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Area fees and logging in tropical timber concessions

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ABSTRACT. Area fees have become an increasingly important component of forest revenue systems in tropical developing countries. They are commonly viewed as having a neutral impact on decisions by timber concessionaires. This view is incorrect. Using both theoretical and empirical models, we demonstrate that area fees can induce concessionaires to accelerate timber harvests and to harvest more selectively. In Cameroon, area fees at recent levels create an incentive for concessionaires to harvest forests in half the estimated sustained-yield period. Countries that wish to encourage concessionaires to comply with sustained-yield requirements must implement measures that counter the depletion-accelerating effects of area fees.

1. Introduction

Timber fees have been at the center of policy discussions about tropical forests since the 1980s (Gillis, 1980; Repetto and Gillis, 1988). Most of the attention has focused on fees that are levied on the volume or value of timber harvested. These harvest fees, or royalties, have been criticized for distorting marginal harvesting decisions. As an alternative, studies supported by the World Bank and United Nations have advocated area fees: fixed annual charges on the total area under contract (Grut *et al*., 1991; Gray, 1997). The perceived allocational advantages of area fees were succinctly summarized in an early report by Gray (1983: 125), who wrote that because 'annual licence fees [i.e., area fees] are lump-sum payments, independent of the forestry activities of concession holders, they will not influence or distort the logging activities of concession holders'. Other oft-cited advantages include lower administrative costs (Ivers *et al*., 2003: 94) and greater transparency, which reduces opportunities for corruption (Contreras and Vargas, 2002: 10). For such reasons, area fees have become a core feature of forestry reform programs in Cameroon (Tanyi Mbianyor *et al*., 2003), Bolivia (Contreras and Vargas, 2002), and various other tropical countries.

Despite the growing importance of area fees as a component of tropical forest revenue systems, studies on timber fees in tropical forests have continued to focus on harvest fees (e.g., Conrad *et al*., 2005). The lack of studies on area fees may have contributed to the widespread perception that they are nondistortionary. In this paper we demonstrate that this perception

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is mistaken. We do not dispute that area taxes have a neutral impact on harvesting decisions when forests are privately owned and are managed in perpetuity for timber production, as in the classic Faustmann model. Many studies have demonstrated the validity of this basic forest taxation result (Heaps and Helliwell, 1985: 444; Johansson and Löfgren, 1985: 101, 131, 149; Gregory, 1987: 168–169; Pearse, 1990: 145–146, 198; Klemperer, 1996: 283; Hartwick and Olewiler, 1998: 328).

Forests in tropical countries, however, tend to be government-owned and harvested under fixed-term, but weakly enforced, concession contracts. We demonstrate that in this institutional setting, area fees create incentives for concessionaires (i) to increase the annual area harvested and thereby accelerate the depletion of timber stocks and (ii) if the annual harvest volume is constrained, to harvest less timber per unit area (i.e., to high-grade). These findings indicate that the advantages of area fees are less than has been assumed. We also find that depletion can be further accelerated when area fees coexist with harvest fees, as they always do in practice.[1] This too contrasts with the literature on taxation of private forests, which emphasizes the tendency of harvest taxes to induce owners to delay harvests (Heaps and Helliwell, 1985: 446; Pearse, 1990: 147; Hartwick and Olewiler, 1998: 327–328). We gauge the empirical significance of these findings by analyzing a representative timber concession in Cameroon. We find that area fees in Cameroon are sufficiently high to cause logging companies to prefer to harvest forests in less than half the standard contract length of 30 years.

We present our theoretical analysis in the next section and our empirical analysis in the section after that. We conclude with a discussion of policy implications. Although policy issues in tropical forests motivate our analysis, our theoretical results apply equally to other types of public forests where logging occurs under fixed-term contracts and constraints on annual areas harvested are imperfectly enforced.

2. Theoretical analysis

Model structure and assumptions

The Faustmann model is the standard model used in forestry taxation studies. The forest owner in that model selects the harvest frequency (the rotation age) that maximizes the net present value of after-tax income from an infinite series of harvests of a single stand of trees. The behavior of a timber concessionaire in a government-owned tropical forest is better modeled as involving decisions about how much of the area under contract to harvest each year and how intensively to harvest a unit area. Logging contracts in tropical forests usually specify the annual allowable harvest area, but such provisions are often violated,[2] and violators seldom face significant sanctions (Ross, 2001). In our model we therefore treat the

[1] That is, tropical countries that have area fees always have harvest fees, too. The reverse is not true.

