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LOGGING EFFECTS OF ILLEGAL CHAINSAW MILLING AND CONVENTIONAL LOGGING IN KROKOSUA HILLS FOREST RESERVE, GHANA

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Abstract

Illegal logging is widely believed to have a greater adverse impact on the forest resource base of many countries, but field studies comparing activities of illegal loggers with their conventional counterparts are few, with some not supporting this general notion. We conducted field assessments in Krokosua Hills Forest Reserve in Juaboso district of Ghana to compare operations of illegal chainsaw millers with conventional loggers in relation to species felled, adherence to regulation on minimum felling diameter, extent of collateral damage at stump site and regard for protection of water bodies in the reserve. We found a total of 139 felled trees belonging to 17 species. Felling by Illegal chainsaw millers constituted 37.4% of total felling. 94% of all trees felled by illegal loggers were below minimum felling diameter and were mainly class 1 species with scarlet star rating (and including species regarded as depleted in Ghanaian forests). By contrast, conventional loggers felled from a wider range of species and conservation priorities with 59% of felling done below minimum felling diameter. Collateral damage at stump site was higher for conventional than illegal loggers, with damage to residual stems being mainly broken stems. Average distance of stump sites to nearest water bodies was 24.2 ± 16.7m for conventional loggers, significantly greater than distance for illegal loggers at 15.2 ± 9.7m, suggesting that illegal loggers were felling closer to water bodies. Findings in this study have important implications for forest resource conservation.

Keywords*: Illegal logging; Logging damage; Diameter felling limit; Chainsaw milling; Conventional logging; Krokosua Hills forest reserve*

Introduction

Conventional logging is regulated by laws, whereby the right for commercial timber exploitation is issued as Timber Utilization Contracts (TUCs) to logging companies in the form of permits detailing the area, volume and sometimes species to be harvested [1]. Illegal logging (including chainsaw milling) on the other hand, refers to situations whereby "timber is harvested, transported, bought or sold in violation of national laws" [2]. Chainsaw milling involves on-site processing of logs into lumber, a practice which is widespread and considered part of illegal logging [1, 3, 4]. Illegal logging in Ghana is estimated at 60%, compared with 35% for Malaysia, 20% to 47% for Brazil, 70% for Papua New Guinea and 80% for Bolivia [5].

Illegal logging (mainly chainsaw milling) provides for most of the Ghana's domestic timber needs [1, 6, 7]. *C.P. Hansen and T. Treue* [8] estimates that 75% of timber on the domestic market of Ghana comes from illegal chainsaw milling operations alone, while *E.*

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Marfo [1] puts this figure at 80%. Illegal chainsaw millers do not operate under any set of regulations and may be flouting many regulations governing the extraction of timber in the country's forests. Relative to conventional logging, operations of illegal loggers (including chainsaw millers) are widely believed to have a greater adverse impact on the forest ecosystem and thus, seen as being more responsible for the rapidly shrinking forest estate of Ghana [9, 10].

Unlike chainsaw millers, operations of conventional loggers have hardly come under critical public scrutiny, perhaps because conventional loggers are widely thought to operate according to prescribed procedures. Regulations on timber harvesting in Ghanaian forests as spelt out in the Manuals of Procedure [11] are important for ensuring a perpetual flow of benefits from Ghana's forests. Flouting such regulations implies less judicious use while depriving future generations of the benefits from these forests. As an example, the felling of smaller trees may prevent natural regeneration and decrease volume stocking. Also, regulations on conservation of rare species have to be observed. Species conservation star rating system is used to assess conservation priority based on global distribution of species such that a higher priority in conservation is given to rare/endemic species. In this system, species are ranked as green, pink, red, scarlet, blue, gold or black stars in increasing order of conservation priority [12].

Studies in some Ghanaian forest reserves have compared conventional loggers and illegal chainsaw millers in terms of their ecological impacts on the forest ecosystem [13, 14]. These studies have shown that illegal loggers felled smaller trees than their conventional counterparts. Paradoxically, the removal of smaller trees rather promoted the regeneration of economic tree species in Nkrabia forest reserve due to creation of smaller canopy openings [14]. However, extent of canopy opening did not differ between the two logger types in the study by *K.A. Asamoah et al* [13] who analysed data from Asenayo forest reserve in Ghana. These two studies show how conventional and illegal loggers may differ in their operations and impacts. Loggers are human actors with different needs and operating with different skill sets and logistics and may vary greatly in their operations and impacts. Therefore, more information is needed from other forest reserves to add to the knowledge base on the operations of these two logger types and their potential impact on the forest ecosystem.

