Fonctionnement et conduite des systèmes de culture tropicaux et méditerranéens

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Agricultural Research For Development

Spatial organization of individuals and ecosystem services in tropical agroecosystems

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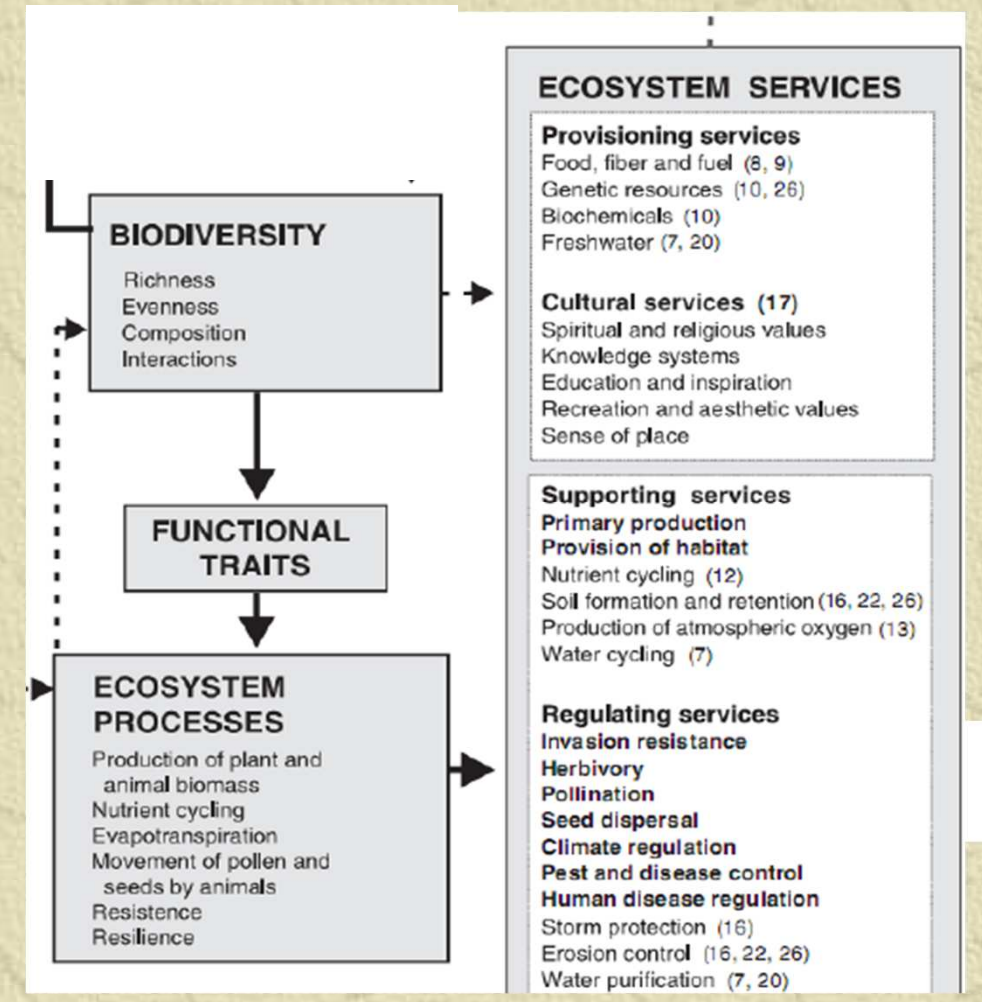
1. Context: sustainability of agriculture

- Improve the sustainability of agroecosystems trough the supply of diverse ecosystem services.



