Legal vs. certified timber: preliminary impacts of forest certification in Cameroon

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Abstract

The concept of Sustainable Forest Management (SFM) has a pivotal role for both the Cameroonian legal framework and market-based instruments such as forest certification. We assess the different impacts on timber harvesting of the forest legal framework as compared to the adoption of forest certification, on the ten Forest Management Unit (FMUs) that had received a Forest Stewardship Council (FSC) certification by mid-2009, and discuss some differences between legal and

certified timber. Results show that the average reduction in the Annual Allowable Cut (AAC) of concerned FMUs is about 11% when legal harvesting rules are adopted, about 18% when the FSC rules as requested by the certifying bodies (CBs) are applied, and about 34% when the 'FSC logic of sustainable harvesting', as agreed upon on paper by logging companies and CBs, is used. Our findings confirms that forest certification has the potential to improve weak normative frameworks that allow the unsustainable use of forests. However, they also suggest that certifying bodies tend to reduce the stringency of the FSC rules in certified FMUs if not backed by a uniform FSC standard and by a stronger legal framework. We elaborate on the reasons why that may occur and provide suggestions for improvements.

Keywords: Cameroon; forest certification; law enforcement; sustainable forest management.

1. Introduction

In the Congo Basin, the concept of Sustainable Forest Management (SFM) has been promoted over the last two decades through new legal frameworks enacted by national governments (Assembe Mvondo, 2009). In 1994, the Government of Cameroon was the first to adopt a new forest law in which SFM plays a pivotal role (Republic of Cameroon, 1994; Karsenty, 2006). To implement SFM, the forestry law mandates the preparation of forest management plans in all Forest Management Units (FMU), but delegates the specifics of the plans' preparation, approval, and control processes to implementing regulations (decrees and guidelines).

The Ministry of Forest and Wildlife (hereinafter the Ministry) issued many of the needed regulations over about a decade, but it did so without a coherent strategy. Texts were often unclear or contradictory (Durrieu de Madron and Ngaha, 2000), and despite being based on international best practice (MINEF and ITTO, 1998), they resulted in an overall weak legal framework which allowed

SFM to be interpreted by the Ministry and the operators not in full accordance with internationally recognised principles (e.g. ITTO and OAB, 2005). Therefore, the first management plans approved by the Ministry in 2004 and 2005 were of dubious quality in terms of the economic, ecological, and especially social aspects (Vandenhaute and Doucet, 2006; Vandenhaute and Heuse, 2006). In the worst cases, logging companies were legally authorised to harvest the most traded species as if no management plan was in place (Vandenhaute and Doucet, 2006; Cerutti *et al.*, 2008).

Forestry laws and regulations are not, however, the only instruments through which SFM can be implemented and forest management improved. Market-oriented instruments such as forest certification are a way to bring about responsible and more transparent forest management (Elliott, 2000; Cashore *et al.*, 2004; Agrawal *et al.*, 2008; Auld *et al.*, 2008), especially through the provision of direct and indirect incentives to logging companies (e.g. Kiker and Putz, 1997; Gale and Burda, 1998; Elliott, 2000; Karsenty and Gourlet-Fleury, 2006; Araujo *et al.*, 2009).

Forest certification, conceptualised by Cashore *et al*. (2004) as a non-state market-driven governance system, has the potential to address certain environmental and social spillovers, such as weak forest legal frameworks, or inadequately implemented ones, that allow the unsustainable – though legal – use of forests (van Kooten *et al.*, 2005; Auld *et al.*, 2008). Evidence of such corrective potential has recently been documented in Latin America, where logging companies had to comply with government laws that were otherwise largely unenforced in order to be certified (Espach, 2006), and in the Asia-Pacific region, where regional codes of practices based on the rules of certification were developed and promoted by national governments (Durst *et al.*, 2006).

The impacts of the forest legal framework and certification, and the corrective potential of the latter on FMU managed according to the forest regulatory framework, have not been researched in Cameroon, mainly because the first Forest Stewardship Council (FSC) certificate was only granted at the end of 2005.

We aim therefore at assessing the impacts of the legal framework as compared to certification on timber harvesting, in the ten FMUs currently holding an FSC certificate. This analysis is important for at least three reasons. First, by assessing whether differences in the implementation of the legal framework and certification on the same FMU exist, the analysis contributes to highlight how legal and certified timber exported from Cameroon differ – useful at a time when many developed countries are discussing the adoption of public procurement policies for their timber imports (FERN, 2009). Second, it quantifies those differences and provides the first set of data from the Congo Basin about the impacts of forest certification on timber harvesting, thus contributing to the literature on the relationship between forest legal frameworks and certification (e.g. Elliott, 2000; Cashore *et al.*, 2004; Cashore *et al.*, 2005; Auld *et al.*, 2008), as well as on the effects of certification on forest management practices (van Kooten *et al.*, 2005; Durst *et al.*, 2006; Espach, 2006; Auld *et al.*, 2008; Araujo *et al.*, 2009; Maletz and Tysiachniouk, 2009). Third, it emphasizes the influences that a weak legal framework, coupled with the lack of national certification standards, could exert on certification. The discussion provides further arguments to the hypothesis that when there is a strong resistance to change by forest companies and owners, 'the FSC and its supporters will have to *conform* to forest company criticisms of the FSC, thus *reducing* the stringency of its rules' (Cashore *et al.*, 2004, p.8). We show that the rules applied to forest companies by certifying bodies (CBs) in Cameroon may tend to be watered-down versions of the FSC ones.