Here, we present data from a field survey carried out in the Krokosua Hills forest Reserve (KHFR) in the Western Region of Ghana. This paper aimed to: i. Assess types of species felled in relation to their conservation status by both logger types (conventional and illegal loggers); ii. Estimate collateral damage at stump sites and compare damage done by the two loggers; iii. Assess sizes of trees felled by the two logger types in relation to minimum felling diameter allowed for each species; and iv. Assess recognition given by both loggers for the protection of water bodies in the reserve. This article makes important contributions to the knowledge base on the actual and potential impacts of the activities of illegal and conventional loggers that may inform certain policy decisions in the timber extraction sector.

Materials and Methods

Study area

The study was carried out in the Krokosua Hills Forest Reserve (6° 33′ 36″ N, 2° 43′ 48″ W) in the Juaboso district of the Western region of Ghana (Fig. 1). The gross area of the reserve is 481.61 km^2 comprising 191 compartments. The reserve has a total of 12.3 km of streams feeding the Draw River and its tributaries. It also has 38 admitted farms.

The approach for primary data collection was a correlational study involving field assessments of two different parts of the forest reserve near two fringing communities (Sayerano and Essakrom).

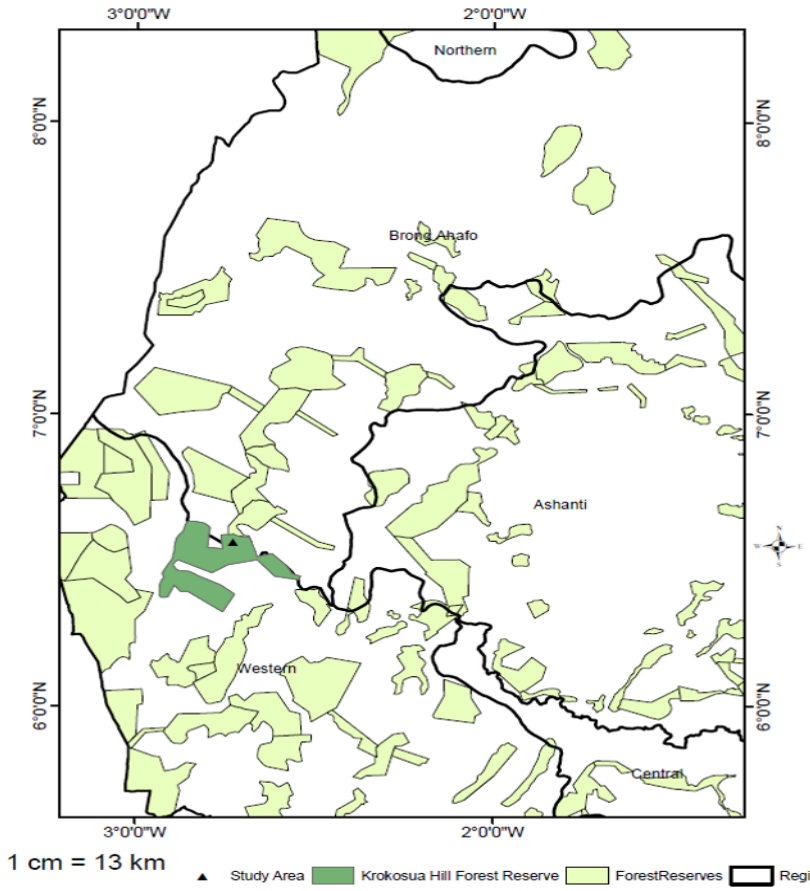

Fig. 1. Map Krokosua Hills forest reserve (green shaded area). The study location is indicated with black triangle.

These areas were purposively selected based on current on-reserve logging operations and reports of alleged persistent illegal chainsaw milling activities. A total of four compartments (two near each community) were assessed by means of three transects at 300 m intervals laid along the long axis of each compartment. At both sides of each transect, we searched for stump sites (locations where trees were felled) up to a distance of 100 m away from transects. Stump sites were categorised as conventional logging sites or illegal chainsaw milling sites based on certain observable characteristics such as presence/absence of stump markings and whether or not there were signs of in-situ log processing, following *K.A. Asamoah et al* [13] (Fig. 2). We took data on stump diameter (as proxy for bole diameter) and recorded the heights at which trees were felled (i.e. stump height). Distances of stump sites to the nearest streams were also estimated.