Diaz et al., 2005 MEA Ch. 11

Some definitions in literature

- Hanson1939 : Ecology in agriculture
- - Azzi, 1956: Agricultural Ecology
- - Altieri, 1989: the science of sustainable agriculture
- - Gliessman 1997: ecological processes in sustainable agriculture
- - Francis et al. 2003: the ecology of food systems

"The interests"

- Global productivity (Fukai and Trenbath, 1993),
- Stability (Aerts, 1999),
- resilience, and moreover resistance (facing pests and diseases) (Trenbath, 1993)
- …

Agroecology/ Ecological Intensification

These concepts are based on the optimization of ecological processes in agroecosystems in order to reduce the use of chemical inputs, maintain productivity and focus on other ecosystem services.

The ecological concept

- The spatial pattern and arrangement of individuals is fundamental in ecological theories" (Janzen, 1970; Connell, 1970) in Batista and maguire, 1998; Ledo,at al., 2012)
- related to ecosystem functioning (Perfecto, & Vandermeer, 2008; Pringle et al., 2010; Vandermeer et al., 2008)

" The interests"

- related to species coexistence (Murrell, 2010; Gonzalez-Moreno et al., 2011; Ngo Bieng et al., 2013)
- related to species productivity (Lamosova et al., 2010, Ngo Bieng et al., in proofs)

Our approach

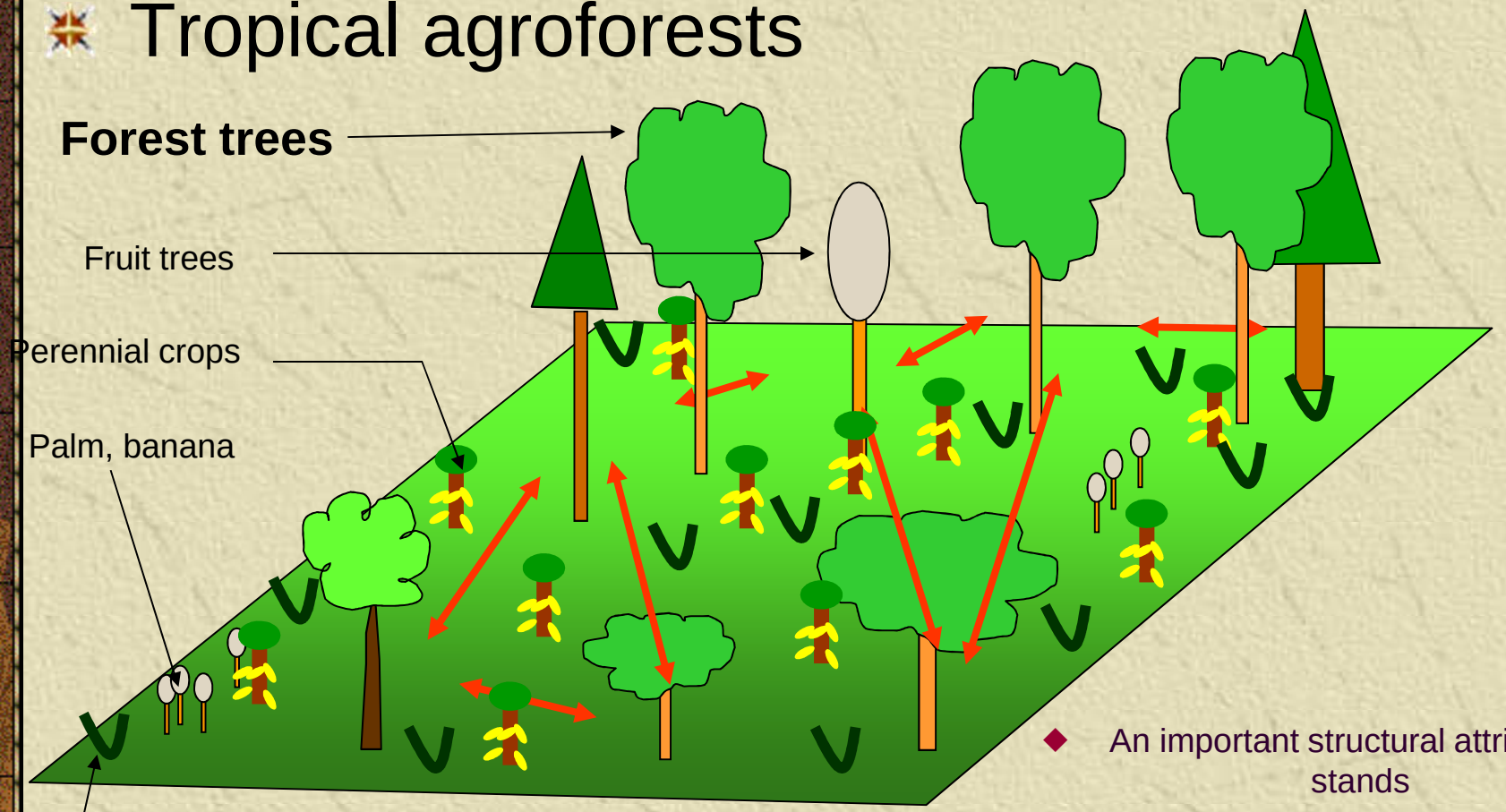
- Apply ecological concepts to the understanding of the functioning of complex agroecosystems
- Integrate it to the design of innovative "agroecological" systems

