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REVIEW

A Critical Comparison of Conventional, Certified, and Community Management of Tropical Forests for Timber in Terms of Environmental, Economic, and Social Variables

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Abstract

Tropical forests are crucial in terms of biodiversity and ecosystem services, but at the same time, they are major sources of revenue and provide livelihoods for forest-dependent people. Hopes for the simultaneous achievement of conservation goals and poverty alleviation are therefore increasingly placed on forests used for timber extraction. Most timber exploitation is carried out unsustainably, which causes forest degradation. Two important mechanisms have emerged to promote sustainable forest management: certification and community-based forest management (CFM). We synthesize the published information about how forest certification and CFM perform in terms of environmental, social, and economic variables. With the caveat that very few published studies meet the standards for formal impact evaluation, we found that certification has substantial environmental benefits, typically achieved at a cost of reduced short-term financial profit, and accompanied by some improvement to the welfare of neighboring communities. We found that the economic and environmental benefits of CFM are understudied, but that the social impacts are controversial, with both positive and negative changes reported. We identify the trade-offs that likely caused these conflicting results and that, if addressed, would help both CFM and certification deliver the hoped-for benefits.

Introduction

Tropical forests have critical ecological and utilitarian values insofar as they harbor much of the world's biodiversity and provide important ecosystem services (Gibson *et al.* 2011; Putz *et al.* 2012) and because they are a major source of subsistence and revenue to millions of forest-dependent people (Shearman *et al.* 2012). Most of the remaining tropical forests are under various forms of for-profit use, most commonly for timber (FAO 2005; Putz & Romero 2014). Especially in the tropics, hopes for the simultaneous achievement of conservation goals and poverty alleviation are therefore increasingly

placed on forests managed for timber. However, the logging that occurs in the vast majority of tropical forests is unsustainable and results in large-scale forest degradation, and often impacts negatively the livelihoods of local communities (Blaser & Zabel 2015). Responding to these challenges, several mechanisms emerged in the last few decades to combat the impoverishment of tropical forests, particularly by the timber industry. The two most prominent mechanisms are (1) forest certification and (2) community forest management (CFM; Charnley & Poe 2007; Romero *et al.* 2013). Both these initiatives aim to secure the sustainability of timber yields, promote environment conservation, and increase human welfare. They are also

sometimes applied in combination through (3) certified CFM.

Forest certification

Forest certification bodies, such as the Forest Stewardship Council (FSC), intend to promote sustainable forest management through recognition and certification of responsible practice with certificates that can be used to obtain product price premiums and improved market access (e.g., Rametsteiner & Simula, 2003; Romero *et al.* 2013). In tropical forests, FSC is the most widespread certification scheme, with about 28,797,000 ha of certified natural and planted forests in Africa, Asia, and South and Central America (Forest Stewardship Council 2015). In theory, an FSC certificate guarantees that the certified Forest Management Unit (FMU) is managed according to FSC's formal principles and criteria that specify political, social, economic, and environmental standards (The Forest Stewardship Council 2015). For example, certified FMUs have to comply with national law, respect indigenous peoples' rights, and extract timber according to reduced-impact logging (RIL) guidelines.

CFM

Although CFM only started to be officially recognized in the 1970s, forests were managed by local communities, many sustainably, before colonial powers began to appropriate land around the globe in the 16th century (Charnley & Poe 2007). After World War II, several factors stimulated increased attention to community forestry, including the growing awareness of widespread deforestation and forest degradation, pressure on national governments to alleviate rural poverty, and the belief that local communities have the knowledge to manage forests efficiently, while governments alone lack the resources to do so (e.g., Charnley & Poe 2007). The concept of CFM encompasses many different approaches, including joint forest management, participatory forest management, and co-management, but central tenets include enhanced community welfare and ecological sustainability (Pagdee *et al.* 2006; Blomley *et al.* 2008). A creation of a community enterprise or a resource management council is a typical approach in CFM (Charnley & Poe 2007).

Certified CFM

Forest certification and CFM share the goals of sustained timber production, enhanced social welfare, and environmental protection. Due to high financial costs and administrative requirements, forest certification and

even compliance with forestry laws and regulations are beyond the reach of many communities (Molnar 2004). To address this issue, the FSC introduced the Small or Low Intensity Managed Forests initiative (SLIMF) in 2004, which streamlined procedures with the aim to reduce certification costs for smallholders and communities (The Forest Stewardship Council 2004).