The first section of this article describes the recent historical evolution of the Cameroonian legal forestry framework and explains the modifications requested by the adoption of certification. Next, following a description of the sources and methods used for the analysis, the impacts of the legal framework and of certification on timber harvesting are assessed. We then present evidence that the hypothesis about the reduced stringency of FSC rules appears to be corroborated by the case of Cameroon. The last section draws the conclusions.

2. The legal framework for forest management in Cameroon

During the second half of the 1990s, the general principles on SFM included in the 1994 law were translated into two guidelines by the Ministry for logging companies to use in the preparation of their management plans (MINEF, 1998b; MINEF and ITTO, 1998). However, when compared, these two guidelines contained contradictions and unclear rules (Durrieu de Madron and Ngaha, 2000).

In 2001, the Ministry decided to streamline existing guidelines, and issued a Ministerial decree (0222/A/MINEF of 25th May 2001) regulating the preparation, adoption and implementation of management plans (MINEF, 2001). The decree clarifies the procedure for the selection of the set of species on which management decisions must be taken: the number of selected, or managed, species must be more than 20, and their aggregated volume must represent at least 75% of the total volume inventoried in the FMU (MINEF, 1998b; art.6, MINEF, 2001), hereafter referred to as the 20/75% rule.

The 20/75% rule had already been proposed in one of the two 1998 guidelines (MINEF, 1998b). Yet, after the 2001 decree the Ministry interpreted the 20/75% rule differently from the past, introducing two fundamental changes. Firstly, the 20/75% rule as expressed in the 2001 decree does not clearly mandate logging companies to take management decisions on all the most commercialised timber species *within each FMU*, contrary to what was stated by the guidelines (MINEF, 1998b; MINEF and ITTO, 1998). Secondly, the targeted *taux de reconstitution* (referred to here as 'regeneration rate' or RR), which represents the ratio of timber that must be available for logging during the next rotation at a given Minimum Cutting Diameter (MCD), was decreased by the 2001 decree from 100% of the harvested volume of *all species* (MINEF, 1998b) to 50% of the number of harvested trees of *each species*. In other words, before the 2001 decree, the Ministry requested logging companies to adopt silvicultural parameters, such as MCDs, that guaranteed a total recovery, from one logging cycle to the next, of the volumes of all the timber species selected with the

20/75% rule, considered as a group (i.e. adopt average RR = 100%. MINEF, 1999, p.31).

With the adoption of another guideline in 2003 (MINEF, 2003), species had still to be selected with the 20/75% rule but they were not considered as a group anymore. Instead, 50% of the number of harvested trees of *each species*, selected with the 20/75% rule, had to be reconstituted for the next rotation. Thus, the minimum legal RR became 50% of the number of selected trees (MINEF, 2003).

Calculating regeneration rates on a species by species basis is a better option in terms of SFM as compared to an average rate calculated on *all* selected species as a group, because logging companies are forced to take management decisions on a per species basis, instead of calculating an average RR for all selected species, which may be sustainable for some species but not for others, as it was done before 2001 (Durrieu de Madron *et al.*, 1998; Forni and Mbarga, 1998; Durrieu de Madron and Ngaha, 2000; Jonkers and Foahom, 2004). Nevertheless, this is only effective if the selected species of the management plan are those actually harvested by logging companies. If not, the RR remains a purely administrative exercise, laid out in the management plan, but with limited impacts on the ground.

In fact, the 2001 decree authorised logging companies to fulfil the 20/75% rule by selecting abundant species that will not necessarily be harvested (Bureau Veritas Certification, 2006; Vandenhaute and Doucet, 2006; Vandenhaute and Heuse, 2006; Cerutti *et al.*, 2008). Conversely, contrary to basic forest management rules (e.g. ITTO and OAB, 2005), several of the most harvested and traded species could be excluded from the list of managed ones by using the 20/75% rule, and thus harvested without applying RR of at least 50%. For instance, two of the most harvested and traded species for more than two decades, ayous (*Triplochyton scleroxylon*) and sapelli (*Entandrophragma cylindricum*), are not included in the managed species of several approved management plans (Cerutti *et al.*, 2008).

As of mid-2009, 67 FMUs covering an area of about 4.5 million ha had an approved management plan. This represents about 65% of the total area of the 101 existing FMUs (MINFOF, 2009).

The first FSC certificate was granted by a Certifying Body (CB) for an FMU in 2005. As of mid-2009, 10 FMUs held an FSC certificate, covering about 870,000 ha, or about 15% of the area of existing FMUs.[1] The shortcomings of the legal framework became evident soon after the granting of the first certificate. The certified company was asked by the CB to reconsider the use of the 20/75% rule and the RRs in its management plan, because several of the most harvested species were being managed in a way that risked being 'not compatible with a sustained production' (Bureau Veritas Certification, 2006, p.24). The same procedure was requested by CBs for companies certified later on (e.g. TRC, 2007). In other words, to avoid the risk of unsustainable production, CBs and the FSC's normative framework required logging companies to modify and improve their management targets, albeit those targets included in the companies' management plans had been previously approved by the Ministry.