[2] See the special issue of the International Tropical Timber Organization's quarterly newsletter, *Tropical Forest Update* (12 January 2002), devoted to forest crime.

concessionaire as free to choose the annual harvest area. We do consider the effects of constraints on annual harvest volume, however, and at the end of the paper we briefly discuss measures that tropical countries have taken to improve compliance with area constraints.

We assume that logging occurs in a mature forest with negligible timber growth.[3] The concession covers A hectares of forest. All hectares are identical and contain a mix of species whose timber values vary. Unlike Conrad *et al.* (2005), we do not model the stocks of different species explicitly; such detail is necessary for their analysis, but not ours. The concessionaire has two decision variables: T, the number of years within which the entire area is harvested, and which we refer to as the concession life; and h, the volume of timber harvested per hectare, which we refer to as harvest intensity. The endogeneity of concession life is another difference compared to Conrad *et al.*, who assume a fixed planning horizon. Each hectare is harvested only once, and so annual harvest area equals $^{A}/_{T}$. $v[h]$ is gross harvest revenue: the sales value of harvested logs. It is increasing in harvest volume ($v' > 0$; marginal log price is positive), with diminishing returns ($v'' < 0$; species are harvested in order from more to less valuable). c is the variable (per cubic meter) cost of logging, and C is the fixed (per hectare) cost. There are two timber fees: an ad valorem harvest fee τ_h, which is a percentage of gross harvest value;[4] and a fixed area fee τ_A, which is assessed on the entire area under contract, not just the annual area harvested. Hence, the choice of T affects the number of years that the area fee is paid, but not the annual payment. r is the concessionaire's discount rate.

The concessionaire seeks to maximize the net present value of timber profits

$$NPV = \left(((1-\tau_h)v - ch - C)\frac{A}{T} - \tau_A A\right)\frac{1-e^{-rT}}{r}. \qquad (1)$$

Our goal is to determine how the area and harvest fees affect the optimal (for the concessionaire) values of concession life and harvest intensity. We consider two cases, depending on whether or not the annual harvest volume is constrained. Concession contracts sometimes place limits on the annual harvest volume. In our notation, $h\frac{A}{T} \leq H$, where H is the annual allowable cut. Volume constraints can be easier to enforce than area constraints in some instances, because the transport of harvested logs and their receipt at mills and port facilities are more visible and thus easier to monitor than logging operations in remote regions. A concessionaire who is effectively (though not necessarily legally) free to choose annual harvest area thus might not be equally free to choose annual harvest volume. The concessionaire in our model chooses both T and h in the unconstrained case but only T in the

[3] This assumption is equivalent to assuming that concessionaires care about existing timber stocks but not regrowth, which is reasonable in tropical countries, where timber growth in natural forests is often slow and concession renewal is often uncertain.

[4] Results are qualitatively the same if the harvest fee is instead a fixed fee per unit volume, in the sense that the sign of the impact of τ_h on T is the same.

constrained case, because h in the latter case is determined implicitly by $h = \frac{H}{A/T}$ (assuming the harvest constraint is binding).

Because we are treating the concessionaire as free to choose T, equation (1) does not include the nominal concession contract length, $\overline{T}$. A concessionaire who selects $T < \overline{T}$ is not obliged to pay the area fee for years $T+1, \ldots, \overline{T}$. This is a reasonable assumption for several reasons. One is that tropical countries have weak legal institutions. Of the world's top 20 exporters of tropical roundwood in 2002,[5] 17 were in the bottom half of the World Bank's rule-of-law rankings for that year,[6] and 11 were in the bottom quarter. A second reason is that ministries of finance, which are typically more powerful than ministries of forestry, might tacitly agree to forgo future payments of area fees in return for the increased current payments of harvest fees generated by accelerated harvesting. An institutional incentive to collect fees while a concession is in operation can thus coexist with, or even undermine, a weaker incentive to enforce restrictions on the annual area harvested.

A third reason is that investors often insulate themselves from fiscal and other liabilities by creating new companies that are the legal holders of concession contracts. A good example is Barama, a joint venture formed by a pair of Malaysian and South Korean industrial groups, which in 1991 signed the contract for the largest concession in Guyana (Sizer, 1996). Concessions themselves are the chief assets of such companies, so governments have few assets to seize in compensation for unpaid future area fees once the companies finish logging. Greenpeace (Anonymous, 1997b; see also Sizer and Rice, 1995) refers to Mitra Usaha Sejati Abadi (Musa) Indosuriname, one of the two leading Indonesian-controlled entities that pursued concessions in Suriname in the 1990s, as having established subsidiary 'shadow companies' for 'evading forest legislation'.

