizean regulatory agencies to put in place effective enforcement deterrence.

From our understanding this study is one of the first illegal logging assessments that actually involved direct field data collection and the method proved to be efficient in both estimating the volume and commercial value of the timber being illegally extracted from the Chiquibul Forest.

Based on the results of this study the following actions are recommended:

1. It is important to continue with the illegal logging monitoring and assessment to collect field data that will allow estimating the volume, waste and deforestation as a direct side effect of illegal logging.

2. Establish a mechanism in order to salvage commercial grade timber that is left as waste by illegal loggers.

3. There is a need to formalize bi-national cooperation between relevant authorities of Belize and Guatemala in order to better address the issue of illegal logging, especially when it comes to law enforcement.

4. A constant presence of law enforcement units with a change in tactics are needed in the area in order to deter illegal logger from penetrating deeper into Belizean territory.

5. An improved synchronization of efforts among regulatory agencies is warranted in order to make best use of the limited resources which can lead to more effective processing of encroachers.

6. Institute a multi-sector task group led by the Ministry of FFSD to address illegal logging, chaired by a high level *Champion*.

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