This overlap of public and private normative frameworks produce a paradoxical situation because both are officially fostering the same sustainability objectives, notably in terms of timber harvesting, and are based on the same scientific knowledge, or lack thereof, produced by two major research projects carried out in the 1990s in Cameroon (e.g. Durrieu de Madron *et al.*, 1998; Jonkers and Foahom, 2004). However, they result in different management implications for logging companies, especially when considering annual available volumes of their most harvested and traded species. Before quantifying those volumes and explaining the reasons behind the different results of the public and private normative frameworks, we detail the methods used in the analysis.

[1] The Cameroonian law makes a distinction between a Forest Management Unit (FMU) and a logging Concession. One Concession can contain more than one FMU, and in this sense, as of 2009, 13 FMUs were certified. However, one FSC 'certification unit' can contain more than one concession, and thus more than one FMU. To avoid confusion, this paper identifies one FMU with one FSC 'certification unit', and as of 2009 there were 10 of them.

3. Methods

A management plan based on a systematic forest inventory is the document of reference when it comes to a) assessing the diameter structure of each species in each FMU, b) establishing the Minimum Cutting Diameter (MCD) at which each species could be cut, and c) calculating the Annual Allowable Cut (AAC) of each species. We gathered the approved management plans of all certified FMUs. The diameter structures of the five most harvested species in each FMU were entered into a database to calculate the RR and the AAC of each species under various MCDs. The analysis on the variations in AAC focuses on the five most harvested species within each FMU because they represent, as they have in the past, the bulk of the Cameroonian timber production (e.g. Hédin, 1930; Chambre d'Agriculture de l'Elevage et des Forêts du Cameroun, 1959; MINFOF, 2006). During the period 2000-2007, the five most harvested species accounted for about 75% of the total national production, with ayous, sapelli and tali (*Erythrophleum ivorense*) constantly ranking in the top three positions. The five most harvested species in the 10 certified FMUs represented on average 84% of the FMUs' annual production after the approval of their management plans.

Minimum cutting diameters, RR and AAC have been calculated using the standard formula prescribed by the law (Appendix A). When FMUs started to be certified, some CBs required logging companies to adopt a different interpretation of the legal formula (Appendix B), demanding more caution in the harvesting of certain species according to 'the FSC logic of sustainable harvest' (hereinafter 'FSC logic', R.P. Pallisco, 2008, p.21). However, other CBs did not require such different interpretation and applied the standard legal formula.

The most relevant consequence of the use of this 'FSC logic' is that, *ceteris paribus*, higher MCDs are needed to reach an RR above 50%, that is, less trees of a given species are harvested. In turn, that causes part of the financial value of the FMU to be preserved for a following rotation while reducing the current financial return of logging activities, as well as providing a higher probability of leaving trees that will produce seedlings.

All the variables included in both the legal formula and the 'FSC logic', such as mortality and growth rates, are initially assigned administrative values by the Ministry. Those values should be evaluated and adapted to the specific conditions prevailing in each FMU, as suggested by common sense and by official guidelines (MINEF, 1998b). However, the analysis of management plans, including those of certified FMUs, shows that all the administrative values are maintained, and that the only variable adjusted to reach a RR higher than 50% is the MCD.

The analysis focuses therefore on MCDs. Three possible choices of MCD were considered (Table 1), resulting in three different possible AACs:

i. the AAC resulting from forest management as presently interpreted by the Ministry and implemented through the legal framework in approved management plans;

ii. the AAC resulting from the implementation of certification in certified FMUs with some logging companies using the standard formula and some others using the 'FSC logic';

iii. the AAC that would result from forest management that uniformly applies 'the FSC logic' to all certified FMUs and to all the most harvested species.

The three AACs were compared to a baseline AAC calculated in each FMU by using the administrative MCD (MCD/adm, Table 1) before approval of the management plan.

INSERT TABLE 1 ABOUT HERE

[Caption] Table 1. Minimum Cutting Diameters considered

The third AAC is considered here because the 'FSC logic' has been required by some CBs, and accepted by several logging companies, on the grounds that some of the FMUs' most harvested species incurred the risk of unsustainable harvesting if they were harvested at the MCD adopted in the management plans (Bureau Veritas Certification, 2006). One would therefore

expect the same logic to be uniformly applied by all CBs, in all certified FMUs, and on all the most harvested species. However, this is not the case, as discussed in the next section.

4. Legal vs. certified timber harvesting

Administrative MCDs (MCD/adm) for any given timber species are established by decree (e.g. MINEF, 1995, 1998a, b). When a FMU is attributed but its management plan is not yet approved, logging companies harvest a legal annual allowable cut (AAC) based on MCD/adm. For this analysis, the AAC at MCD/adm is considered the baseline as it represents the largest possible harvested volume, which is reduced when larger MCDs are applied (Figure 1).