Murky ownership confounds government efforts to pursue investors' other assets. Examples of unclear ownership include Suri-Atlantic Industries, the other leading Indonesian entity in Suriname (Anonymous, 1997b), and numerous companies in Papua New Guinea that are linked to the Malaysian Rimbunan Hijau group (Anonymous, 2006). In the latter case, 'The ownership and control of [the companies] is obscured by undisclosed buyouts, outdated company records, foreign ownership and the widespread use of tax havens, proxy directors and shareholders' (p. 3). Demerara Timbers Ltd, a Malaysian-controlled concessionaire in

[5] Based on the series, quantity of exports of tropical nonconiferous industrial roundwood, in the UN Food and Agriculture Organization's online database, FAOSTAT Forestry (faostat.fao.org, accessed 4 July 2006). The 20 countries were, from largest to smallest, Malaysia, Gabon, Papua New Guinea, Myanmar, Indonesia, Liberia, China, Equatorial Guinea, Republic of Congo, Central African Republic, Cameroon, Côte d'Ivoire, Laos, Guyana, Panama, Guinea, Suriname, Ecuador, Colombia, and Australia.

[6] Based on data downloaded from the World Bank's 'Governance & Anti-Corruption' website (info.worldbank.org/governance/kkz2004/tables.asp (accessed 4 July 2006).

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Guyana, provides an example of investors attempting to shield their assets by registering in offshore havens (in this case, the British Virgin Islands; Anonymous, 1997a). The prevalence of examples of companies logging rapidly, violating forestry regulations in the process, and facing few consequences for their transgressions after exiting the industry or countries has led environmentalists to label the tropical timber industry with the epithet, 'cut and run' (Glastra, 1999). Such companies have an incentive to pay area and harvest fees while concessions are in operation because doing so avoids putting the remaining years of logging at risk, but they face few consequences after they have stopped logging.

Case 1: annual harvest volume is not constrained

In this case the concessionaire maximizes the NPV expression given by equation (1) by selecting both harvest intensity, h, and concession life, T. The first-order condition for h is

$$(1-\tau_h)v' = c. \tag{2}$$

Timber is harvested within a hectare up to the point where marginal revenue, net of the harvest fee, equals the unit logging cost. With $v'' < 0$, we thus obtain the standard result that the harvest fee induces high-grading: a reduction in the volume harvested per hectare, with only the more valuable trees harvested. Note that this condition is not affected by either the other decision variable, T, or the other timber fee, τ_A. Harvest intensity is independent of concession life and the area fee.

The first-order condition for T is more complicated

$$\left(((1-\tau_h)v - ch - C)\frac{A}{T} - \tau_A A\right)e^{-rT} = \left(((1-\tau_h)v - ch - C)\frac{A}{T^2}\right)\frac{1-e^{-rT}}{r}. \tag{3}$$

The left-hand side is the marginal benefit of extending concession life by one year: the present value of an additional year of profit. The right-hand side is the corresponding marginal cost: the present value of the sum of the reduction in profit that occurs each year as a result of the smaller annual harvest area. Note that the area fee τ_A appears only on the left-hand side and carries a negative sign: increasing it decreases the marginal benefit of an additional year of concession life. This implies that concession life is negatively correlated with the area fee. This result can be demonstrated formally by totally differentiating the first-order condition with respect to T and τ_A and solving for ${}^{dT}/_{d\tau_A}$

$$\frac{dT}{d\tau_A} = \frac{Ae^{-rT}}{\left(\frac{\partial^2 NPV}{\partial T^2}\right)}. \tag{4}$$

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The denominator is negative under the standard assumption that the profit function (*NPV*) is convex, and so ${}^{dT}/_{d\tau_A} < 0$: an increase in the area tax induces the concessionaire to harvest the forest within a shorter period.[7]

The impact of the harvest fee τ_h on concession life is not clear from inspection of equation (3), because the fee appears on both sides of the equation. A harvest fee reduces the marginal benefit of extending concession life, because it reduces the gain in profit from an additional year of harvest, but it simultaneously reduces the marginal cost, because it also reduces the loss of profit that results from a smaller harvest in each year. The total differential yields

$$\frac{dT}{d\tau_h} = \frac{v\dfrac{A}{T}\left(\dfrac{(1+rT)\,e^{-rT}-1}{rT}\right)}{\left(\dfrac{\partial^2 NPV}{\partial T^2}\right)}. \tag{5}$$

The term in parentheses in the numerator is negative for positive values of r and T, and so an increase in the harvest fee unambiguously increases concession life (recall that the denominator is negative): ${}^{dT}/_{d\tau_h} > 0$. This parallels the standard result concerning the impact of a harvest tax on rotation length in the Faustmann model and is consistent with Conrad *et al.*'s conclusion that harvest fees most likely shift harvests toward the future.