Secondary information utilised in this study were mainly data on the minimum felling diameter set for commercial timber species in Ghana in 1997 [25] as well as star ratings of species felled [12]. Additionally, the Manuals of Procedure [11] makes a prescription of 25 m to 50 m wide riparian strip (depending on size of water body) for the protection of water bodies during yield allocation. This was used as a yardstick to evaluate consideration given by loggers for protection of water bodies.

Fig. 2. Photos of some illegal chainsaw milling sites in the reserve. Sawdust, and abandoned logs, boards, billets, slabs characterise such sites. These characteristics were used to distinguish illegal logging sites from conventional logging sites.

Data Analysis

We explored number of trees felled belonging to different species and conservation status (star ratings) which were felled by illegal and conventional loggers using descriptive statistics. Mean stump height was tested for differences between logger types (as fixed effects) in linear mixed effects model [15]. For each tree felled, we gave a yes (1) if it was felled at/above its species specific diameter felling limit, otherwise a no (0) was indicated. The resulting binary data were then tested for differences between illegal and conventional loggers using a binomial analysis (with Logit Function) in generalised linear models (GLM) [16].

We tested fixed effects of logger type and diameter class (without including their interaction in the model) on number of damaged trees/saplings around stump sites in generalized linear mixed models (GLMM) using Poisson distribution (with log link function) [15]. Diameter classes were compared pairwise with Sidak adjustment. Number of individuals in each damage category (as a fixed factor) was also tested for differences in GLMM.

To determine whether loggers differed in the level of consideration given for protection of water bodies, average distance from stump sites to nearest streams for felled trees were tested for differences using Median test with Yate's continuity correction which is more accurate for smaller number of observations [17]. This analysis was done only for species that were felled in common by both logger types.

We evaluated recognition given by loggers for the protection of water bodies by comparing the mean stump site distance (averaged over all felled trees per species) to nearest water bodies with the benchmark distance of 25 m set for the protection of water bodies in the manuals of procedure [11], which we coin here as threshold Distance for Water Protection (TDWP).

Results and Discussions

Species felled

A total of 139 felled trees belonging to 17 species with varying conservation priorities were enumerated in the four (4) compartments of the forest reserve at the time this survey was completed (Table 1). 62.6% of trees felled were identified as conventional felling while illegal felling accounted for 37.4% of total felling done in the assessed areas. Majorities (58%) of all trees felled by Illegal chainsaw millers had a scarlet star rating and were selected from only five species namely; *Entandrophragma utile*, *Khaya ivorensis*, *Triplochiton scleroxylon*, *Milicia excelsa* and *Terminalia ivorensis*. Also, single individuals of *Terminalia superba* and *Aningeria altissima*, species with pink and red star ratings respectively, were felled. Apart from *Triplochiton scleroxylon, Terminalia ivorensis* and *Terminalia superba* which are class 2 species and available in Ghanaian forests with moderate market demand, all other species felled by illegal loggers were class 1 species with high market demand, but regarded as depleted in Ghanaian forests [11]. This reflects selective removal of (highly priced) species by illegal loggers.

Table 1. Tree species felled, their diameter felling limits and star ratings in Krokosua Hills Forest Reserve, Ghana.

Species	Number felled at/above diameter limit	Number felled below diameter limit	Minimum felling Diameter (cm)	Star rating
Aningeria altissima	0	15	90	Red
Antiaris toxicaria	1	1	110	Pink
Ceiba pentandra	6	2	110	Green
Celtis zenkeri	5	2	70	Green
Chrysophyllum albidum	2	0	70	Pink
Cylicodiscus gabunensis	0	1	70	Pink
Daniellia ogea	0	4	110	Pink
Entandrophragma angolense	0	4	110	Red
Entandrophragma utile	1	11	110	Scarlet
Khaya ivorensis	0	15	110	Scarlet
Milicia excelsa	0	12	110	Scarlet
Nesogordonia papaverifera	3	2	70	Pink
Piptadeniastrum africanum	5	0	70	Pink
Pycnanthus angolensis	5	1	70	Pink
Terminalia ivorensis	0	5	90	Scarlet
Terminalia superba	0	20	90	Pink
Triplochiton scleroxylon	11	5	90	Scarlet