At a time when over two-thirds of forests worldwide are under some form of for-profit, commodity-based management (FAO 2005), it seems critical to assess the impacts of certification, CFM, and certified CFM. Unfortunately, there are almost no rigorous case studies on the impacts of certification or CFM that avoid the pitfalls of selection bias and false attribution, and otherwise meet the standards for formal impact evaluation established by the Collaboration for Environmental Evidence (www.environmentalevidence.org) and the Initiative for Impact Evaluation (www.3ieimpact.org). In full recognition of the shortcomings of the available evidence, we see an urgent need to assess these schemes with a synthetic overview of current knowledge. By so doing, we hope to provide preliminary answers to the following questions: (1) Do certification and CFM deliver the hoped-for changes towards economic, social, and environmental sustainability of forest management? (2) Do they lead to any trade-offs between improvements in one area (e.g., biodiversity protection) and deterioration in another (e.g., access to forest resources)? (3) What are the major information gaps that should be filled by rigorous impact assessments (Baylis *et al.* 2015)?

The potentials and limitations of synthesizing existing knowledge

This review is based on a qualitative synthesis of the existing literature, searched for according to the guidelines for systematic review (see Supporting Online material for the detailed methodology), which compares variables relevant to key goals of forest management (Table 1) under different management regimes, or before and after management is implemented. Our study is restricted to tropical forests and the following management comparisons: (i) certified or RIL-based industrial forest management versus conventional industrial forest management; (ii) CFM versus open-access use of forest resources by local inhabitants; (iii) certified CFM versus CFM; and (iv) certified industrial forest management versus certified CFM. From each study, we extracted information on whether one management regime was better, the same, or worse for a particular variable (Table 1), but not by how much because many studies did not quantify the outcomes.

Table 1 Variables describing the achievement of management goals of forest certification and community forest management, identified during the literature review

Variable	Core variable	Notes
Deforestation and fragmentation	ENV, Carbon, biodiversity	Illegal conversion within FMUs for shifting agriculture or other uses, fire control, afforestation
Carbon stock and emissions	ENV, <i>Core variable</i>	Measure in terms of above and below ground biomass, and its loss
Road and skid trail density	ENV, Carbon, biodiversity	Achieved through better harvest planning, including log landings
Animal diversity	ENV, Biodiversity	Richness and abundance, various biodiversity indices
Tree diversity	ENV, Biodiversity	Richness and other biodiversity indices
Canopy loss, gap size	ENV, Carbon, biodiversity	Achieved by directional felling, better planning, vine cutting. Measured per ha, tree felled, or volume of wood extracted.
Collateral damage	ENV, Carbon, biodiversity	Achieved by directional felling, better planning. Measured per ha, tree felled, or volume of wood extracted. Trees destroyed, injured.
Set asides and buffer zones	ENV, Carbon, biodiversity	Protected areas within concessions, buffer zones, no logging at steep slopes.
Environmental crime	ENV / SOC, Carbon, biodiversity, welfare	Includes illegal logging, conversion to cattle ranches.
Hunting	ENV / SOC, Biodiversity, welfare	Animal population viability, bushmeat availability. Beyond environmental implications, it influences human-wildlife conflict and nutrition.
Water regulation	ENV / SOC, Biodiversity, welfare	Includes occurrence of flooding and water availability.
Ground disturbance	ENV, Carbon, biodiversity	Through better skid trail planning, use of cable extraction. Measured in area disturbed.
Access to resources	SOC, Welfare	Access to forest for collection of NTFP, bushmeat, timber for sale, land for conversion, food security.
Infrastructure and institutions	SOC, Welfare	Workers' unions, schools and education opportunities, active committees, roads.
Living & working conditions of employees	SOC, Welfare	Healthcare, social care such as unemployment, safety at work, waste disposal, amenities at logging camps, permanent contracts, training.
Jobs	SOC / ECON, Welfare	Can be considered a core economic variable for communities.
Human-wildlife conflict	SOC, Welfare	Particularly crop damage by wildlife from forest concessions (e.g. elephants).
Conflicts with company & government	SOC, Welfare	Over access to forest, direct payments, employment conditions, sacred sites.
Internal conflict	SOC, Welfare	Financial misappropriation by community members, decision-making powers within community.
Land grabbing, land tenure	SOC, Welfare	More secure land tenure, connected to environmental crime.
Direct economic benefits to community	SOC, Welfare	Fees and compensation paid by logging companies to local communities, fees from ecotourism, investment by company to community.
Compliance with harvest regulations	SOC / ECON, Welfare, profit	Connected to timber stock in future; relates to respecting logging intensities, bans at steep slopes, labor law, and other national laws.
Community wellbeing and livelihoods	SOC / ECON, <i>Core variable</i>	Welfare of community members, even if not directly participating in logging. Includes waste management, health status, air pollution, and household assets.
Awareness, empowerment, participation	SOC, Welfare	Contributes to social capital. Creation of committees, improved workers' skills, knowledge of the Forest Management Unit status.
Equality, less marginalization	SOC, Welfare	Contributes to empowerment, refers to different segments of society (age, gender, poverty levels)
Price premium on products	ECON, Profit	Theoretically, should be obtained for certified products. Not related only to the willingness of buyers to pay extra for certified products.
Profit	ECON, <i>Core variable</i>	Summarizes costs and benefits. Different studies include different cost and benefit components, therefore most studies are not comparable.
Timber stock (sustainability of income)	ECON / ENV, Profit, carbon	Depends on logging intensity, management interventions, and length of logging cycles.
Total cost of logging operations	ECON, Profit	Workers, machinery, building of roads and skid trails, skidding.
Harvest efficiency	ECON, Profit	Wood volume produced compared to wood volume felled, depends on planning and experience of logging crews.
Management and administration	ECON, Profit	Efficiency, administrative complexity of regulations.
Market access	ECON, Profit	Access to international, national, regional, certified markets.
Pre-logging costs	ECON, Profit	Road and skid trail planning, tree mapping, inventory.
Lower skidding costs	ECON, Profit	Cost of transporting felled trees to log landings.
Worker productivity	ECON, Profit	Volume of timber produced per worker hour.