Case 2: annual harvest volume is constrained

The only first-order condition in this case is the one for T, and it is now given by

$$\left(\left((1-\tau_h)\,v - c\frac{H}{A/T} - C\right)\frac{A}{T} - \tau_A A\right)e^{-rT}$$
$$= (1-\tau_h)\left(v - v'\frac{H}{A/T} - C\right)\frac{A}{T^2}\,\frac{1-e^{-rT}}{r}. \tag{6}$$

The derivative ${}^{dT}/_{d\tau_A}$ continues to be given by equation (4): an increase in the area fee accelerates depletion of the concession. Given that annual harvest volume is fixed, however, the reduction in concession life necessarily causes harvest intensity to fall: an increase in the area fee causes high-grading. The area fee is thus doubly distortionary.

Another difference compared to the unconstrained case is that the impact of the harvest fee on concession life is now given by the following expression

[7] In a similar vein, Heaps and Helliwell (1985: 457–458) note that fixed annual fees accelerate mineral depletion.

instead of by equation (5)

$$\frac{dT}{d\tau_h} = \frac{v\frac{A}{T}\left(\frac{(1+rT)\,e^{-rT}-1}{rT}\right) + v'H\left(\frac{1-e^{-rT}}{rT}\right)}{\left(\frac{\partial^2 NPV}{\partial T^2}\right)}. \tag{7}$$

The difference is the second term in the numerator, which unlike the first term is positive for positive values of r and T. Signing the numerator is not possible without making more specific assumptions about A, H, and v. The impact of the harvest fee on concession life is therefore ambiguous when harvest is constrained. As we will see in the next section, the impact in our empirical example is negative: the harvest fee contributes to a shortening of concession life.

3. Empirical analysis

Context and objectives

The Government of Cameroon made more changes to its public forest policies than probably any other country in the world during the past decade. In particular, it completely altered forest tenure and the fiscal regime for timber (Brunner and Ekoko, 2000). It created a permanent forest estate with three zones: commercial timber production forests, protected areas, and communal/community forests. Within the commercial production zone it established large-scale, long-term forest management concessions (*unités forestières d'aménagement*; UFAs). UFAs are harvested and managed by private parties under 15-year contracts that are renewable once, for a maximum duration of 30 years. Thirty years is the Ministry of Environment and Forests' estimate of the sustained-yield harvest cycle for forests in the country. The area of UFAs varies, with a median of around 70,000 hectares. In one of its boldest innovations, the government introduced sealed-bid auctions to allocate the UFAs. Winning bidders not only obtain exclusive timber harvesting rights; they also take on responsibility for preparing and implementing forest management plans. Before the reforms, management of public forests was the government's responsibility.

Bids in UFA auctions are expressed in terms of the annual area fee (*redevance forestière annuelle*) that companies are willing to pay. The area fee is assessed on the total area of a UFA, not just the area actually harvested in a given year. The first UFA auction was held in November 1997, and several more have been held since. In the early 1990s, before auctions were introduced, the area fee had been less than US$0.20 per hectare. The auctions increased it dramatically: mean winning bids were nearly $2 per hectare in the first auction (Bikié *et al.*, 2000) and nearly $5 per hectare in the second one, which was held in 2000 (Collomb and Bikié, 2001). Inflation was low in Cameroon during this period, and so the relative increase was nearly as large in real terms. The area fee coexists with several direct and indirect harvest fees, including ones assessed on the entire volume harvested, the volume processed by local mills, and the volume exported.

Per conventional forest planning procedures, the Ministry of Environment and Forests limits the annual area that a concessionaire can legally harvest – the annual allowable coupe (*assiette de coupe*) – to the inverse of the harvest cycle, i.e. 1/30th of a UFA.[8] Violations of area constraints were one of the most widespread forms of illegal logging throughout central Africa in the 1990s, however (Friends of the Earth, 1997). The objectives of our empirical analysis are: (i) to determine whether the increase in the area fee in Cameroon has created an incentive for concessionaires to commit such violations and thereby completely harvest their UFAs before the end of their contracts, (ii) to quantify the magnitude of this harvest-accelerating effect, and (iii) to quantify the magnitude of its interaction with the harvest fees. We conducted the analysis using a simulation model calibrated to data from southeastern Cameroon, which is where the largest area of UFAs is located. We describe the structure of the model before presenting our results.