On the other hand, 39% of trees removed by conventional loggers were of pink star rating, followed closely by scarlet at 34.5%. Fifteen (15) trees (constituting 17% of total felling done by this logger type) of *Ceiba pentandra* and *Celtis zenkeri*, species with green star rating were removed. Conventional loggers also felled a total of 8 trees (constituting 9.2% of felling) of *Aningeria altissima and Entandrophragma angolense*, species with red star rating. Thus, in contrast to illegal loggers, conventional loggers felled a wider range of species (and star ratings) as expected of regulated logging.

A greater percentage of felling in the assessed compartments in the reserve having been done by conventional loggers only meets expectation as the assessed areas were part of a concession under exploitation by a TUC holder. Nonetheless, we add to increasing evidence that illegal chainsaw milling occurs in Ghana's forest reserves [1, 7, 18], although some studies have suggested that illegal chainsaw millers prefer farms and other off-reserve areas for their operations [4]. The practice of chainsaw milling continues to thrive despite the ban and the reasons may not be far-fetched. *M. Vit and J. van Dam* [4] have suggested that apart from the high demand for cheap wood, in many countries such as the Philippines, DRC, Ghana and

Cameroon, regulations governing the use of chainsaw are often unclear and only randomly enforced, a situation same authors attributed mainly due to corrupt practices where certain officials derive personal benefits from illegal chainsaw milling activities.

Sizes of trees felled

Overall, 72 % of all trees felled were below the prescribed diameter felling limits set for those species. 94% of all trees felled by illegal loggers were below prescribed diameter felling limits, significantly higher (Wald Chi-square = 6.524, df = 1, p = 0.011) than percentage of trees felled by conventional loggers below diameter felling limit at 59%. *Triplochiton scleroxylon* was the only species felled above its diameter felling limit by illegal loggers, while 8 species were felled at/above their diameter felling limits by conventional loggers. Averagely, all trees were felled at a height of 0.70 ± 0.21 cm and did not differ significantly ($F_{1, 75} = 0.123$, p = 0.726) between conventional (at 0.69 ± 0.22 cm) and illegal loggers (at 0.71 ± 0.20 cm).

These findings indicate that majority of trees felled in this reserve had much smaller diameters than permitted by law, suggesting that trees in their productive stages were being felled. This is consistent with findings in other forest reserves in Ghana. For example, *K.A. Asamoah et al* [13] who worked in both Asenayo and Nkrabia forest reserves and Herrmann [14] in Nkrabia forest reserve, found that majority of trees felled by illegal chainsaw millers were below legal felling diameters. Illegal chainsaw millers may be unaware of felling restrictions on minimum diameters to harvest [14] or perhaps, they just do not care what sizes they remove so long as a desired purpose is served. For conventional loggers, this may be due to the fact that the yield formula allows for removal (by TUC holders) of a certain number of trees immediately below the diameter felling limit [19]. It appears conventional loggers were also in violation of minimum diameter prescription considering that 59% of all trees felled by them, at the time this survey was completed, were below minimum diameter. However, such a conclusion cannot be arrived at without information on total yield allocation to the TUC holder. If there was any violation of this prescription, it may have resulted from ineffective supervision to ensure that only trees included in the yield allocation were being felled.

Silviculturally, application of diameter felling limit increases basal area and volume stocking over the period of the felling cycle [13, 20]. It also enhances the production of viable seeds [21]. Therefore, felling of trees in their productive stages may have adverse consequences for volume stocking and natural regeneration in KHFR (but see *D.T. Herrmann* [14]). Also, because, class one species (with a higher star rating and some considered as depleted) are being targeted by illegal loggers, potentially or in reality, the conservation status of these species are being worsened.

Average stump height was similar for both loggers suggesting that neither logger was wasting wood by cutting too high on the bole. However, illegal logging sites were characterised by abandoned logs, boards, slabs and billets (Fig. 2). Although, we did not quantify log recovery (as an indicator of waste), it seemed to us that chainsaw milling is more wasteful as has been the general notion [22], but there are studies that have suggested the contrary (see *K.A. Asamoah et al* [13], *K. Frimpong-Mensah* [23]).