This synthesis of existing studies cannot reach conclusive findings due to various confounding factors, self-selection biases, and unknown patterns in background land-use change (Romero *et al.* 2013; Baylis *et al.* 2015). None of the studies we reviewed employed methods that conform with the recommendations of the Collaboration for Environmental Evidence that, for example, call for detailed theories-of-change and rigorous selection of counterfactuals (Centre for Evidence-Based Conservation 2013). Whereas we fully support rigorous evaluation methodologies, we also recognize that demonstration of causation is and will remain very challenging for complex adaptive systems like tropical forests. Nevertheless, it is important that our findings be interpreted as correlations between the management alternatives and differences in economic, social, and environmental variables, rather than causative relationships.

Both certification and CFM comprise many individual interventions or activities, which complicates their evaluation. For example, whereas all FSC-certified concessions are required to use RIL, not all concessions that claim to employ RIL techniques are certified. Furthermore, RIL itself consists of many elements that are reportedly applied consistently (e.g., directional felling and minimization of skid trail lengths) and other recommended practices that are often disregarded (e.g., prohibitions on skidding on slopes >30%; Dykstra & Heinrich 1996). In this review, we included both studies that compared conventionally logged concessions with certified industrial concessions, as well as with those that were not certified (yet), but logged according to the RIL guidelines (Table S1). Our study goes beyond the comparison of RIL and conventional logging insofar as we consider reported improvements beyond the scope of RIL, such as establishment of set-asides and social impacts. Ideally, we would investigate the impact of each element of certification and CFM separately, but that is currently impossible with the existing literature.

What does certification bring to industrial forest management?

Our assessment of certification and CFM is based on a total of 318 comparisons from 50 studies that were well distributed across Africa, Asia, and South and Central America (Figure 1, Table S1). A total of 185 comparisons concern industrial forest management, out of which 79 compare economic, 38 social, and 68 environmental variables.

In terms of economic variables (Table 1), certified or RIL management was better than conventional logging in 44%, no different in 14%, and worse in 42% of com-

parisons (Figure 1). Price premiums for certified products were reported in most cases, but they rarely met the expectations of forest managers. Furthermore, reported price premiums varied over time and were highly species-, product-, and country-dependent (Nebel *et al.* 2005). The total direct costs of certified forest management operations were mostly higher than for conventional logging, presumably due to higher prelogging costs and lower worker productivity (RIL is more time-consuming than conventional logging) (Medjibe & Putz 2012, but see Holmes 2015). We found certified management to be overall less profitable than conventional logging in the majority of cases (Figure 1), but this pattern may be reversed if more than one logging cycle is considered, given that future profitability of RIL concessions will likely be higher (Boltz *et al.* 2003).

