Peer Community In Forest & Wood Sciences

Allowing natural forest regeneration to provide shelter for cocoa trees in tropical agroforestry

Bernard Thibaut *based on peer reviews by* ***Tancrède Alméras*** *and 1 anonymous reviewer*

Aimé K. Kouassi, Irié C. Zo-Bi, Bruno Hérault, Isaac K. Konan, Marie R. Dago, Baptiste Lasbats, Sylvain Schmitt, Anny E. N'Guessan, Raphaël Aussenac (2024) Tree growth in West African cocoa agroforestry systems : high timber yields and superior performance of natural regeneration. HAL, ver. 2, peer-reviewed and recommended by Peer Community in Forest and Wood Sciences. https://hal.science/hal-04638492

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Scientific context

A large part of deforestation in Ivory Coast is due to cocoa plantations, but the need for timber is increasing with population growth. A good compromise for farmers should be for agroforestry to combine cocoa and timber income. Tree for timber management may come from natural regeneration by the large diversity of available seed stock in the cocoa plots, fostering the safeguarding of biodiversity (Vroh et al. 2019, Kouassi et al. 2024)

Questions, hypotheses, methodology

Besides trade-off with cocoa productivity, this very new way of practising agroforestry raises many questions about timber productivity, the geometry of trunks or timber quality in connection with population needs.

Agroforestry trees should be less slender with lower branches than forest trees. This was studied here by Kouassi et al. (2024) using a very large sampling (150 plots) that covered the whole cocoa production zone on the south Ivory Coast. The description of many trees, including diameter at breast height, log height and tree age, allowed accurate modelling of tree growth and building of growth trajectories for 23 species of commercial interest.

Main results and interpretations

Using modelled diameter growth and bole volume trajectories, associated with the ongoing rule for harvesting based on minimum logging diameter, makes it possible to predict timber harvesting at different ages of the cocoa plantation.

Moreover, natural regeneration proves to be more efficient than plantation using saplings, but logs are more conical and with lower branches than their counterparts in natural forests, as expected.

Recommendation

This is a very interesting paper on agroforestry for fruit (cocoa) and timber production, full of interesting data coming from a large number of study areas (150 plots) where both spontaneous (natural regeneration from past forest seeds) or planted fast-growing trees are used. Using a Bayesian scheme, models are built to predict (1) the changes in diameter with tree age, (2) the relationship between diameter and height, and (3) the relationship between tree dimensions and bole volume. Predictions about the change in bole volume with age are deduced from these models. This makes it possible to build scenarios for adding value to the wood produced by the agroforestry system, depending on the current or future technical and socio-economic context.

References:

Kouassi AK, Zo-Bi IC, Hérault B, Konan IK, Dago MR, Lasbats B, Schmitt S, N'Guessan AE, Aussenac R (2024) Tree growth in West African cocoa agroforestry systems: high timber yields and superior performance of natural regeneration. HAL, ver.2 peer-reviewed and recommended by PCI Forest and Wood Sciences https://hal.science/hal-04638492

Vroh TA, Abrou NEJ, Gone BI, Adou Yao CY (2019). Système agroforestier à cacaoyers en Côte d'Ivoire : connaissances existantes et besoins de recherche pour une production durable. Rev. Mar. Sci. Agron. Vét. (2019) 7 (1): 99-109.

Reviews

Evaluation round #1

DOI or URL of the preprint: https://hal.science/hal-04638492
Version of the preprint: 1

Authors' reply, 28 December 2024

Download author's reply

Decision by Bernard Thibaut, posted 05 September 2024, validated 09 September 2024

Decision for round 1

Based on the reviewer's expertise and my own one, the paper is found as an interesting and original contribution to a specific case of agro-forestry for cocoa plantations in West Africa.

The paper can be improved in some ways by minor corrections or complements that are suggested in the 2 reviews and the comments added by me in the text (attached file vu BTh).

In a wider view, mostly for further works on the same subject, I would like to make a general comment.

I find very interesting your way of changing the usual paradigm of planted forest associated to planted agro-food, letting trees naturally colonize the crop from the existing seed bank made of a large number of tree species, well adapted to the local climate conditions, with a low planting cost. But I am a little disappointed by your conservatism in the way to take values from the trees which is half of forestry job. In my opinion, classical concepts as "Minimum logging diameter" (MLD) or "species identified as potentially suitable for wood

production" i.e. "commercial species" are totally out of scope considering both available sawing of veneer cutting technologies using mostly log diameters between 30 to 45 cm DBH, and the specific socio-economic situations of cocoa farmers.

Wood stems are always very good mechanical beams allowing trees to resist external forces, whatever the species. So timber issued from every species growing in the cocoa field is always a good solution for mechanical conception of many objects or structure. This can be checked in cultural heritage everywhere in the world. The reasons for use are linked to different timber availability, the existence of local knowledge and know-how and socio-economic consideration, but not to wood ability to perform a mechanical function. This is the reason why I suggest you to take into consideration all the species that you have measured in order to be able to have a sound base for forest products use in the cocoa AF system.