Collateral damage at stump site

Analyses of collateral damage (in terms of number of trees, saplings and seedlings damaged) at stump site showed that damage differed significantly ($F_{6, 39} = 39.437$, $p < 0.001$) among different tree diameter classes, with greater damage recorded for lower diameter classes (up to 10 cm dbh) beyond which damage was small and not different among dbh size classes (Fig. 3). Amount of damage also differed significantly ($F_{1, 39} = 18.547$, $p < 0.001$) between conventional and illegal logging, with higher logging damage at stump site recorded for conventional than illegal logging. Averaged over compartments and logging types, the type of damage to residual stems at stump site was mainly broken stems recorded for an average of 57 (± 27) individuals, dead saplings/seedlings were 34.3 (± 12.5) on average, while bruised, but standing individuals were 32 (± 9). Differences among damage types were found to be

significant ($F_{2, 18}$ = 5.672, p = 0.012). No significant difference was found between the two loggers types in terms of type of damage caused to residual stems at stump sites.

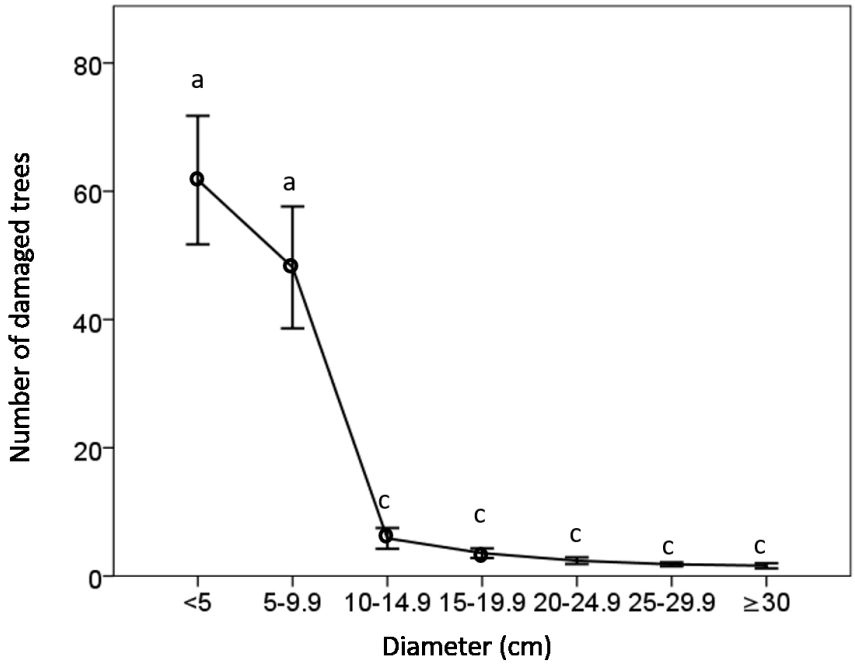

Fig. 3. Number of damaged woody plants per diameter class (an indication of collateral damage at stump site) in Krokosua Hills Forest Reserve, Ghana. Diameter classes are compared pairwise (GLMM with Sidak adjustment). Significant differences ($p \leq 0.05$) are indicated by different letters.

Conventional loggers usually clear larger areas around stump sites to pave way for felling and skidding. Illegal loggers on the other hand operate discretely without the use of any heavy machinery at stump site since skidding is usually not done. This operational difference at stump site and also, the fact that conventional loggers felled larger trees (which are more likely to cause higher collateral damage at stump site), could account for the observed higher collateral damage by conventional than illegal loggers in our study area. However, mean area disturbed around stump sites in Nkrabia forest reserve in Ghana was found to be higher for illegal chainsaw millers than conventional loggers because more trees and saplings were being cleared around fallen trees to make it easier for milling crew to operate [13].

Consideration for protection of water bodies

On the average, illegal chainsaw millers felled at a distance of 15.2 ± 9.67m from water bodies significantly closer (Chi-square = 4.083, df = 1, p = 0.043) to water bodies than average stump site distance from water bodies for conventional loggers (24.2 ± 16.7m). For this analysis, equal numbers of trees felled (n = 24 for each group) belonging to species that were felled in common by both conventional loggers and illegal chainsaw millers were used.

When mean distances from water bodies to felled trees were pooled per species and compared with a threshold distance of 25m prescribed for protection of water bodies, we found that 7 out of 8 (i.e. 88%) species felled in common were felled below the threshold distance for water protection by illegal loggers whereas 4 out of 8 (50%) were felled below this threshold distance by conventional loggers (Fig. 4).