INSERT FIGURE 1 ABOUT HERE

[Caption] Figure 1. AAC variations (%) in certified FMUs by type of MCD applied (five most harvested species)

After the approval of management plans ('MCD/adm to MCD/MP', Figure 1), the AACs of the 10 FMUs decreased between about 1% (FMU 3 and 4) and 22% (FMU 10). On average, the annual reduction in the harvestable volume of the five most important species, as compared to the baseline MCD/adm, is about 11% after the approval of management plans.

Following certification ('MCD/adm to MCD/FSC', Figure 1), reductions in the AAC as compared to MCD/adm range between 1% (FMU 4) and 45% (FMU 2), with an average reduction of about 18%. The larger average reduction required after certification (18%), as compared to the average reduction required by the management plans (11%) is caused by the three FMUs (FMU 1, 2 and 3) that were required by the CBs to increase MCD and recovery rates (RR) for sustainability reasons (adoption of the 'FSC logic').

However, the comparison between the second (MCD/FSC) and the third bars (MCD/FSC-logic) of each FMU in Figure 1 show that the 'FSC logic' is not applied by all CBs. Figure 1 also shows that, even when the 'FSC logic' is used,

it is not applied consistently. In FMU 1, the actual reductions required by the CB did not reach the expected one, and in FMU 2 and 3, larger AAC reductions were required by the CBs than what would have been the case if the 'FSC logic' were applied. In all cases, no scientific explanation is provided to justify the adopted reductions (MCD/FSC).

Overall, the average reduction expected in the AAC of the 10 FMUs by adopting the 'FSC logic' on all the five most harvested species (third bar, Figure 1) is about 34%, almost double the actual reduction requested by CBs (18%), and triple the reductions requested by the adoption of management plans (11%).

The most direct cause of this random application of harvesting rules is the lack of a national FSC standard to be followed by CBs. As a result, fundamental harvesting parameters can still be negotiated between the CBs and logging companies, and negotiations may lead to a 'race to the bottom', in which CBs authorise logging companies to adopt silvicultural criteria closer to those authorised by the weaker legal framework than to the stricter standards already required by other CBs under the FSC sustainability logic.

We do not argue negotiations considering the economic viability and the ecological sustainability of a FMU should not occur. We do argue, however, negotiations should be backed by scientific evidence presented by logging companies, on any given species, that justifies harvesting at a RR lower than 50%. In fact, as already noted, the management plans analysed for this paper do not use improved scientific knowledge on any given species and/or adopt *ad hoc* silvicultural parameters for any species in the formula used to calculate MCDs, RRs and AACs (Appendix A and Appendix B).

The lack of improved scientific knowledge to support negotiations also risks weakening the overall credibility of certification schemes, especially when one notes there exists a clear trend in CBs authorising the regular harvesting of the top harvested species at RR values much lower than those that would be required by the 'FSC logic', while requiring values closer to that logic for the less harvested species (Figure 2).

Figure 2 shows that the adoption of the 'FSC logic' for the first and fifth most harvested species in certified FMUs would require a similar reduction in the AAC of about 34% (third bar, Figure 2). However, the CBs recommended a reduction of about 5% for the first most harvested species, just above the 2% reduction adopted in the management plans (second and first bar, Figure 2, respectively), and a reduction of 30% for the fifth most harvested species (second bar of 5th most harvested species in Figure 2). The trend shown in Figure 2 is even more significant when noting that the first most harvested species represents about 47% of annual production in the ten certified FMU, while the fifth most harvested one represent only about 4% of their total annual production.

INSERT FIGURE 2 ABOUT HERE

[Caption] Figure 2. AAC variations (%) of the five most harvested species in certified FMUs (by type of MCD applied)

From a purely quantitative perspective, the total volume in each FMU may well be recovered by the end of the rotation period thanks to the growth of the vast majority of unharvested species, both selected and not selected. However, a significant change in the quality of the available timber stocks will result, with direct consequences on the long-term economic and ecological sustainability of Cameroonian forests and forestry sector. The few harvested and traded valuable species will not be able to provide a financial return similar to the present one at the next logging cycle in FMUs, all the more so if they are over-harvested. And unless market preferences on timber species, which have not changed over several decades, will change abruptly in the short to medium term, it will be more and more difficult for the Ministry to auction at a good price FMUs depleted of all their most valuable trees. As a consequence, Cameroon risks losing not only a large part of the volumetric revenues presently paid on those valuable species, such as felling and sawmill-entry taxes, but also the area fees (which accounted for about 60% of all forestry taxes over the period 2000-2008) that logging

companies are presently willing to pay exactly because of the quality of the top harvested species inside those FMUs.

5. Conclusions

In Cameroon, the notion of SFM in logging concession was initially introduced by the 1994 forest law. Management plans to be approved by the Ministry of Forests were identified as the primary tool for the effective implementation of the law. A decade later, the first FSC certificate was granted to a logging company operating in Cameroon. Although the company had an approved management plan, the certifying body required stricter silvicultural parameters to be adopted, because the management of several of the most harvested species was 'not compatible with a sustained production' (Bureau Veritas Certification, 2006, p.24).