Structure of the simulation model

The model pertains to a concession in a mature forest. The concessionaire is a forward-looking agent who 'mines' the timber in a single pass and seeks to maximize the net present value of logging profits. Annual logging profit is

$$\pi = \frac{A}{T}\left(\sum_{i,j}((1-\tau_h)p_{ij} - c_j)h_{ij} - C\right) - \tau_A A. \tag{8}$$

A, T, C, τ_h, τ_A are defined as in the theoretical model: concession area, concession life, fixed logging cost, and the harvest and area fees, respectively. As in Cameroon, the harvest fee is a percentage of gross harvest value. p_{ij} is the market price of logs of species group i ($i = 1, \ldots, m$) and diameter class j ($j = 1, \ldots, n$), c_j is the variable cost of harvesting and transporting logs of diameter class j from the forest to a mill, and h_{ij} is the per-hectare volume of timber harvested in species group i and diameter class j. Variation in p_{ij} across species groups and diameter classes results in marginal revenue diminishing with volume harvested, $v'' < 0$, as in the theoretical model.

The concessionaire selects T and the vector $\mathbf{h}$, whose elements are h_{ij} , to maximize

$$NPV = \pi\frac{1-e^{-rT}}{r}. \tag{9}$$

[8] The Ministry also requires concessionaires to prepare forest management plans, which provide detail on road building, logging methods, environmental safeguards, and other management issues. These plans are especially important in view of the fact that a concession contract limited to a single 30-year harvest cycle does not encourage concessionaires to consider the impacts of their harvest decisions on the future productivity of the forest.

The concessionaire faces an annual harvest constraint of H, so that $\frac{A}{T}\sum_{i,j} h_{ij} \leq H$. We will say more about this constraint below. Formally, the concessionaire's problem is

$$\max_{\{T,\mathbf{h}\}} NPV \tag{10}$$

subject to

$\mathbf{s}$	(initial conditions: vector of timber stocks, s_{ij})
$\mathbf{h} \leq \mathbf{s}$	(biological harvest constraint)
$\frac{A}{T}\sum_{i,j} h_{ij} \leq H$	(capacity constraint)
$T, \mathbf{h} \geq 0$	(non-negativity constraints).

We applied this model to a hypothetical, but representative, timber concession in southeastern Cameroon, 300 kilometers from the two milling centers in the country (the capital Yaounde, and the main port Douala). We set the area of the concession equal to the approximate median UFA value of 70,000 hectares. We set the harvest constraint H equal to 40,000 cubic meters per year, which is the approximate median capacity of a sawmill in Cameroon (Abt *et al*., 2002: 45). UFAs are typically associated with specific mills, largely because owning a mill was a requirement for bidding on UFAs until the early 2000s.[9] Moreover, a phaseout of log exports in the late 1990s made local mills the only source of demand for timber. Even today there is not much of an internal log market in the country. This tight link between concessions and mills is the reason for the inclusion of the harvest constraint in the model.

We obtained data on forest composition from the Cameroon forest inventory.[10] The spatial units of the inventory are termed *unités de compilation*. We used data from *unité de compilation* no. 4125. Table 1 shows the composition of an average hectare in this unit. The table provides information on two standard forestry measures, the number of trees and the basal area (the sum of the cross-sectional areas of tree trunks measured 1.3 meters above the ground). In both the table and the model, we assigned the hundreds of tree species to five groups: ayous; sipo, sapelli, and kossipo; other important commercial species;[11] potentially commercial species; and noncommercial species. As indicated, we aggregated trees into 10-cm diameter classes, which was the level of detail in the inventory. We used procedures from Brown (1997) to calculate the gross timber volumes of trees

[9] In principle we should include the salvage value of the associated mill in the concessionaire's maximization problem, but milling technology in Cameroon is so simple, and depreciation rates are so high, that salvage value would be small even for the shortest concession lives predicted by our simulation model.

[10] We are grateful to the Canadian International Development Agency for making these data available.

[11] This group includes a mix of species with low values and some with very high values (e.g., afromosia, bubinga, doussie, moabi, iroko). The high-value species account for a small portion of timber stocks in the group, between 1.5 and 5 per cent of standing volume.

