Assessing the level of organization in agroforestry systems

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Agroforestry systems are generally characterized by several parameters: number of plant species, density of each species, various biodiversity indexes.

Many systems have a main crop, like coffee or cacao; the ratio of the number of trees of the main crop to the total number of trees is also used to characterize the system. This parameter assesses the relative density of the main species, but it does not provide an idea of the organization of a system.

In our study, we tried to define parameters able to assess the organization of a system. We used cocoa plots from agroforestry systems in Cameroon and Costa Rica.

Material and methods

For 18 plots, we assess the density of cocoa trees and the density of other trees for the whole plots and for the sub-plots in:

- 6 plots in Cameroon – each plot was split into 9 sub-plots
- 12 plots in Costa Rica – each plot was split into 10 sub-plots

Relative densities of cocoa trees *i.e.* $RD = \frac{\text{nb cocoa trees}}{\text{nb cocoa trees + nb other trees}}$

for all plots (RD) and sub-plots (rd_i)

Several indices to assess the organisation: $Var(rd_i)$, $OI = \frac{\min(rdi)}{RD}$ convergence of $\frac{\sum_{\text{subplot i}} \min(rd_i)}{RD}$

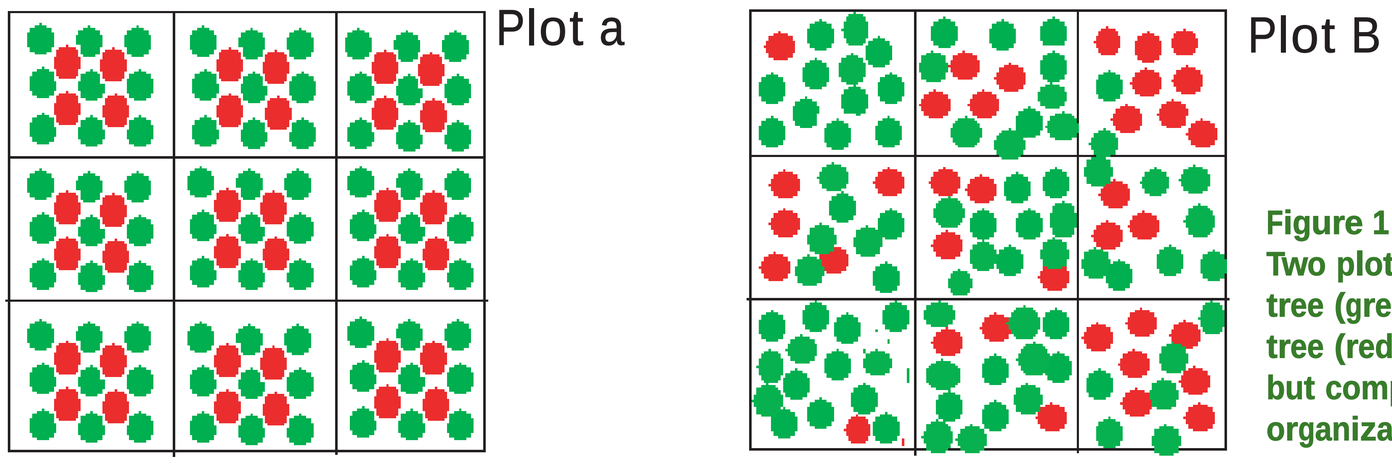

Figure 1:
Two plots, same density for cocoa tree (green), same density for shade tree (red), same relative density (RD), but completely different organization; 9 sub-plots

Plot a: $Var(rd_i) = 0$, $OI = \frac{\min(rdi)}{RD} = 1$ Plot b: $Var(rd_i) = 0.054$, $OI = \frac{\min(rdi)}{RD} = 0.289$ (with 9 sub-plots each).

For the same relative density, the system may be completely spatially regular or completely disordered with pockets of the pure main crop alternating with pockets without main crop trees.

Results

In Cameroon

Plot	A	B	C	D	E	F
Var(rd_i)	0.007	0.003	0.003	0.003	0.008	0.001
OI	0.837	0.897	0.907	0.917	0.806	0.918
Slope	0.016	0.010	0.008	0.009	0.021	0.008

In Costa Rica

Plot	A	B	C	D	E	F	G	H	I	J	K	L
Var(rd_i)	0.012	0.066	0.072	0.008	0.046	0.046	0.042	0.012	0.120	0.080	0.054	0.008
OI	0.878	0	0.353	0.781	0.456	0	0.391	0.752	0	0	0.255	0.833
Slope	0.011	0.059	0.051	0.017	0.039	0.046	0.043	0.018	0.11	0.046	0.047	0.011

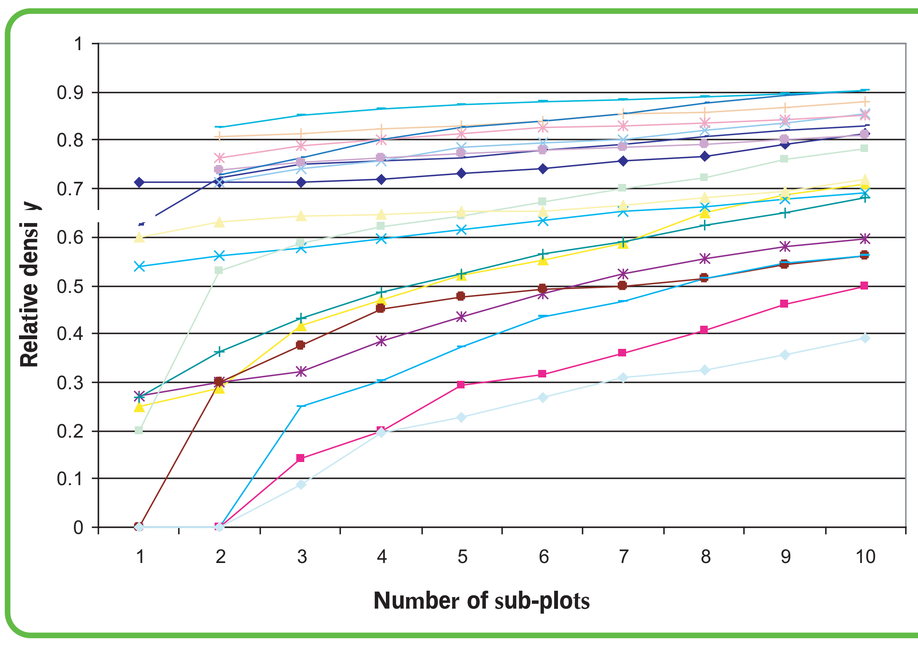

Figure 2: Speed of convergence of the relative density (rd), in function of the size of the sub- plots.

Conclusion

To estimate the level of organization in agroforestry systems with a main crop, we propose an index which varies from 0 to 1: the plot is split into *n* sub-plots with the same area. In each sub-plot, the relative density is estimated, *i.e.* the number of trees of the main crop out of the total number of trees. The index OI is expressed as the ratio of the relative minimum density obtained in one of the n sub-plots to the relative density estimated for the whole plot. In the case of a very regular system OI =1 whereas in very irregular systems OI --> 0.
A second index of the organization of the system is the speed of convergence of OI_n to OI when n decreases (n --> n/2 … --> 1). Several examples are presented to illustrate the relevance of these parameters, which could help to more effectively compare agroforestry systems.

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