As of mid-2009, ten FSC certificates had been granted in Cameroon. We focussed our analysis on the changes occurring to the annual allowable cuts of the five most harvested and traded species in certified FMUs as compared to the changes required by the adoption of management plans. We found that the adoption of management plans required logging companies to reduce their annual allowable cut by 11% on average, while certified FMUs underwent an average reduction of about 18%. This is a clear positive impact of certification allowing a better recovery of valuable species for the next rotation and mechanically reducing the damages to the residual stand by lowering the harvest intensity.

We also show that while some certifying bodies required the adoption of more conservative silvicultural parameters, others did not. Only three FMUs out of ten were required by certifying bodies to be managed according to 'the FSC logic of sustainable harvest' (R.P. Pallisco, 2008, p.21), and this did not even apply to all of the most harvested species in those three FMUs. If the 'FSC logic' were applied by all certifying bodies, on all the most harvested species, the average reduction in the annual allowable cut of all certified FMUs would be about 34%, almost double the actual reduction of 18% and more than triple the

average reduction required by approved management plans (11%). The complete adoption of the 'FSC logic' would also require larger reductions in the annual allowable cuts of the top harvested species than on the lesser harvested ones, as compared to the actual reductions required so far by the CBs.

We neither downplay the financial reasoning of logging companies which could justify such choices, nor we discuss the silvicultural options authorised by the certifying bodies, but we argue there is no sound reason for the rules to calculate fundamental silvicultural parameters, such as the annual allowable cuts, to differ among certifying bodies. The scientific knowledge on which those rules are based in Cameroon is common for all FMUs, and since several FMUs were requested by certifying bodies to adopt stricter parameters on the grounds that harvesting as authorised by the legal framework risked to be unsustainable, a uniform national FSC standard should be used by all certifying bodies and the legal standards on timber harvesting must be improved.

We do not argue that certification standards should be the same as the legal ones. Certification maintains its raison d'être because its requirements about many environmental and social issues – such as the management of non-timber forest products, the mapping and respect of high-conservation value forests and the respect of international labour codes – are stricter than the requirements of national regulations. However, sustainable timber harvesting, to be carried out according to the best available knowledge, is at the core of both the 1994 Cameroonian forest law and forest certification schemes. Therefore, authorising harvesting not compatible with a sustained production should be an option neither for some certifying bodies nor for logging companies unwilling to engage in forest certification.

Our findings confirm that forest certification has indeed the potential to address certain environmental problems, such as weak normative frameworks or inadequately implemented good regulations that allow the unsustainable use of forests, as already shown for other countries (e.g. van Kooten *et al.*, 2005; Durst *et al.*, 2006; Espach, 2006; Auld *et al.*, 2008). However, both the lack of a transparent and uniform national standard to be followed by all certifying bodies,

and the wanting quality of management plans (Vandenhaute and Doucet, 2006; Cerutti *et al.*, 2008), concur to reduce the corrective potential of certification by weakening the negotiating power of certifying bodies. As a result, the stringency of FSC rules is reduced, as hypothesised by Cashore *et al*. (2004).

If certifying bodies are not backed and strengthened in their negotiations by a transparent and uniform national FSC standard, which provides them with clear rules on timber harvesting to support their arguments vis-à-vis logging companies, companies may have the upper hand in negotiating harvesting parameters close to the lowest limits allowed by the legal framework. Companies seek this outcome not only because they have to compete with companies that sell the same few species, but not certified, on the same markets, but also because they know that some certifying bodies allow weaker harvesting rules to be adopted, and this is profitable for the companies.

Regrettably, the Government of Cameroon, albeit very aware at least since 2000 of the weaknesses of the legal framework (Durrieu de Madron and Ngaha, 2000), has not been responsive to the improvements in the rules on timber harvesting introduced by some certifying bodies since 2005. As of 2009, not a single certified FMU had been required to update its approved management plan to take into account the improvements required by certifying bodies. A process of legal reform started in mid-2008, but past experience shows it might take years for reform to be translated into clear and practical management rules for all logging companies to conform to. Meanwhile, the gap between the potential benefits of forest certification and the actual improvements introduced by the legal framework on timber harvesting remains wide, with direct impacts also on the stringency of adopted FSC standards.

The example of progressive companies opting for forest certification and implementing stricter harvesting rules shows that the adoption of improved forest management in Cameroon is indeed possible, notwithstanding its costs. Some limitations may still exists, but standards can be improved through periodic audits, as it is in the nature of forest certification (Putz and Romero, 2001). However, certification is a voluntary process that several companies might not be

willing to adopt. Those companies should not be allowed to harvest their timber legally but unsustainably, and the role of public policies and of the government willingness to enforce them remain central to sustainable forest management.

Acknowledgements: Preliminary results of this research were presented at the 'Sustainable Forest Management in Africa' symposium, held in Stellenbosch, South Africa, from 3 to 7 November 2008. Useful comments from participants are acknowledged. We wish to thank the Cameroonian Ministry of Forests and Wildlife for the data made available for this research. Our thanks also go to the representatives of certified logging companies and certifying bodies operating in Cameroon for their availability to discuss some of the issues covered in this paper. Particular thanks go to Elena Petkova for commenting on a draft version of this paper. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the organizations with whom they are associated.