In terms of social variables, 20 of 38 comparisons (53%) indicated that certified management was better than conventional, 2% worse, and 45% showed no difference. Certification is often associated with better employee living and working conditions, including better housing and health care, better work contracts and medical insurance, and a perceived stronger purchasing power of workers (Cerutti *et al.* 2014; Miteva *et al.* 2015). Certification is also associated with improved well-being of neighboring communities, partly due to better local infrastructure, such as roads, schools, and health care facilities (Bacha & Rodriguez 2007; Cerutti *et al.* 2014; Miteva *et al.* 2015). In contrast, certification apparently does not always directly alleviate poverty by increasing access to forest resources, or by direct economic benefits such as fees paid by logging companies to local inhabitants (Cerutti *et al.* 2014; Miteva *et al.* 2015). In one case, certification reportedly aggravated a conflict between a company and a community because, in contrast to conventional management, the certified management enforced a government restriction on community access to forest resources, particularly wildlife (Cerutti *et al.* 2014).

Certified and RIL management reportedly performed better in 76% of 68 environmental comparisons, did not differ from conventional management in 18%, and was worse in 6% of comparisons (Table 1, Figure 1). Certified management practices, such as RIL, clearly resulted in less ground disturbance and a lower density of roads and skid trails (Feldpausch *et al.* 2005). This benefit derives mostly from better planning, but is sometimes also influenced by lower logging intensities commonly associated with RIL, even though reduced logging intensity is not one of the principles of RIL (Medjibe *et al.* 2013). Comparisons based on logging intensity showed that once intensity is accounted for, RIL does not always provide additional benefits in terms of reduced collateral damage, canopy loss, or short-term carbon emissions

VARIABLES		FSC/RIL industrial vs Conventional					FSC industrial vs FSC-CFM			CFM vs Open Access			FSC-CFM vs CFM								
ENVIRONMENTAL	Reduced deforestation and fragmentation	3	43	16	43	2	2	2	2	2	2	2	2	2	2	2					
	Higher carbon stock and lower emissions	40	1	7	22	30	30	30									15	15	34		
	Lower road and skid trail density				1	11	13	14	20	44											
	Animal diversity				7	12	12	28	29												
	Tree diversity	1	40															34			
	Smaller canopy loss, gpp size	17	35	35	1	37	11	17	18	20	37	38	38	38	42						
	Lower collateral damage	17	20	20	21	37	1	13	20	22	23	23	35	38	38	44					
	More set, slides and buffer zones						7	44													
	Less environmental crime																				
	Less hunting						3														
Water regulation																					
Less ground disturbance																					
SOCIAL	Access to resources	3	3	27	43	43															
	Infrastructure and institutions	3	3	43	43	27															
	Living & working conditions of employees	3	3	3	3	3	3	3	3	3	3	3	3	27							
	Jobs						42	42	42												
	Human-wildlife conflict																				
	Less conflicts with company & government	3	3	33																	
	Less internal conflict																				
	Less land grabbing, better land tenure																				
	Direct economic benefits to community						27	3													
	Better compliance with harvest regulations						27	44													
ECONOMIC	Community wellbeing and livelihoods	43	43	43	43																
	Awareness, empowerment, participation	3	27																		
	Equality, less marginalization						3														
	Price premium on products	19	19	19	19	33	42	19	19	19	19	19	19	19	32	42					
	Profit	36	35	42	42	42	44	45	46	48	33	47	49	16	37	38	42				
	Timber stock (sustainability of income)						1	44													
	Total lower cost of logging operations																				
	Harvest efficiency						23	35	36	44	46	47	45	48	35	38	39	49			
	Improved management and administration						33	33	42												
	Market access																				
Lower pre-logging costs						17	35	36	37	38	38	44	39								
Lower skidding costs																					
Worker productivity						23	35	36	37	38	44	17	38								

LEGEND
 meta-analysis
 better (green)
 same (yellow)
 worse (red)

Figure 1 Overview of the available data on environmental, economic, and social variables (rows, detailed in Table 1) in four comparisons (vertical panels). Each square represents one comparison, made by a study listed below the figure, and fully detailed in Supporting Online Material (Table S1). FSC/RIL = FSC-certified industrial natural tropical or subtropical logging concessions, or concessions that were logged according to reduced-impact logging (RIL) guidelines; Conventional = conventional industrial selective logging; CFM = community forest management; FSC-CFM = community managed forests certified by the FSC; Open Access = open access areas with no explicit management plan.

