Understanding the links between cocoa management and productivity, biodiversity and ecosystem services in West Africa

Calum Maney[1,2], Ken Ejiri[2], Marieke Sassen[2], and Samantha L. L. Hill[1]

[1] UN environment programme WCMC

[2] WAGENINGEN UNIVERSITY & RESEARCH

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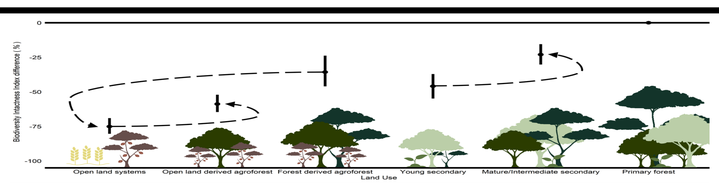
CocoaSoils

TRADE, DEVELOPMENT & THE ENVIRONMENT HUB

BACKGROUND → OUR RESEARCH → NEW FINDINGS

Biodiversity



High levels of biodiversity can be sustained by retaining the natural shade in existing cocoa-based agroforestry systems

Incentivising planted shade agroforestry could enhance biodiversity intactness in degraded areas

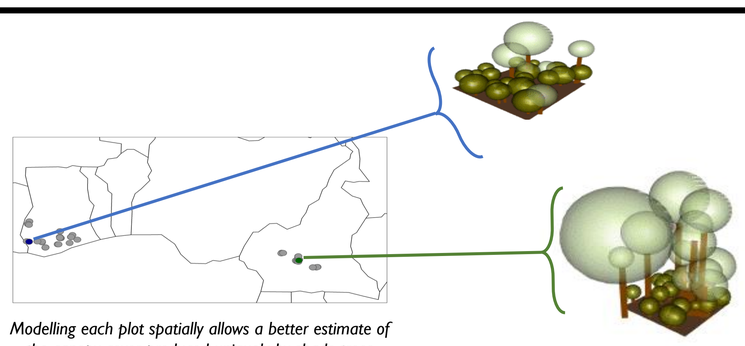
Cocoa production planning seeking to achieve biodiversity benefits should consider the direction of land use and biodiversity transitions (e.g., planted shade isn't good for biodiversity if native trees are currently in place)

Caveats to this work:

- Not West Africa specific
- No representation of low-shade systems or cocoa monocultures
- No chronosequence to assess effects over time

Map of cocoa sampling sites in PREDICTS

Read our previous paper: *Modelling biodiversity responses to land use in areas of cocoa cultivation*



Modelling each plot spatially allows a better estimate of the canopy cover produced uniquely by shade trees

The designations employed and the presentation of material on the above map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

We surveyed 78 farms between Ghana and Cameroon.

We carried-out understorey vegetation surveys, tree surveys, leaf litter surveys, and interviews to determine management practices, perceived costs and benefits of biodiversity, and the land-use history of each site.

Surveys took place between March and May 2022.

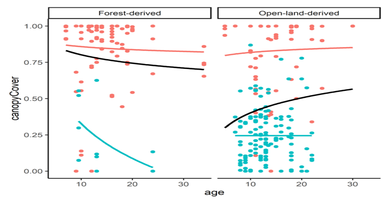
In total, we found over 700 uniquely-identified species of understorey plants in cocoa plantations.

In addition, we found over 150 tree species used in shading, including many endemic species.

Further surveys in Nigeria and Côte d'Ivoire will supplement this data to make it more representative of the West African context.

Preliminary results

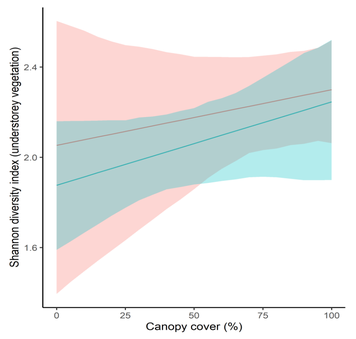
Canopy cover falls in both Ghanaian and Cameroonian cocoa systems over time when they are forest derived. This is consistent with known trajectories.



Trends in canopy cover over time in Forest-derived and open-land-derived cocoa plantations in Ghana and Cameroon.

In both countries, open-land-derived cocoa systems maintained tree cover. However, an increase over time (beyond 10 years) was not seen, and mean coverage in Cameroon was much higher, suggesting differences in farmer preference.

Understorey biodiversity has a positive relationship with shade tree canopy cover (a management variable) in both forest-derived and open-land-derived cocoa systems.



Modelled relationship between understorey plant diversity and canopy cover, disaggregated by land-use history.

Further modelling will assess the relative contributions of management, land-use history and landscape-level forest cover effects on plant and on native/forest/endangered plant diversity in cocoa.