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Appendix A

Minimum cutting diameters, RR and AAC have been calculated by applying the formula prescribed by the law [Equation A.1].

[Equation A.1] Recovery rate (RR%) = $[N_0(1-\Delta)(1-\alpha)^T]/N_p$

At any particular MCD at which a given species is harvested, 'N_0' is the number of trees that will grow up to that MCD after the end of the first logging cycle, and thus 'N_0' reflects the annual growing rate of the species considered.

For instance, if a tree grows by 1cm/yr, during a logging cycle of, say, 30 years, it will have grown by 30 cm. Thus, if the MCD is, say, 100 cm, all trees that had a diameter of 70 cm at the time of the first cycle, will have reached the MCD of 100 cm at the beginning of the second cycle, and thus they can be harvested.

'Δ' is a factor accounting for the harvesting damages, 'α' is the mortality rate of the species considered, 'T' is the duration of the logging cycle, and 'N_p' is the number of trees harvested during the current cycle, with a diameter larger than the MCD considered. The first diameter considered in [1] is always the administrative one (MCD/adm).

A more detailed explanation of 'N_p' is worth making, especially in view of the changes (discussed in the main text) that CBs requested to certified FMUs. The legal interpretation of 'N_p' (hereinafter 'N_p-legal') does not consider all the diametric classes above the MCD/adm, but at best only three classes above it, i.e. MCD/adm+30cm. If, for instance, the species being evaluated has a MCD/adm of 50cm, the first iteration in [1] will consider 'N_p-legal' as the number of trees between the classes of 50cm and 80cm (bold cells, Table A.1).

INSERT TABLE A.1 ABOUT HERE

[Caption] Table A.1. Example of calculation of 'N_p-legal'

If, on the contrary, RR<50% at MCD/adm = 50cm, the second iteration in [1] will consider 'N_p-legal' as the number of trees between the classes of 60cm and 80cm, then the number between the classes of 70cm and 80cm, and finally only the number of trees in the class of 80cm (8,748 trees in the example shown in Table A.1). If RR never reaches a value higher than 50% with the four possible iterations, by applying the 20/75% rule a company can decide to exclude it from the list of selected species and harvest it at MCD/adm.

In theory, all the parameters considered in the formula vary with the forest being considered, and the forest manager has several alternative choices in terms of the optimal AAC, MCD, or RR, to be assessed against the company's economic, ecological, and social targets (Durrieu de Madron *et al.*, 1998; Karsenty and Gourlet-Fleury, 2006).

But in practice, in Cameroon all parameters are assigned nationwide standard values by the Ministry, and in spite of the fact that the Cameroonian guidelines suggest the use of *ad hoc* parameters when improved knowledge is

available, none of the 67 management plans approved as of 2009 adopted values different from those suggested by the Ministry. Harvesting damages are fixed at 7%, mortality rates at 1% and logging cycles at 30 years.

As a consequence, in terms of timber harvesting, the only variable that may be modified to reach the legal management objectives of a RR higher than 50% is the diameter at which a tree can be cut (i.e. its MCD).

//END Appendix A

Appendix B

In order to calculate the recovery rate (RR), some CBs use the same formula adopted by the law (Appendix A), but with their own interpretation for the calculation of the number of trees harvested during the first rotation ('N_p', hereafter 'N_p-FSC').

When RR<50% at MCD/adm, and more iterations are required, 'N_p-legal' considers a maximum of four iterations possible, because the largest value allowed is MCD/adm+30cm (Table A.1). Instead, 'N_p-FSC' has no fixed largest value and it is always equal to the MCD being considered plus 30cm.

For instance, if the MCD/adm being considered is equal to 50cm and a second iteration is required, 'N_p-FSC' will include all trees between the classes of 60cm and 90cm, instead of the trees between the classes of 60cm and 80cm as with 'N_p-legal', and a third iteration will include the trees between the classes of 70cm and 100cm, instead of the trees between the classes of 70cm and 80cm. If a fourth iteration is needed, instead of counting only the number of trees in the class of 80cm (8,748 trees, class of 80cm, Table B.1), as with 'N_p-legal', the trees between the classes of 80 and 110 will be counted (27,487 trees, classes included between 80cm and 110cm, Table B.1).

INSERT TABLE B.1 ABOUT HERE

[Caption] Table B.1. Example of calculation of 'N_p-FSC'

The result of the use of 'N_p-FSC', as compared to 'N_p-legal', is that higher MCDs are needed to reach RR>50%, because the denominator of the RR

formula [Equation A.1] decreases slower by using more diametric classes, i.e. by including more trees.