OUR AIM: understand the interactions between spatial organization of individuals and ecosystem services in tropical agroecosystems

- Spatial organisation of individuals as a lever of Ecological intensification
- Identify in complex agroecosystems the interaction between spatial organisation and ecosystem services
- Find rules to optimise the supply of ecosystem services trough an optimisation of spatial organisation of cultivated individuals in innovative agroecosystems

2. The agroecosystems studied, the data and methods

Tropical agroforests



- An important structural attribute of stands
- Canopy trees in agroforests
- Influence on the cropping understorey (spatial distribution of resources, microclimate)

Describing and modelling
- spatial structure

- the interactions with : species richness (Biodiversity)
- the interactions with pest and disease regulation
- the influence on spatial distribution of resources

OUR AIM: Understand the interactions between spatial organization of individuals and ecosystems services in tropical agroecosystems

- 29 Cacao agroforests plots (1000m²) in Talamanca (Costa Rica)

PhD work of Cynthia Gidoin: Interactions between spatial structure of individuals and species composition, cacao diseases, in cacao agroforests in Costa Rica and Cameroon

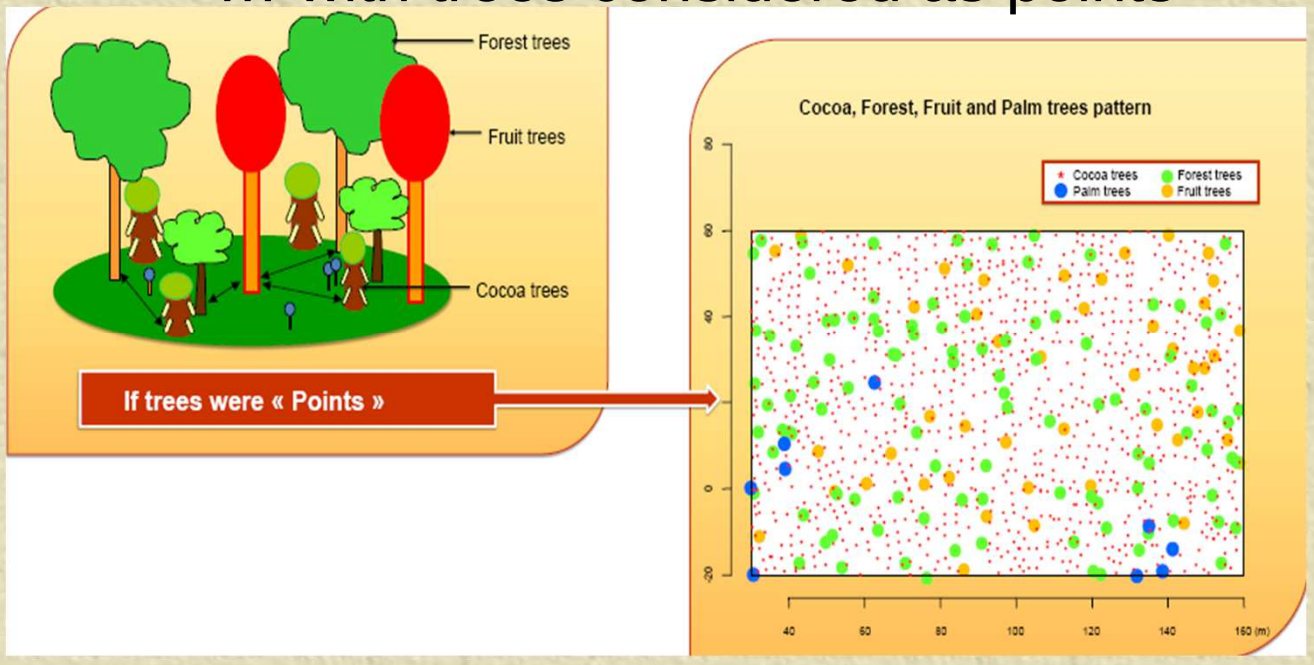
Cameroon

Costa Rica

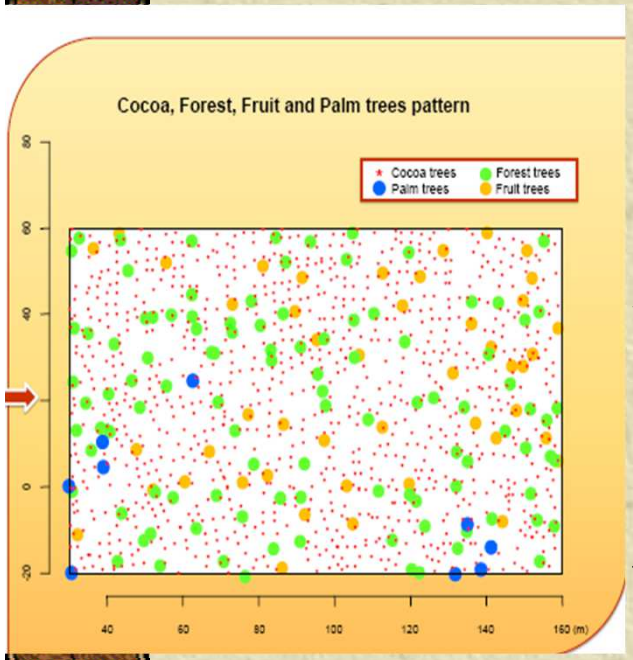
Method: the stand as a set of points

Studied plots…

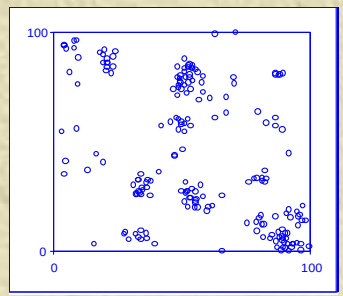
… with trees considered as points



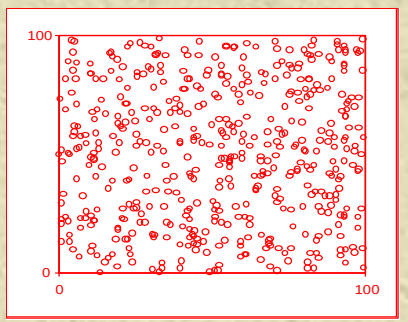
Method: Ripley function (Ripley, 1977)



