

Additional file 2

Opportunity cost of carbon sequestration with respect to timber production in a forest concession in central Africa:

Break-even price of carbon for different management parameter values

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In this additional file, we redo the computation of the break-even price of carbon with different values of the management parameters, to assess the robustness of the estimate of the break-even price.

1 Break-even price of carbon when damage rate varies across management scenarios

By default, we used a constant logging damage rate of 10%, irrespective of management scenario. To relax this simplifying assumption, we also computed the break-even price of carbon when logging damage depends on the density of logged trees. We used the relationship given by Picard et al. (2012) between logging damage ℓ (dimensionless) and the density of logged trees h (in stems ha^{-1}):

$$\ell = 1 - \frac{1}{(1 + 0.09135h)^{0.7046}}$$

where h is computed from $\mathbf{N}_s$ using: $h = \sum_s \mathbf{1}'(\mathbf{I} - \mathbf{H}_s)\mathbf{N}_s$, where the sum on s is over commercial species only, and $\mathbf{1}$ is the vector of length K full of ones (see section “Model of forest dynamics” of the manuscript). The resulting break-even price of carbon for a contribution margin of US\$25/m³ is given in Table S3-1.

2 Break-even price of carbon for a discount rate of 8%

By default, we used of discount rate of 12%. When the discount rate is lowered to 8%, the break-even price of carbon is slightly modified (Table S3-2), which is consistent with the result of the sensitivity analysis that showed that the break-even price of carbon was slightly sensitive to the discount rate.

Tab. S3-1: Opportunity cost of carbon sequestration for different alternative management scenarios in the Haut-Abanga concession, when logging damage is a function of the density of logged trees. The break-even price of carbon sequestration π_C^* is computed for a contribution margin of US\$25/m³ for all commercial species. Σ Credits is the sum of carbon credits. Δ Volume is the total reduction in harvested wood volume. Δ PVT_T is the loss in the net present value of timber.

Scenario	Δ Volume (m ³ ha ⁻¹)	Σ Credits (tCO ₂ ha ⁻¹)	Δ PVT _T (US\$/ha)	π_C^* (US\$/tCO ₂)
Lengthened rotation (+5 yr)	1.8	8.5	34.2	8.9
Lengthened rotation (+10 yr)	3.3	16.0	60.5	8.9
Lengthened rotation (+15 yr)	4.7	22.7	81.2	8.8
Raised cutting limits (+10 cm)	8.9	22.6	65.5	7.9
Raised cutting limits (+20 cm)	17.5	41.9	124.2	8.1
Raised cutting limits (+30 cm)	24.5	55.3	166.2	8.4
Raised cutting limits (+40 cm)	29.5	63.5	193.6	8.6

Tab. S3-2: Opportunity cost of carbon sequestration for different alternative management scenarios in the Haut-Abanga concession, for a discount rate of 8%. The break-even price of carbon sequestration π_C^* is computed for a contribution margin of US\$25/m³ for all commercial species. Σ Credits is the sum of carbon credits. Δ Volume is the total reduction in harvested wood volume. Δ PVT_T is the loss in the net present value of timber.

Scenario	Δ Volume (m ³ ha ⁻¹)	Σ Credits (tCO ₂ ha ⁻¹)	Δ PVT _T (US\$/ha)	π_C^* (US\$/tCO ₂)
Lengthened rotation (+5 yr)	1.8	7.1	41.6	10.5
Lengthened rotation (+10 yr)	3.3	13.0	75.3	10.7
Lengthened rotation (+15 yr)	4.7	18.2	102.9	10.9
Raised cutting limits (+10 cm)	8.9	10.3	89.4	16.7
Raised cutting limits (+20 cm)	17.5	19.5	170.4	16.9
Raised cutting limits (+30 cm)	24.5	26.3	229.9	17.1
Raised cutting limits (+40 cm)	29.5	30.7	269.5	17.3

3 Break-even price of carbon for a growth rate of 0.172 cm yr⁻¹

By default, we used a dbh growth rate of $a = 0.3$ cm yr⁻¹, which corresponds to a dbh distribution at steady state (without logging) that is exponential with parameter $m/a = 0.033$ cm⁻¹, where $m = 1\%$ yr⁻¹ is the default value of the mortality rate. The pre-harvest dbh distribution in the Haut Abanga concession was exponential with parameter 0.058 cm⁻¹, which corresponds to a dbh growth rate of $a = 0.172$ cm yr⁻¹. When the dbh growth rate is lowered from 0.3 to 0.172 cm yr⁻¹, the carbon stock has an overall trend that is decreasing (Figure S3-1). However, the break-even price of carbon is slightly modified (Table S3-3), which is consistent with the result of the sensitivity analysis that showed that the break-even price of carbon was slightly sensitive to the dbh growth rate.