//END Appendix 2

Figure 1

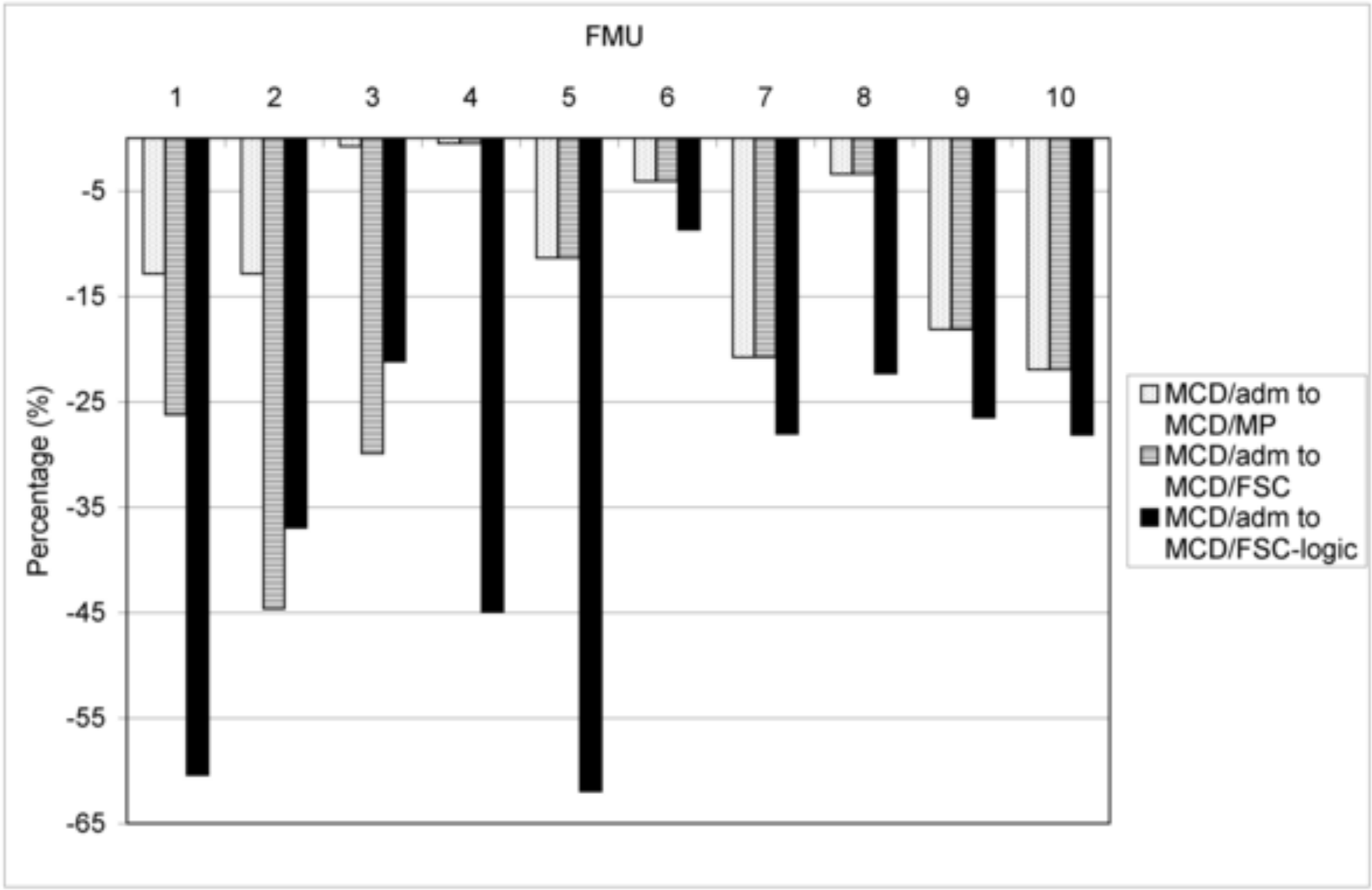
FMU
1
2
3
4
5
6
7
8
9
10
-5
-15
-25
-35
-45
-55
-65
Percentage (%)
MCD/adm to MCD/MP
MCD/adm to MCD/FSC
MCD/adm to MCD/FSC-logic