Table 1. *Composition of an average hectare of forest in unité de compilation no. 4125 in southeastern Cameroon*

Diameter class (cm)	*Number of trees per hectare by species group*						*Basal area (m^2/ha)*
	A	*S*	*C*	*O*	*N*	*Totals*	
20–30	0.416	0.289	2.898	11.069	61.277	75.949	3.728
30–40	0.325	0.111	2.099	6.578	24.277	33.392	3.213
40–50	0.343	0.060	2.102	3.398	11.681	17.584	2.797
50–60	0.352	0.066	2.045	2.163	7.714	12.340	2.932
60–70	0.500	0.033	1.620	1.557	4.482	8.193	2.719
70–80	0.482	0.063	1.268	1.184	2.627	5.623	2.484
80–90	0.578	0.075	0.994	1.042	1.702	4.392	2.492
90–100	0.443	0.066	0.819	0.759	1.533	3.620	2.566
100–110	0.271	0.027	0.280	0.304	0.545	1.428	1.236
110–120	0.108	0.015	0.139	0.160	0.295	0.717	0.745
120–130	0.048	0.009	0.069	0.057	0.123	0.307	0.377
130–140	0.051	0.006	0.057	0.048	0.114	0.277	0.397
140–150	0.024	0.000	0.030	0.021	0.042	0.117	0.194
150–160	0.015	0.000	0.114	0.021	0.042	0.193	0.364
160+	0.000	0.000	0.000	0.006	0.000	0.006	0.013
Totals	3.956	0.820	14.534	28.367	116.454	164.138	26.256

Notes: A = ayous
S = sipo, sapelli, kossipo
C = other important commercial species
O = potentially commercial species
N = noncommercial species
Source: Cameroon national forest inventory.

in particular species groups and size classes, and we converted gross timber volumes to net volumes by multiplying by 0.55 (MINEF, 1995).

We collected data on log prices and logging costs through interviews in Cameroon during December 1999 and January 2000. The data on log prices refer to logs of medium quality (grade BC). Table 2 shows these data. For logging costs, we supplemented the interviews with data from various published sources (CIRAD and I&D, 2000; Durrieu de Madron *et al.*, 1998: 63, 70; Bakouma and Buttoud, 1999; Mertens *et al.*, 2001). Table 3 shows the logging cost estimates used in the model. Based on the interviews, we set the concessionaire's discount rate equal to 10 per cent.

We constructed and solved the model using the 'Solver' routine in Microsoft *Excel*. We defined scenarios as particular combinations of area and harvest fees. We input values for these fiscal parameters into the model and solved for the NPV-maximizing values of concession life (T) and harvest intensity ($\mathbf{h}$). We perturbed the starting values of T and $\mathbf{h}$ to confirm that the solutions were global maxima. We expressed the concessionaire's NPV and other monetary values in the Cameroonian currency, the central African franc (FCFA; 700 FCFA ≅ 1 US$ in 1999–2000). We increased the area fee by increments of 1,000 FCFA from zero to the value that made the concession

Table 2. *Log prices in Douala ('000 FCFA/m^3)*

Diameter class (cm)	*Species group*				
	A	*S*	*C*	*O*	*N*
< 70	0	0	0	0	0
70–80	0	0	36	0	0
80–90	0	40	36	0	0
90–100	50	50	37	0	0
100–110	50	50	37	0	0
> 110	50	65	41	0	0

Note: Species groups are the same as in Table 1.
Source: Interviews (December 1999–January 2000).

Table 3. *Logging costs*

Activity	*Cost*
Road construction & other fixed costs	15,000 FCFA per hectare
Felling	2,000 FCFA/m^3
Skidding, loading, unloading	9,500 FCFA/m^3
Transportation	50 FCFA/m^3/km

Sources: Interviews and documents cited in text.

unprofitable to harvest. We ran these scenarios with and without the harvest fee. We set the harvest fee equal to 8.5 per cent of log price. The felling tax (*taxe d'abattage*) in Cameroon is assessed as 2.5 per cent of 85 per cent of log price, but in 1999–2000 it generated only about one-fourth of the total revenue from all volume-based timber fees. The composite harvest fee was thus about 8.5 per cent of log price.

Simulation results
Figure 1 displays the key simulation results. Concession life is on the vertical axis, and area fee is on the horizontal axis. Concession life is expressed in years. Area fee has been converted to US dollars from the increments of 1,000 FCFA used in the simulation model, which explains why the labels on the horizontal axis are not round numbers. The dots show results for scenarios with only the area fee, while the triangles show results for scenarios that also included the harvest fee.