Ecosystem Services

Ecosystem services in cocoa

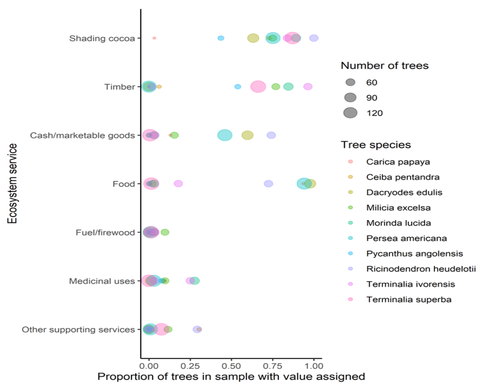
- Ecosystem services in cocoa have been the topic of recent investigation (Niether *et al.*, 2020).
- There have been several attempts to link ecosystems services at multiple scales to management in cocoa, most often related to shade cover (Niether *et al.*, 2020; Smith Dumont *et al.*, 2014; Tondoh *et al.*, 2015).
- So far, we have applied carbon sequestration values from literature in different scenarios of agroforestry implementation across Ghana and Côte d'Ivoire and used existing modelling tools (e.g. InVEST) to link cocoa-related land cover to different ecosystem services.
- We found a lack of consistency in cocoa agroforestry definitions in relation to carbon sequestration and other ecosystem services, and models like InVEST do not include agroforestry types, meaning large assumptions about management-ecosystem service relationships.

Ecosystem service surveys

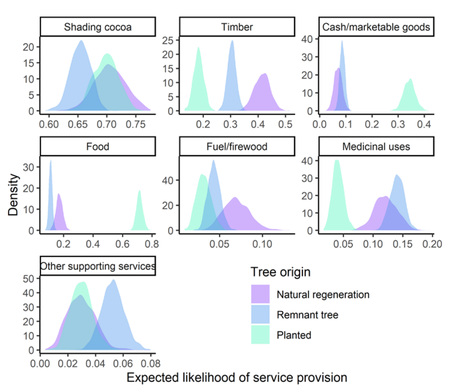
Surveys were carried out both on a by-tree and by-plant basis, thanks to farmer engagement in the biodiversity surveys. Farmers provided the origin of each plant (planted, or natural growth?) as well as reasons for leaving/cutting it, its benefits, and any costs related to its species. We also asked farmers about the overall ecosystem service values of their cocoa-producing land as part of the interview at the end of the surveys.

Current *vs.* planned work

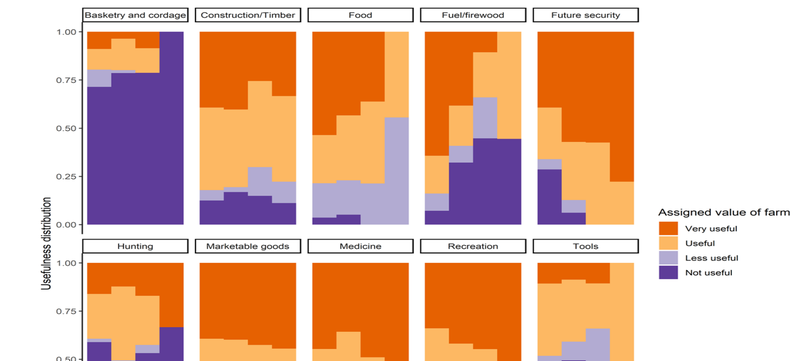
- There is value in establishing a baseline set of relationships between biodiversity facets and ecosystem services.
- Here, we investigate the relationship between shade tree species, their perceived usefulness on a cocoa farm, and the overall perception of the farm in providing a number of key ecosystem services.



Above: the ecosystem services attributed by farmers to the 10 most common shade tree species in the survey.



Left: the expected likelihood of a given tree being perceived as contributing to a range of ecosystem services (1000 resamples).

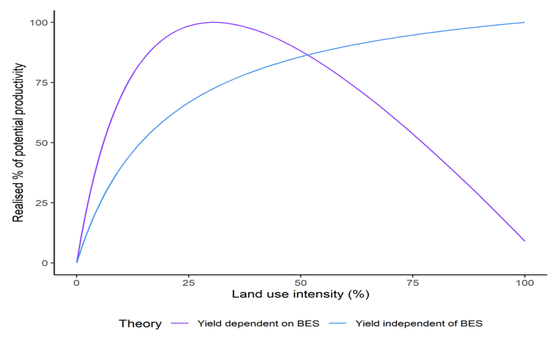


*From farmer surveys: the proportion of farms listing their perception of the **ecosystem service values** of all their cocoa-producing land, in response to the **shade tree richness** of the plots on-farm that we surveyed.*

Preliminary results

At first inspection, our surveys suggest that farms that are richer in shade tree species play an important role in delivering several key ecosystem services, relative to those which are less diverse. This may reflect different perspectives on the role of cocoa in providing for smallholders' needs, and suggests possible ecosystem service benefits for some tree-based interventions.