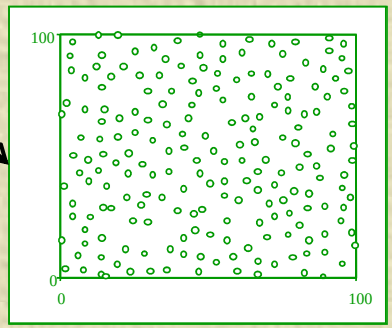
Studied plots



Clustered



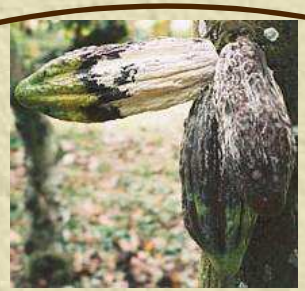
Random



Regular

- Method: Comparison of variables related to ecosystem services between the studied plots in the different spatial configurations
- The variables

- Cacao potential production (total number of pods on 2008 and 2009)
- forest tree species richness (number of forest tree species)
- Pest and disease pressure

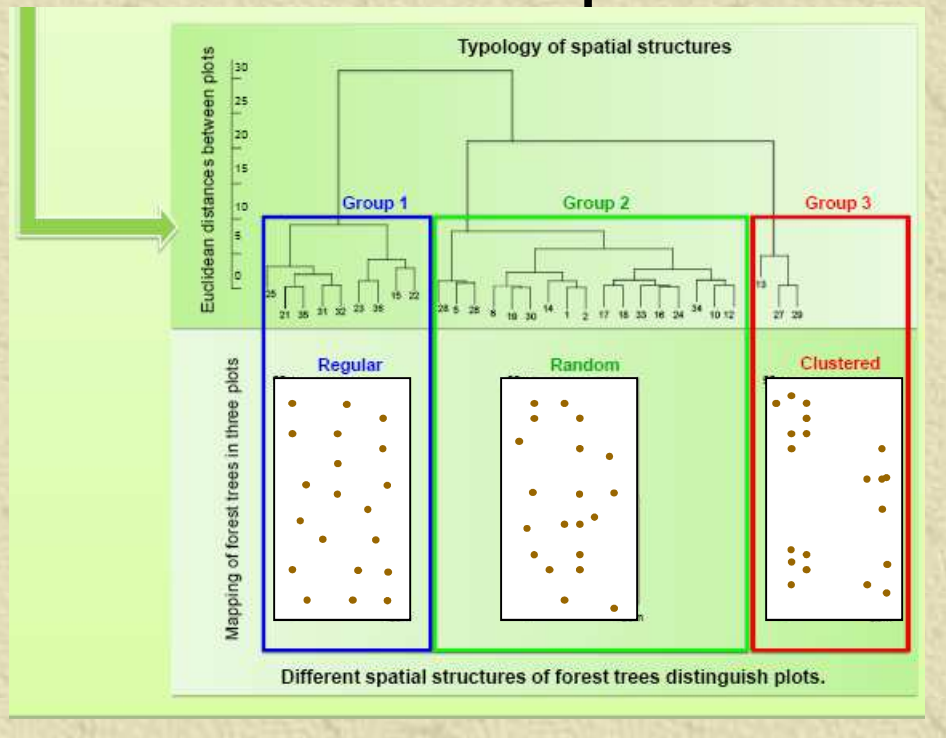


Frosty pod rot (*Moniliophthora Roreri)* in Costa Rica
Number of damaged pods

Mirid bugs (*Sahlbergella singularis*) in Cameroon
Population density

3. Results

Different spatial configurations of forest trees in the studied plots



On 29 agroforests plots cacao based in talamanca, Costa rica

15 random

8 regular

6 **clustered**

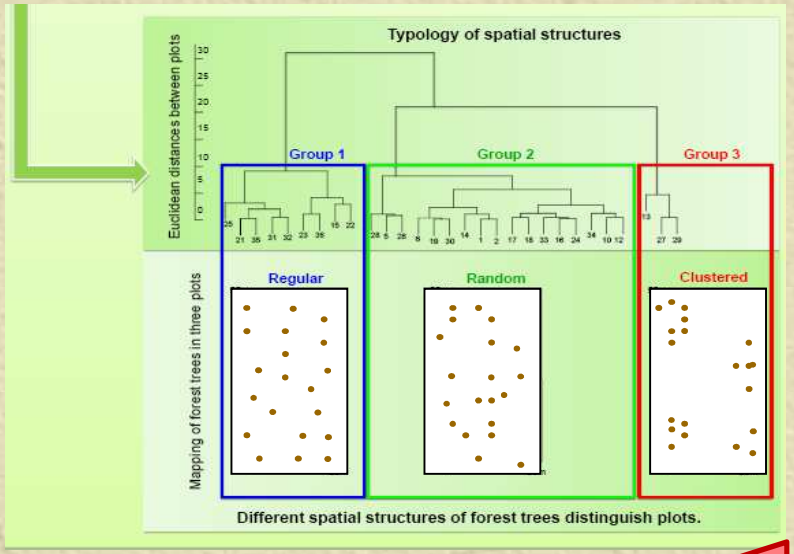
(Ngo Bieng et al., 2013)

The variables studied are different in the higlighted spatial configurations

Variables	Spatial structure of shade trees			ANOVA / KW-test	
	Regular	Random	Clustered	F-value (df=2)	p-value
Total number of pods (potential production)	488 ± 79	479 ± 33	764 ± 127	2.83	0.08
Number of damaged pods (damaged production)	**67b ± 25**	**56b ± 8**	**139a ± 27**	**4.49**	**0.02**
				H-value (df =2)	p-value
Species richness of shade forest trees	4.00 ± 0.53	4.47 ± 0.53	6.17 ± 0.79	4.79	0.09

Analysis of variance between species richness and cacao yield variables among the different types of spatial structure of shade trees. Variables in bold were significantly different. Within rows, values with the same letter are not significantly different (Tukey HSD test at $p<0.05$)

Interaction between spatial structure of forest trees and variables related to ecosystem services



Potential production} Provisioning

Damaged production } Regulating

Species richness} Services related to biodiversity

Density of mirid bugs (Cameroon) PhD work of Cynthia Gidoin

4. Discussion

OUR AIM: Understand the interaction between Spatial organization of individuals and ecosystems services in tropical agroecosystems