When both fees are absent, concession life is 27 years. This is not much different from the 30-year harvest cycle that the Cameroon Ministry of Environment and Forests prescribes. Given the annual harvest constraint of 40,000 cubic meters, sustained-yield management is thus close to privately optimal in the absence of area and harvest fees. This is confirmed by the NPVs for $T = 27$ and $T = 30$, which differ by just 2 per cent.

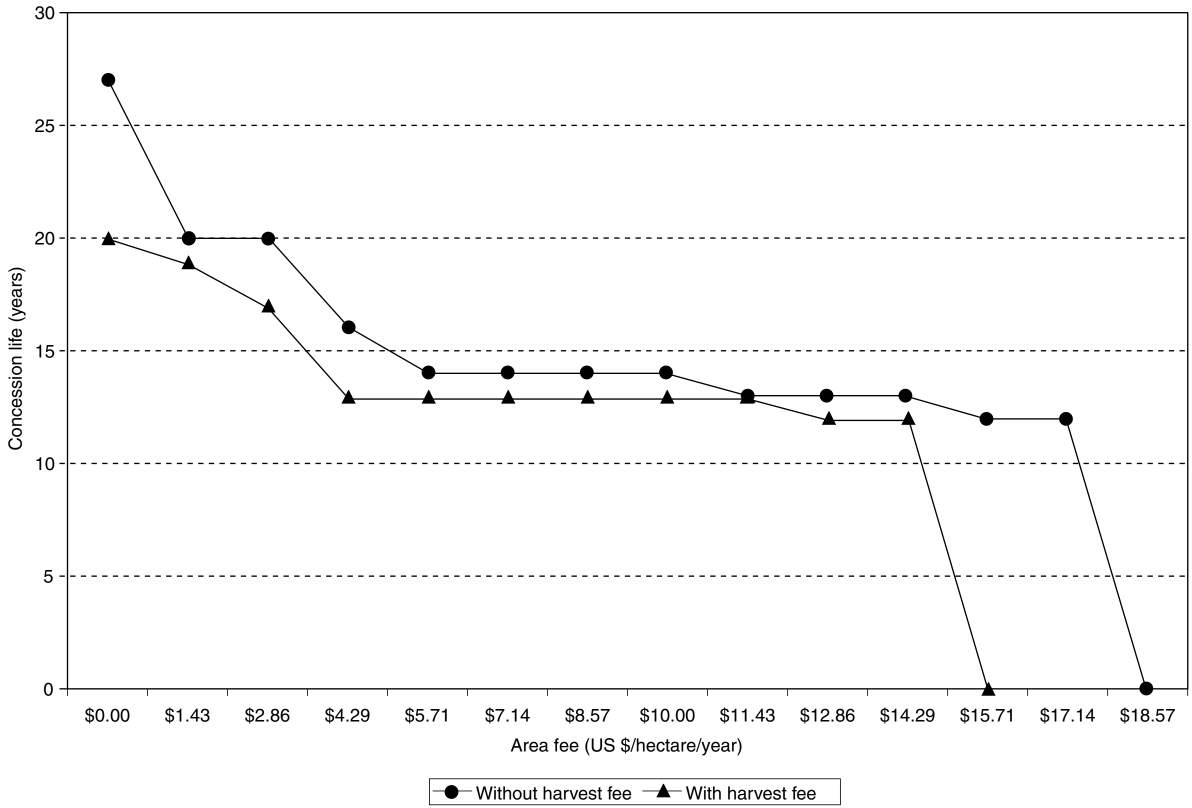

Figure 1. *Impact of an area fee on concession life, with and without a harvest fee*

In the absence of the harvest fee, introducing an area fee of US$1.43 (1,000 FCFA) causes concession life to drop by a quarter, to 20 years. This level of the area fee is well below the mean bid in the 1997 UFA auction. A substantial decrease in concession life therefore does not require implausibly large area fees. Concession life falls further as the area fee rises. The decline is not smooth, because differences in marginal timber rent between species groups and diameter classes are discrete, not continuous. An area fee in the vicinity of US$5 (3,500 FCFA), which is about the mean bid in the 2000 UFA auction, causes concession life to fall to 15 years—half the sustained-yield harvest period. Harvest intensity is also half of the sustained-yield level, with mainly larger and more valuable trees in the ayous and sipo, sapelli, kossipo groups being harvested. The area fee thus causes high-grading, even though it is not assessed on the volume of timber harvested. The concession remains barely profitable at an area fee of US$17.14 (12,000 FCFA). Profitable operation is no longer possible when the area fee reaches US$17.90 (12,528 FCFA), regardless of the choice of concession life and harvest volumes.