Social-ecological Feedbacks



Simulated biodiversity-mediated yield response to intensification, adapted from Seppelt et al. (2020).

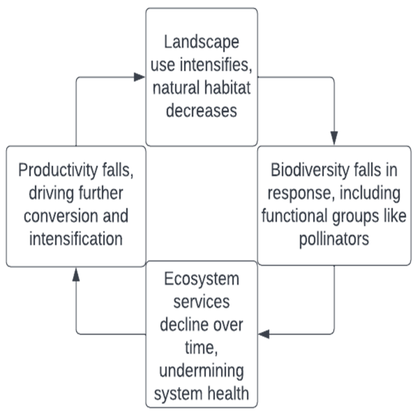
Explore the implications of a potential ecosystem feedback on cocoa productivity yourself!

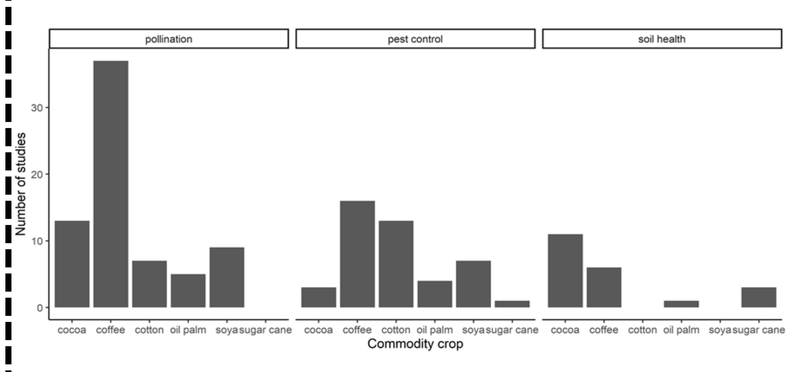
Background to feedbacks

Intensifying production systems when there is a dependency on inimitable ecosystem services can lead to a self-reinforcing trajectory of low yields and high biodiversity impacts.

In such a scenario, interventions could aim to limit or mitigate impacts on key biodiversity facets, or better imitate or replace ecosystem services.

Due to time delays in biodiversity and ecosystem responses, the impact of intensification may initially be obscured.





Literature search results for studied interactions between biodiversity facets and supporting services among surveyed commodity crops

Data collection

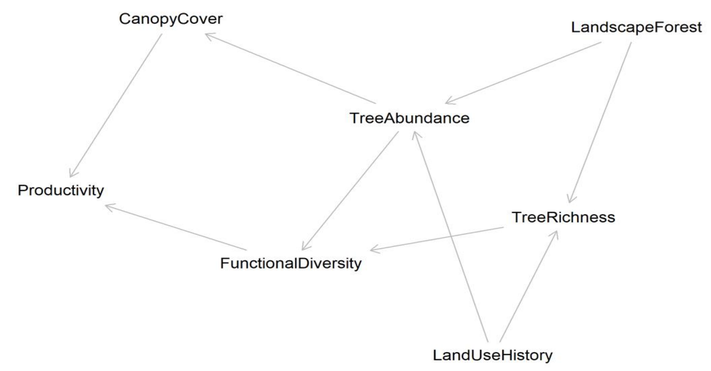
In order to assess potential ecosystem feedbacks in cocoa systems, we investigate the following for our study sites:

- Land-use history
- Landscape-level forest cover and density
- Management including controlled fertiliser treatment
- Yields and yield losses as a result of pest/disease damage
- Tree and understorey diversity
- [unconfirmed] flower visitor and flying insect diversity; pest abundance.

Review summary (cocoa)

We reviewed 6 common agricultural commodities for potential ecosystem feedbacks. The main biodiversity facets identified in supporting cocoa systems are:

- Spiders (natural enemies)
- Skinks (natural enemies)
- Birds (natural enemies)
- Ants (natural enemies, notably *Oecophylla longinoda*, and pollination via disturbance of other species)
- Tree species (microclimate regulation, disease resistance, via other species as habitat)



With data on management, ecosystems, history, and productivity, we can construct and challenge potential causal models to detect the likely structure and strength of ecosystem feedbacks in cocoa. This could help to identify interventions with a win-win for biodiversity and productivity (above: one such example of a potential causal model, based on variables we have measured).

The future

With a growing understanding of how drivers of change, biodiversity, and ecosystem services are connected in West African cocoa systems, and how decision-making is influenced by perceptions of benefits and costs of different features, we can begin to understand how land systems may develop in the future in response to demand.

This work opens up the possibility of scenario-building and land-use modelling that incorporates the potential dependence of such production systems on nature, and how interventions at the farm, supply chain, and policy level could contribute to restoration and conservation goals, as well as supporting livelihoods in areas of cocoa production.