Figure 2

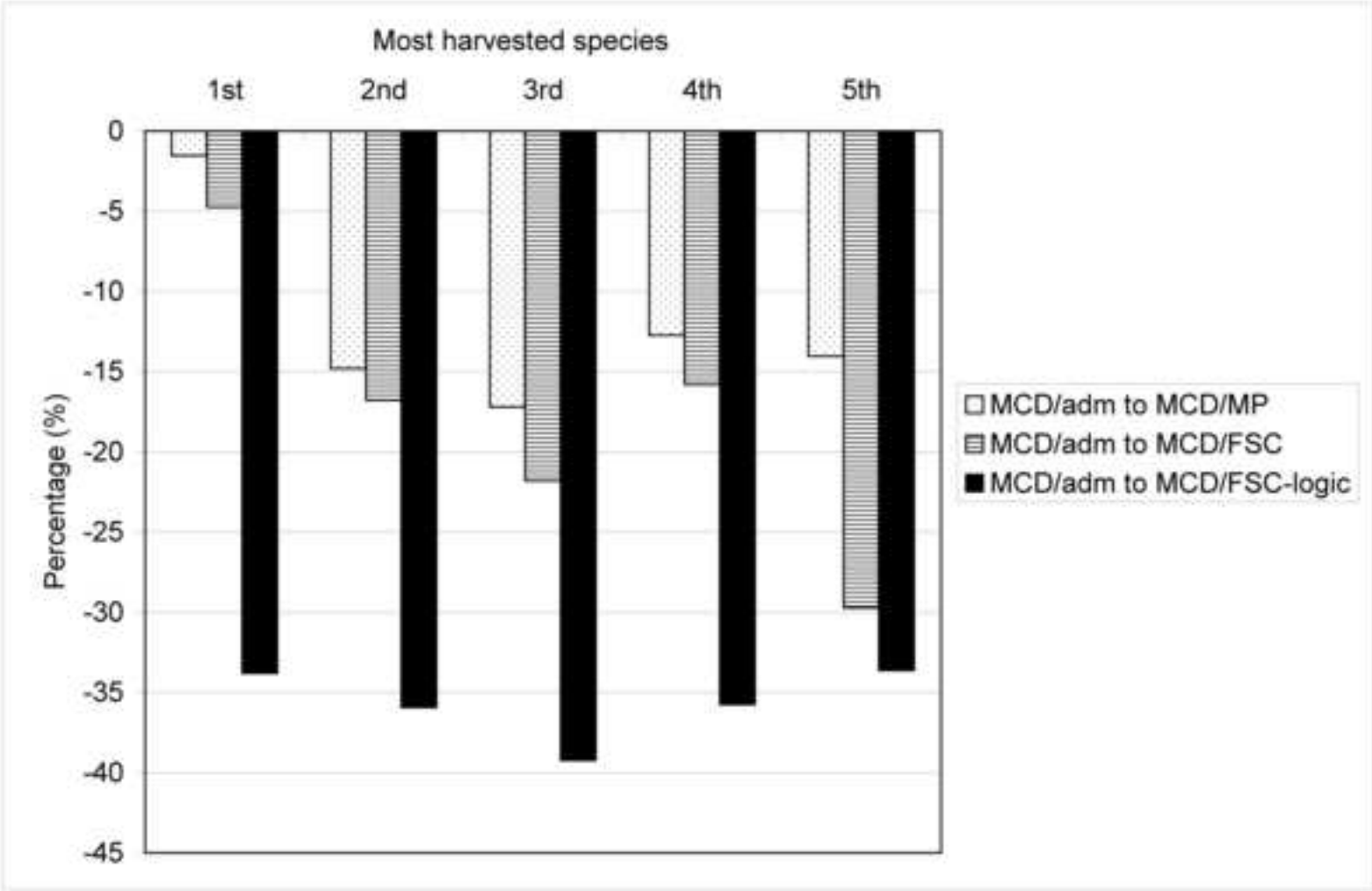
Most harvested species
1st
2nd
3rd
4th
5th
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Percentage (%)
MCD/adm to MCD/MP
MCD/adm to MCD/FSC
MCD/adm to MCD/FSC-logic

Table 1. Minimum Cutting Diameters considered

Type of MCD	Source	Note
MCD/adm	Official list with all species published by the Ministry.	Established by the Ministry for all species on the entire national territory. Not required to guarantee RR>50%
MCD/MP	Management plan (list of managed species).	Applied to species selected by using the 20/75% rule (see text), i.e. managed species. Calculated by logging companies using the standard formula described in Appendix A. Required to guarantee RR>50% for selected (managed) species.
MCD/FSC	Summary of management plan (required by FSC rules).	Actual MCD applied to timber species in certified FMUs. Calculated by some logging companies using the standard formula described in Appendix A, and by some other using the CB's interpretation of the formula (as described in Appendix B) but only for some species. Not required to guarantee RR>50% for all species.
MCD/FSC-logic	Author's calculations using data provided in the summary of management plan (required by FSC rules).	Theoretical MCD calculated by authors using the formula described in Appendix B, and applied as if all certified logging companies adopted the 'FSC logic of sustainable harvesting' (see text) on all their most harvested species

Table A1

Table A.1. Example of calculation of 'N_p-legal'

First iteration with Np-legal, MCD/adm = 50cm														
Diameter (cm)	20	30	40	50	60	70	80	90	100	110	120	130	140	>150
Essence Y (trees)	3059	2956	4583	4619	6988	9305	8748	8525	5287	4927	428	165	143	0
Last iteration with Np-legal, MCD/adm = 50cm														
Diameter (cm)	20	30	40	50	60	70	80	90	100	110	120	130	140	>150
Essence Y (trees)	3059	2956	4583	4619	6988	9305	8748	8525	5287	4927	428	165	143	0

Table B1

Table B.1. Example of calculation of 'N_p-FSC'

First iteration with Np-FSC, MCD/adm = 50cm														
Diameter (cm)	20	30	40	50	60	70	80	90	100	110	120	130	140	>150
Essence Y (trees)	3059	2956	4583	4619	6988	9305	8748	8525	5287	4927	428	165	143	0
Last iteration with Np-FSC, MCD/adm = 50cm														
Diameter (cm)	20	30	40	50	60	70	80	90	100	110	120	130	140	>150
Essence Y (trees)	3059	2956	4583	4619	6988	9305	8748	8525	5287	4927	428	165	143	0