The addition of the harvest fee accelerates depletion of the concession. Concession life falls to 20 years when the harvest fee is introduced in the absence of an area fee. This is the same as the drop caused by an area fee of US$1.43 (1,000 FCFA). When added to the area fee, the harvest fee never causes concession life to rise. The concession is now unprofitable for area fees above US$14.29 (10,000 FCFA).

4. Discussion

We have demonstrated analytically, and confirmed empirically using data from Cameroon, that an area fee can encourage a timber concessionaire to accelerate the harvesting of public forests. We have also demonstrated that an area fee can induce high-grading when it is combined with a harvest constraint. These findings contradict conventional wisdom and suggest that an area fee is less consistent with sustained-yield management regimes than has been assumed.

The distortionary effects that we have identified differ from two distortions associated with area fees that *have* been discussed in the literature. One is what Gillis (1980: 82) labels 'type 2 high-grading': an area fee being set at such a high level that it eliminates the profitability of harvesting lower quality sites. The other is that fixed annual fees discourage investment by risk-averse contractors who face fluctuating market conditions (Heaps and Helliwell, 1985: 446; Pearse, 1990: 207). The distortions that we have identified do not depend on heterogeneity across sites or stochastic market conditions.

The relevance of our results for Cameroon must be interpreted in view of the fact that area fees in that country are self-assessed by concessionaires, through the bidding process in UFA auctions. If bidders believe that annual allowable logging areas will be strictly enforced, then they can be expected to bid amounts that do not create an incentive to deplete UFAs sooner than 30 years. This was probably not the case during the first two UFA auctions, which coincided with a large increase in logging violations (Brunner and Ekoko, 2000).

The fact that area fees can encourage violations of annual allowable logging areas does not mean that countries should not use area fees in public forests. No fiscal instrument is perfect, and area fees do have some desirable properties. In particular, the total payment that a concessionaire owes could not be easier to calculate than for an area fee, as it is simply the product of concession area and the fee per hectare. Moreover, tropical countries are not homogeneous. One of our key assumptions, that a concessionaire faces no risk of being held liable for area fees during the remaining years of a concession contract if he depletes the concession sooner, holds less strictly in countries with stronger legal institutions, with ministries of finance that are less driven by short-run revenue imperatives, and with transparent ownership of the companies holding concession contracts. This risk dampens the concessionaire's incentive to select a concession life shorter than the concession contract.

Where this risk is low, governments that wish to discourage concessionaires from violating annual allowable logging areas must couple area fees with measures that counter their depletion-accelerating effects. A variety of such measures exists, including more vigorous monitoring and enforcement, steeper penalties, performance bonds (Paris *et al.*, 1994; Panayotou, 1998; Boscolo and Vincent, 2000), and revocation clauses in concession contracts (Gillis, 1992). Although the details of these measures will vary depending on forest characteristics and the institutional setting, improved monitoring is fundamental: a concessionaire's calculation of the risk of negative consequences from area violations starts with the probability that violations will be detected at all. Performance bonds appear to be an especially attractive financial deterrent to couple with improved monitoring, as they can in principle be set at levels that offset the private gains from accelerated timber depletion. If the gains are large and insurance markets are not well-developed, however, then companies might face practical difficulties in financing the bonds. For example, in our model an area fee of US$5.71 (4,000 FCFA) reduces the concession life to 14 years when the harvest fee is zero. At a 10 per cent discount rate, the present value of the 16 years of unpaid area fees is $3,129,483. This is nearly 6 times the annual profit earned by a concessionaire who abides by the 30-year concession contract.

Measures to discourage area violations depend on the existence of reasonably well-functioning legal institutions. Claims in the literature that area fees are administratively less costly than harvest fees must take into account the costs of these measures and their effectiveness in curtailing excessively rapid harvesting. Cameroon has introduced several of the measures listed above since the second UFA auction, and its experience is encouraging so far: Global Witness (2003: 18) reported few violations of annual harvest areas within UFAs during the period December 2001 to June 2003. On the other hand, the possibility of replicating this apparent success in other countries is not clear, as the measures were conditionalities attached to a series of structural adjustment loans from the World Bank and the International Monetary Fund to the country (Brunner and Ekoko, 2000). The true test of these measures will come in the future as the influence of the Bank and the Fund wanes.

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