

# Biodiversity of herpetofauna in Central American cocoa based agroforests

Deheuvels, O.<sup>1,2\*</sup>, Soto Quiroga, G.<sup>2</sup>, Cerda, R.<sup>2</sup>, Gutierrez R.<sup>2</sup>, Andino, C.<sup>2</sup>,  
Molinares, B.<sup>2</sup>, Toro, J.J.<sup>2</sup> and Somarriba, E.<sup>2</sup>.

<sup>1</sup>: CIRAD, UMR System, F-34070 Montpellier, France

<sup>2</sup>: CATIE, DID, 7170, Cartago, Turrialba 30501, Costa Rica

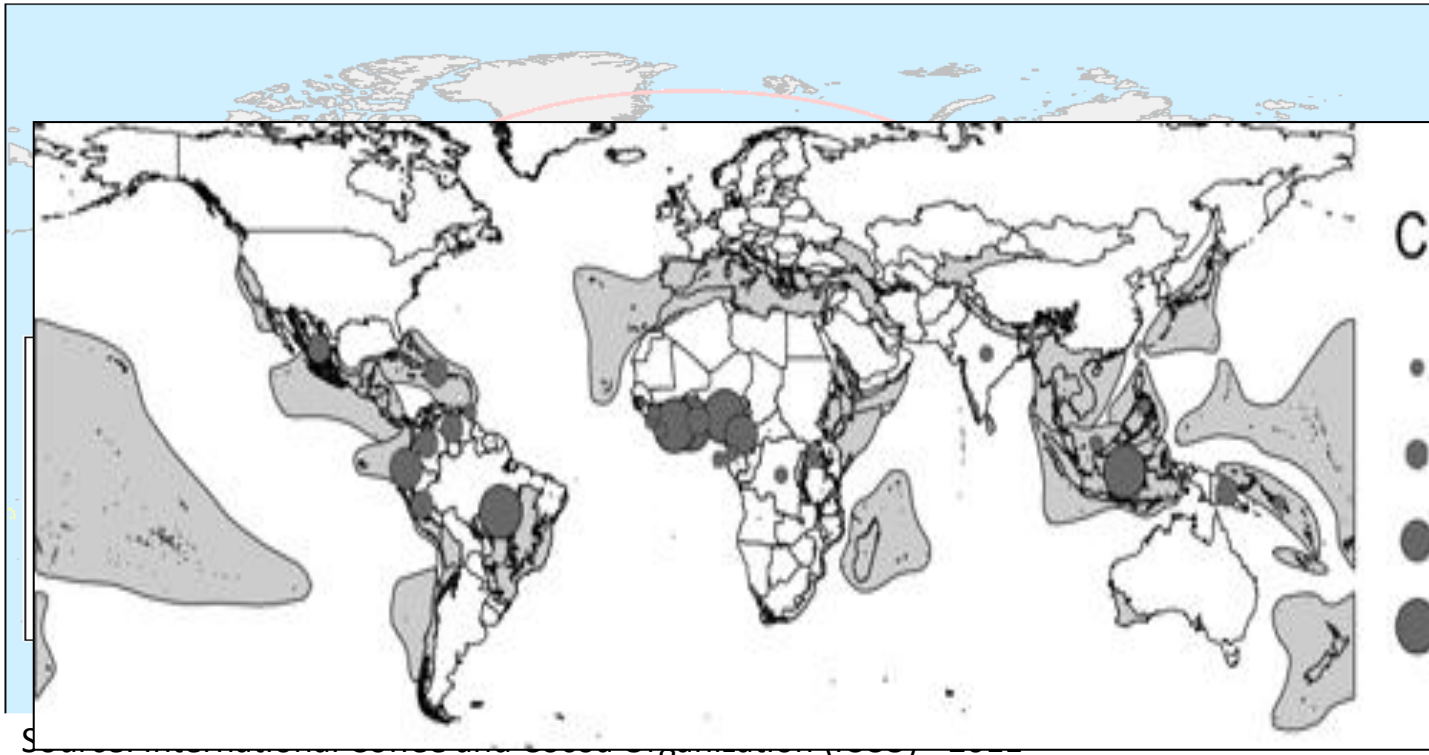
\* Corresponding author. Tel.: +506 25 58 23 44, fax: +506 25 58 20 45. E-mail address :  
[deheuvel@catie.ac.cr](mailto:deheuvel@catie.ac.cr) / [olivier.deheuvels@cirad.fr](mailto:olivier.deheuvels@cirad.fr)



Mesoamerican  
Agroenvironmental  
Program



Production and net exports of cocoa beans in 2005/06



Cacao cultivation (ha)

- 10000 - 50000
- 50000 - 250000
- 250000 - 500000
- > 500000

Source: Clough et al. (2009)

World map of biodiversity hotspots shaded in light grey, with area of cacao production per country in dark grey. (*production data 2007, FAOSTAT 2009*)

NOTA: The Guinean Forests of West Africa hotspot is obscured.