- The clustered spatial organisation of trees was corelated (NS) to a higher cacao potential production…

OUR AIM: Understand the interaction between Spatial organization of individuals and ecosystems services in tropical agroecosystems

- The clustered spatial organisation of trees was corelated (NS) to a higher cacao potential production…
- … and to a higher species richness …

- heterogeneous resource distribution resulting in a variety of local environments which favour the coexistence and the dynamics of different functional types (spatial niches) Gonzalez-Moreno et al. 2011; Mokany et al. 2008
- increase the chances of survival of the inferior competitor by limiting interspecific or intertype competition (Goreaud et al., 2002; Lamosova et al. 2010)

OUR AIM: Understand the interaction between Spatial organization of individuals and ecosystems services in tropical agroecosystems

- The aggregated spatial organisation of trees was corelated (NS) to a higher potential production…
- … and to a higher plant species richness …
- … but also to unplanned diversity, such as the diversity of pathogens threatening cacao production (FPR in Costa Rica, Mirids bugs in Cameroon.
- Resource Hypothesis (Mitchell et al., 2002)
- Microclimatic hypothesis (Schroth, et al.,2000)

Shade tree spatial structure and pod production explain Frosty Pod Rot intensity in cacao agroforests, Costa Rica. Gidoin et al., submitted

To conclude: In the studied stands

- Spatial structure appears as a lever for the ecological intensification in agroecosystems.

- A clustered structure of shade trees appears to supply a trade-off between biodiversity and productivity, but is unfavourable to pest and disease regulation.

- A dilemna:

1- accept the losses as other services are supplied

2- Land sharing vs land sparing

Prospects

- The trends in other agroforests plots
- Understand the mechanisms involved
- Other variables related to different services (animal diversity: pollinators or auxiliaries for example)
- Find rules to design innovative “Agroecological” agroecosystems

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