(Winkler 1997; van der Hout 1999; Armstrong 2000; Martin *et al.* 2015). In interpreting these results, substantial variation in what constituted RIL in the various studies needs to be kept in mind, as does the short time scale of most of the analyses.

Compared to conventionally logged forests, areas subjected to RIL reportedly retain more plant and animal species and a higher abundance of animals, even after logging intensity is taken into account (Bicknell *et al.* 2014; Burivalova *et al.* 2014; Martin *et al.* 2015). This effect is additional to the finding that certified forests suffer less deforestation than conventionally logged forests, which further mitigates the impacts of logging on biodiversity (Damette & Delacote 2011; Gaveau *et al.* 2013; Miteva *et al.* 2015). Hunting remains a crucial but understudied issue in managed tropical forests (Brodie *et al.* 2015). It is often mentioned as important in terms of environmental, economic, and social impacts, but there are almost no explicit measurements of changes in hunting with certification (Bicknell & Peres 2010).

Is CFM better than open access?

In the total of 52 environmental, economic, and social comparisons of forests managed by the community with open access areas, we found that CFM performed better in 56%, equally in 25%, and worse in 19% of the comparisons (Figure 1). Both positive and negative outcomes were relatively evenly distributed across the three continents. We found almost no data on the economic performance of CFM (but see Blomley *et al.* 2008; Schreckenberg & Luttrell 2009). While this data gap is important, it might also indicate that financial profit is not considered as an appropriate standard to use in evaluations of community forest enterprise success (McDaniel 2003). Profit maximization may not be the principal objective of CFM—job creation or social capital building might be even more important. Community enterprises may therefore be judged successful even if no profits are generated (McDaniel 2003; Humphries *et al.* 2012).

The social impacts of CFM relative to open access logging (51% better, 23% no different, and 26% worse) reportedly include direct financial benefits and improvements in infrastructure and social institution functionality (Klooster & Masera 2000; Palmer & Engel 2007; Schreckenberg & Luttrell 2009). However, evidence is accumulating that the benefits of CFM are not distributed evenly; indeed, some studies suggest that the poorer households become even poorer due to CFM (Schreckenberg & Luttrell 2009). Whereas new CFM schemes can cause internal conflicts, they reportedly also lead to increased awareness, participation, and empowerment (Oyono 2005; Palmer & Engel 2007).

Only a handful of environmental variables have been compared in CFM and open access forests (Figure 1). When they differed, rates of deforestation were lower in CFM more frequently than they were higher. Interestingly, deforestation rates in CFMs were reported to be lower than those in protected areas (Porter-Bolland *et al.* 2012), although this finding was later challenged (Casse & Milhøj 2013). We did not include this comparison in our study, as protected areas do not share the same goals as CFM. We conclude that the widespread assumption that community-managed forests are better than open access areas in terms of environmental and economic variables should be tested with more rigorous measurements at several scales.

Is FSC certification associated with additional benefits for CFM?

All six studies that compared certified and noncertified community managed forests were from South America (61 comparisons, Table S1). FSC community certification appeared to bring additional benefits when compared to noncertified CFM in 47% of the 61 comparisons, no additional benefits in 51%, and worse outcomes in 2%.

Certification appeared to have mostly little effect on economic variables in community forests (Carrera *et al.* 2004; de Lima *et al.* 2008; De Pourcq *et al.* 2009). The price premiums for certified managing communities were sometimes small, not sustained, and obtained only for the highest grade timber (Carrera *et al.* 2004), but were reported to be positive in other cases (Humphries *et al.* 2012). We found evidence of no additional improvement in administration and management of forestry operations (Figure 1).

Most of the positive impacts attributed to CFM certification related to social variables, such as worker and community well-being, empowerment through committee creation, more secure land tenure, and better compliance with national regulations (Carrera *et al.* 2004; de Lima *et al.* 2008). Internal conflicts were sometimes exacerbated due to some community members feeling excluded (Carrera *et al.* 2004). There is little evidence for environmental benefits of CFM certification relative to CFM without certification, but one study in Tanzania demonstrated that FSC-certified community management was associated with improved forest structure and reduced fire occurrence, in comparison with open access management areas (not included in our analysis; Kalonga *et al.* 2015).