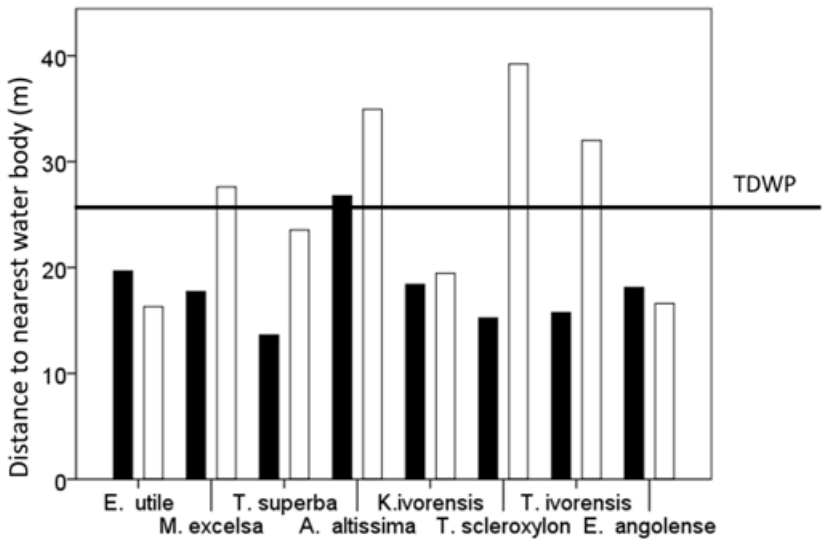

Fig. 4. Average distance of stump sites to nearest streams in KHFR, pooled per species and separated by conventional loggers (black bars) and illegal chainsaw millers (open bars). Threshold distance for water body protection (TDWP) defines safe operating distance from waterbodies below which degradation of waterbodies could occur. TDWP of 25 m is taken from the manuals of procedure for the management of high forest in Ghana [11].

Therefore, whereas conventional loggers observed, to some extent, the 25 m threshold for protection of water bodies, illegal loggers operating in this area clearly disregarded this prescription consistent with reports in the literature. In the Philippines, for example, *J. van der Ploeg* [24] reported illegal logging activities to be concentrated around major river systems of a protected area, confirming the assertion by *M. Wit, J. van Dam* [4] that generally, areas that are not accessible for conventional logging due to physical or regulatory barriers often become hotspots for illegal activities as a result of higher densities of merchantable or economic trees. Also, *E. Marfo* [1] observed in Ghana that conventional loggers are given a yield that will not include trees in ecologically sensitive areas, but because operations of illegal chainsaw millers are not regulated, they fell wherever they find easy access to highly merchantable trees. In the KHFR, the Sayere River which runs through the reserve has many commercial trees along its banks and since per the prescriptions of the manuals of procedure, these trees cannot be included in yield allocation for TUC holders, this area therefore attracts a lot of illegal activity, possibly explaining our finding.

Conclusions

Illegal logging is widely believed to more adversely impact the forest resource base of many countries and this has put activities of illegal loggers in the limelight for some time now. But recent interest in comparative evaluation of the logging activities of conventional loggers and illegal chainsaw millers in terms of ecological impacts have not always supported this general notion. Our study which was designed to expand existing knowledge on adherence to logging regulations and also to quantify collateral damage at stump site by the two logging types showed that illegal chainsaw milling takes place in KHFR. It shows also that illegal chainsaw millers fell smaller trees than allowed by law. Conventional loggers also felled a number of trees below their diameter limits, but on a much smaller scale than illegal loggers.

Collateral damage at stump sites was higher for conventional loggers than illegal loggers, but type of damage done to residual stems was similar for both loggers. Felling height

(stump height) was similar for both loggers, but we found evidence of abandoned logs, boards, slabs and billets in chainsaw milling sites.

Conventional loggers showed greater consideration for protection of water bodies than illegal chainsaw millers. Thus, regulation on riparian vegetation is adhered to in yield removal by conventional loggers. Activities of illegal chainsaw millers could adversely impact quality and quantity of stream water in the study area as they were felling too close to streams.

We recommend that while it is crucial to check activities of illegal loggers in the area, strict supervision of operations of TUC holders is equally necessary to ensure that standards are adhered to.

Acknowledgement

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