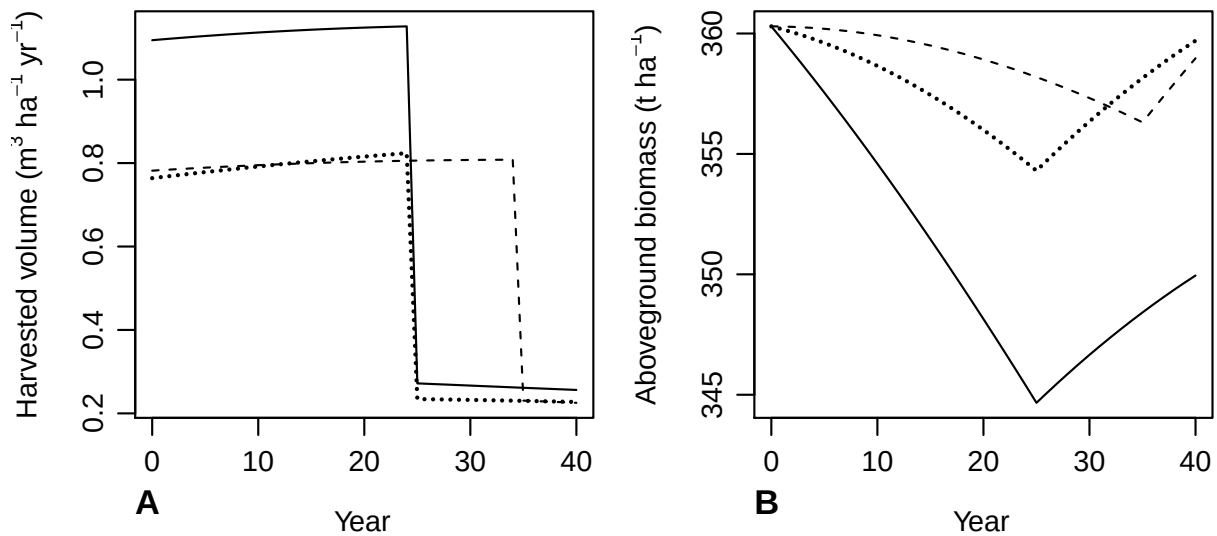


Fig. S3-1: Temporal forecasts in the Haut-Abanga forest concession, Gabon, when using a dbh growth rate of 0.172 cm yr^{-1} . Harvested wood volume (panel A) and aboveground biomass (panel B) are forecast according to three management scenarios: solid line is the reference scenario (T^{ref} , d_s^{ref}); dashed line is an alternative scenario with a longer felling cycle $T = T^{\text{ref}} + 10 \text{ yr}$; and dotted line is an alternative scenario with higher cutting limit diameters $d_s = d_s^{\text{ref}} + 10 \text{ cm}$.

Tab. S3-3: Opportunity cost of carbon sequestration for different alternative management scenarios in the Haut-Abanga concession, for a dbh growth rate of 0.172 cm yr^{-1} . The break-even price of carbon sequestration π_C^* is computed for a contribution margin of US\$25/ m^3 for all commercial species. $\Sigma \text{Credits}$ is the sum of carbon credits. ΔVolume is the total reduction in harvested wood volume. ΔPVT_T is the loss in the net present value of timber.

Scenario	ΔVolume ($\text{m}^3 \text{ ha}^{-1}$)	$\Sigma \text{Credits}$ ($\text{tCO}_2 \text{ ha}^{-1}$)	ΔPVT_T (US\$/ha)	π_C^* (US\$/ tCO_2)
Lengthened rotation (+5 yr)	1.5	5.9	32.1	11.6
Lengthened rotation (+10 yr)	2.7	10.8	56.7	11.6
Lengthened rotation (+15 yr)	3.9	15.1	75.9	11.6
Raised cutting limits (+10 cm)	8.5	9.2	63.3	16.3
Raised cutting limits (+20 cm)	16.3	17.3	119.2	16.4
Raised cutting limits (+30 cm)	22.2	23.1	157.6	16.4
Raised cutting limits (+40 cm)	26.1	26.7	182.2	16.5

References

- Picard, N., S. Gourlet-Fleury, and E. Forni, 2012. Estimating damage from selective logging and implications for tropical forest management. *Canadian Journal of Forest Research* **42**:605–613.