Our results show that it is not yet clear whether certification benefits CFM. Despite this lack of evidence, Molnar (2004) argued against certification on the basis

of it being administratively too complex and at times undermining sustainable traditional practices. Other researchers remark that many communities produce too little timber to be viable exporters to markets interested in certified products, at least without the help of local, chain-of-custody certified buyer (De Pourcq *et al.* 2009, Wiersum *et al.* 2011). Furthermore, the maintenance of certification is reported to be expensive, subsidies from donor institutions usually cease after certification is achieved, and long-term financial sustainability is rare (Carrera *et al.* 2004; Molnar 2004; Wiersum *et al.* 2011). Some authors have suggested that motivation for CFM certification comes mostly from external NGOs, rather than from the communities themselves, which can result in disappointment to the latter when the promised benefits are not secured (van Dam 2003; Humphries & Kainer 2006). We call on further, rigorous studies of the impact of certification on CFM prior to acceptance of any such conclusions.

Does industrial certification work better than CFM certification?

Only one study compared FSC-certified industrial and FSC-certified community forests. The study is from Guatemala's Maya Biosphere Reserve, which includes FSC-certified industrial concessions, FSC-certified community-managed concession, open access buffer zones, and strictly protected areas (Radachowsky *et al.* 2012). This study reported that for most variables, including internal conflicts within communities, incidences of land grabbing, deforestation, forest fragmentation and burning, and the occurrence of environmental crime, the most important factor was not whether an area was industry or community managed. Instead, it was more important whether there were anyone physically resided in the area. Nonresident-certified communities and certified communities with a long tradition of forest management performed as well as, and in some cases better than FSC-certified industrial concessions. In contrast, concessions managed by communities of recent immigrants to the region performed far worse in terms of the above-mentioned variables (Radachowsky *et al.* 2012).

There is clearly insufficient evidence to draw conclusions about whether, once certified, private companies perform better than community-owned enterprises. Nevertheless, an important point emerges: multiple aspects of CFM must be taken into account when evaluating management impacts, including whether community members reside in the forest, whether the community has a long tradition of forest management, whether it manages its forest for commercial production, and

whether it has only management rights or also broader decision-making power (Schreckenberg & Luttrell 2009; Radachowsky *et al.* 2012; Rasolofoson *et al.* 2015).

Trade-offs and data gaps

Sustainable forest management is an overarching goal of certification and CFM, but that goal is unlikely to be attained simultaneously for all variables, at all scales, and from the perspectives of all relevant stakeholders. The following trade-offs, which emerged from our literature synthesis, may help forest managers to set realistic management goals and help prevent perverse outcomes. They may also partly explain some of the controversial findings revealed by our review.

Limits on harvest intensity and illegal logging versus poverty reduction

Lower harvest intensities or better enforcement of bans on illegal logging will help sustain forest resources but also reduce short-term profits or community access to forest resources. Given that the poorest households are often the most dependent on forest resources, they are also likely to be the most affected by these restrictions (Schreckenberg & Luttrell 2009; Hensbergen *et al.* 2011). Unless specific provisions are made, the poor are at risk of becoming poorer with the requirement for and the enforcement of forest management plans, be it in certified industrial concessions or community managed forests (Gilmour *et al.* 2004). This trade-off points to an important data gap: longer term studies are needed to determine whether the marginalization of poor households persists, or if long-term profits outweigh any immediate increases in poverty.

Hunting restrictions versus human-wildlife conflicts

Enforcement of hunting bans or regulations in certified industrial concessions or community-managed forests favors biodiversity retention but can also increase human-wildlife conflicts, such as those related to crop damage by elephants (Schreckenberg & Luttrell 2009). Hunting bans can also have profound consequences for the welfare of local communities where bushmeat is an important source of protein (Alvard *et al.* 1997). Hunting reportedly escalates in conventional logging areas in the tropics, but is thought to decrease in certified logging concessions. More research is needed on the actual rates of hunting in different types of logging concessions (Brodie *et al.* 2015), as well as on the potential overflow

of increasing animal populations from areas under hunting ban into areas where hunting is allowed.

Market access versus market exclusion

Certification can provide improved access to environmentally conscious international markets and also higher prices. At the same time, if certification increases production costs, it may disadvantage communities and small holders that do not produce volumes large enough to enter international markets (Molnar 2004) or that produce timber from species for which there are no certification-demanding markets (McDaniel 2003).