Besides, there are strong differences between species and trees within a species for stem geometry, and wood properties that are not strictly linked to structural uses: resistance to fungi, insects or bacteria, aesthetical advantages, dimensional stability, acoustic properties and so on. Most of these properties are linked to the large cocktail of organic molecules (extractives) which is a species chemical signature and are and treasures for fine chemistry.

At the end of a cascade use of timber all wood species are excellent fuels with the same energy content par unit dry mass.

Cocoa farmers are nor big timber companies looking a very homogeneous resource for a given fruitful process and, at least at the R&D level, all opportunities should stay open.

Your experimental data is a very good mine of information and you should share it with the scientific community as well as enhance R&D projects for AF systems. **Download recommender's annotations**

Reviewed by Tancrède Alméras, 04 September 2024

This article addresses the question of the productivity (change in bole volume with age) of trees in agroforestry systems (AFS) in Côte d'Ivoire. The applicative context is very well described, and the implications of the study for AFS management are provided. The study is based on a large dataset about the age and size of trees (diameter at breast height and bole height) in AFS in Côte d'Ivoire. Using a Bayesian scheme, the authors build models to predict (1) the changes in diameter with tree age, (2) the relationship between diameter and height, (3) the relationship between tree dimensions and bole volume. From these models, predictions about the change in bole volume with age are deduced. The authors consider the origin of the tree (natural regeneration or transplanted) and evidence a strong effect of this origin, natural regeneration having a better potential for wood production.

The title of the article may be a good summary of its content, but I found it difficult to understand (it is a complex phrase without verb).

L46-47: "more subject to variations in temperature and humidity, influencing their mechanical structure". I don't really understand this argument. I think the main effects of microclimate on AFS are those mentioned earlier, light and wind. Please either develop of delete this comment.

L100: please specify the number of trees in that subset.

L115: unfortunately, Bayesian statistics are not yet so widespread, so that it would be useful to remind the reader what are the advantages of this technique compared to classical statistics.

L116: "Team et al." is probably not the appropriate citation for the R software (it's R Core Team, not Team, RC).

L148-149: here you mention measurements of annual growth rates. Are they used later in the manuscript?

L193: "(equation 2)": missing parenthesis

L205-208: to me, the fact that Dopt is lower than the minimal diameter you set is an indication that the model of annual growth rate (eq. 3) is in some way not really adapted to describe the evolution of AGR in AFS.

This is probably linked to the changes in light availability during ontogeny, that strongly differ between forest trees and AFS.

L235: I was surprised by the low value of exponents of the allometric model. I would expect them to be closer to 2 and 1, since the volume of a cylinder is proportional to DBH^2*BH. These exponents suggest that the "form factor" ($BV/DBH^2/BH$), which is related to stem taper, strongly decreases with size. I suggest that you comment about these exponents, and show the relationship between predicted and measured bole volumes, to convince the reader that this model is not biased.

L282: the relationship between diameter and volume is a power relationship rather than exponential (you may also say "convex" relationship).

L313: "(trans)planted": parenthesis not at the right place

L321-322: It is not surprising that the bole volume is found negatively correlated to wood density, since a negative relationship between AGR and wood density has been assumed in the model (L136). Please reformulate, to avoid that the reader believes that this relationship is purely an output of the model.

Reviewed by anonymous reviewer 1, 30 July 2024

- The title clearly reflects the content of the article;
- The abstract presents the main finding of the study;
- The research questions are clearly presented;
- The introduction describes the relevant research in the field;
- Analyses are sufficiently detailed, but methods can be improved;
- Results are well described, but interpretation can be improved;
- The limits of their study are not considered in the discussion, but the conclusions are strongly supported by the results.

Interesting paper on agroforestry for fruit (cocoa) and timber production, full of interesting data coming from a large amount of study areas (150 plots) representing the cocoa production regions of Cote d'Ivoire.

To be published this paper needs some small improvements that could help the readers in understanding the whole study.

First of all it would be good to have some explanation about the methods of cocoa cultivation in the introduction. Without an explanation that emphasizes that cocoa trees must be covered by other trees because they suffer from direct sunlight, the reader may find it a little strange that an agricultural crop can accept the birth and growth of spontaneous trees within the cultivation.

Secondly, it is not clear whether the list of trees in Table 1 is valid for both planted and spontaneous tree species. Of course only Cedrela cannot be spontaneous, but all the other trees can be found among the transplanted **and** spontaneous trees?

Thirdly, very little is said about the commercial quality of logs. Has an assessment been made of the typical defects and how they could limit the profitability of wood for the most valuable uses?

This is a series of important assessments, which should cover both the quality of cocoa produced and that of wood production. Agroforestry is an activity that must have an economic value: those who produce cocoa are interested in obtaining the maximum possible yield from the sale of the product. But if you add wood to cocoa, it means that the farmer wants to keep the remuneration from cocoa, but by adding that from timber. But the remuneration is obtained through the quality of both products, not only by the quantities.