Empowerment versus dependence on external support

Whereas CFM may empower communities, success often depends on financial subsidies and other inputs from external organizations, especially when certification is involved (Wiersum *et al.* 2011; Humphries *et al.* 2012).

Benefits at the expense of leakage to other forests

Reductions in both deforestation and illegal logging within FSC-certified industrial concessions or community-managed forests may cause leakage to neighboring unmanaged or conventionally managed areas. For example, as a part of a CFM project in Tanzania, restrictions on timber harvest reportedly motivated community members to exploit forests in neighboring communities that were not part of the project (Schreckenberg & Luttrell 2009). To evaluate fully and fairly the impacts of complex interventions, such as forest certification, such cases of leakage must obviously be taken into account (Romero *et al.* 2013).

Cost of certification and management versus reduced timber yield

Where enforcement of RIL and other certification principles and criteria reduces harvest volume, price premium and the financial benefit of increased market access may not fully compensate for the lost profit and cost of certification. FSC-certified community-managed forests, in particular, reportedly struggle to secure sufficient price premiums (Carrera *et al.* 2004). Moreover, RIL causes less structural damage than conventional logging, which, in certain forest types, might reduce regeneration opportunities for light-demanding commercial timber species (Fredericksen & Putz 2003). Under such conditions, expensive silvicultural interventions (e.g., enrichment

planting) are often required to sustain timber yields (Putz & Romero 2015).

Socioeconomic benefits versus equality of benefit distribution

Management interventions that benefit one segment of the community (e.g., young men) might be detrimental to others (e.g. marginalized women; Schreckenberg & Luttrell 2009). For example, whereas certified CFM reportedly increased community income in Tanzania, it decreased income equity within individual households in the same community (Schreckenberg & Luttrell 2009).

Conclusions

We used a literature review to evaluate the environmental, social, and financial impacts of forest certification, CFM, and their combination. Although few of the studies reviewed were rigorous enough to truly assess the impacts, our review revealed that none of the interventions consistently fulfilled all the expectations, and were sometimes associated with worse outcomes than conventional or no management. In particular, certification and CFM often do not seem to be financially sustainable without external subsidies, at least over the short term and until positive externalities of good management are captured. Improved market access and price premiums seldom seem to provide sufficient incentive for certification, as reflected by its slow uptake by industry and communities in tropical and subtropical forests (Romero *et al.* 2013).

We conclude that certification is likely associated with social and environmental benefits that justify its promotion, despite it being often less profitable than conventional management. Most importantly, it appears that deforestation rates are reduced in certified areas. Through employment of RIL practices and generally lower extraction intensities, certification is also associated with less deleterious impacts on biodiversity. Certification also appears to be associated with improved welfare of certified communities and communities living in the vicinity of certified industrial concessions. However, more research is needed to substantiate these results, especially on the potential trade-offs and leakage effects.

The environmental and social benefits of CFM are, based on our synthesis, open to question and certainly warrant further research through well-designed studies. Whereas there is evidence for a general improvement of social welfare under CFM, it does not always reach all layers of society and can be associated with new conflicts. Importantly, the success of CFM seems to depend on several factors, including whether commercial

use of resources is permitted (Rasolofoson *et al.* 2015), the decision-making power of the community (Charnley & Poe 2007), and whether the community has a long tradition of forest management (Radachowsky *et al.* 2012). We conclude that CFM should not be judged as a single management alternative nor evaluated with a single metric, as communities might have different priorities and means to achieve forest management and societal goals.

Forest managers and policy makers face an increasing number of different, sometimes opposing management goals. With this review, we hope to help them navigate the forest management goal landscape and minimize unwanted trade-offs to move towards more evidence-based management.

Conflict of interest

During a part of this study, ZB was financially supported by Precious Woods, AG, Switzerland, which is a FSC-certified logging company. The funder played a role in formulating the research question, but had no influence on data collection, analysis, result interpretation, or the preparation of the manuscript.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Supporting Online Material

Table S1. Details of comparisons obtained through a literature review of economic (ECON), environmental (ENV), and social (SOC) variables compared under conventional industrial logging (CL), Forest Stewardship Council certified industrial logging (FSC), community forest management (CFM), certified community forest management (FSC-CFM), and open access forests (OA).

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