# Ecological Services of interest for ecologically intensive agriculture

## SERVICES INTRANTS

### De fourniture de ressources et régulations

- Stabilité structurale du sol
- Disponibilité en eau
- Fertilité des sols
- Régulation du microclimat

### De régulations biotiques

- Contrôle des bioagresseurs
- Contrôle des invasions biologiques
- Pollinisation
- Santé des animaux domestiques



## SERVICES D'APPROVISIONNEMENT

### Production primaire:

- Rendement
- Stabilité

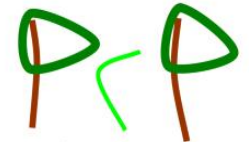
### Production animale:

- Rendement
- Qualité des fourrages
- Qualité des produits animaux

### Autres produits commercialisables

## EXTERNALITES

- Disponibilité en eau
- Purification des eaux
- Régulation du climat global & régional
- Mitigation des incendies
- Conservation de la diversité
- Valeurs culturelles et esthétiques

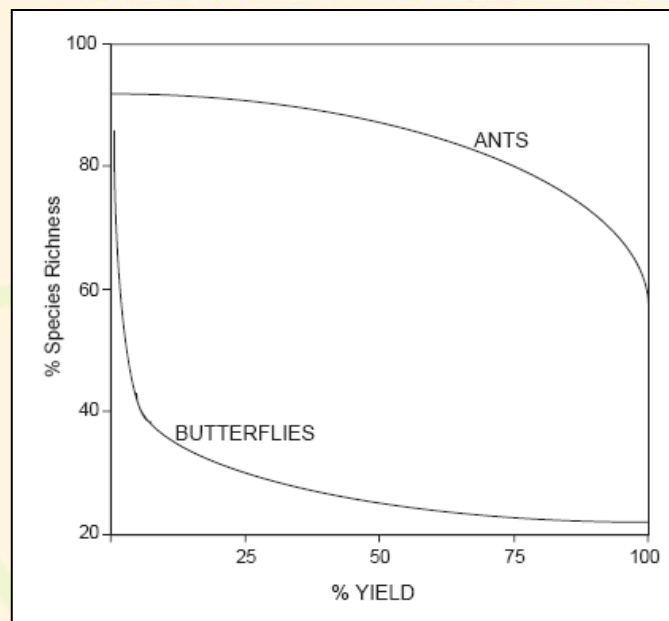
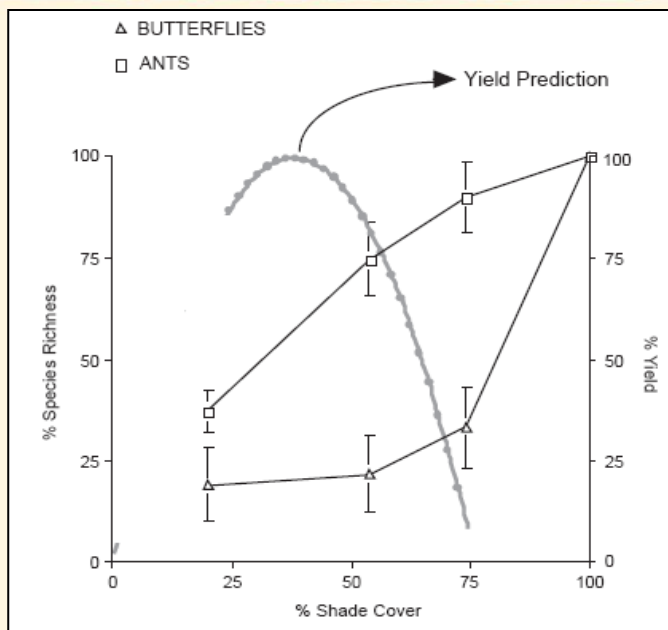


agroforestry systems  
with perennial crops

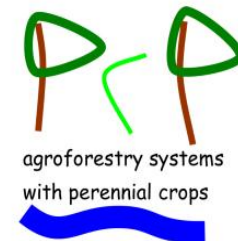


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From Bonny, S. (2010), adapted from Zhan et al.(2007), Lavorel et Sarthou (2008) et Lavorel (2010).



Perfecto et al., 2005



## Hypotheses:

- 1- Variability in vegetation structure of SAF cacao can be characterized on a structural gradient reflecting contrasting management intensity levels.
- 2- The cocoa productivity depends on the vegetation structure in the cocoa field.
- 3- The wild biodiversity found in the cocoa field is also affected by the vegetation structure.



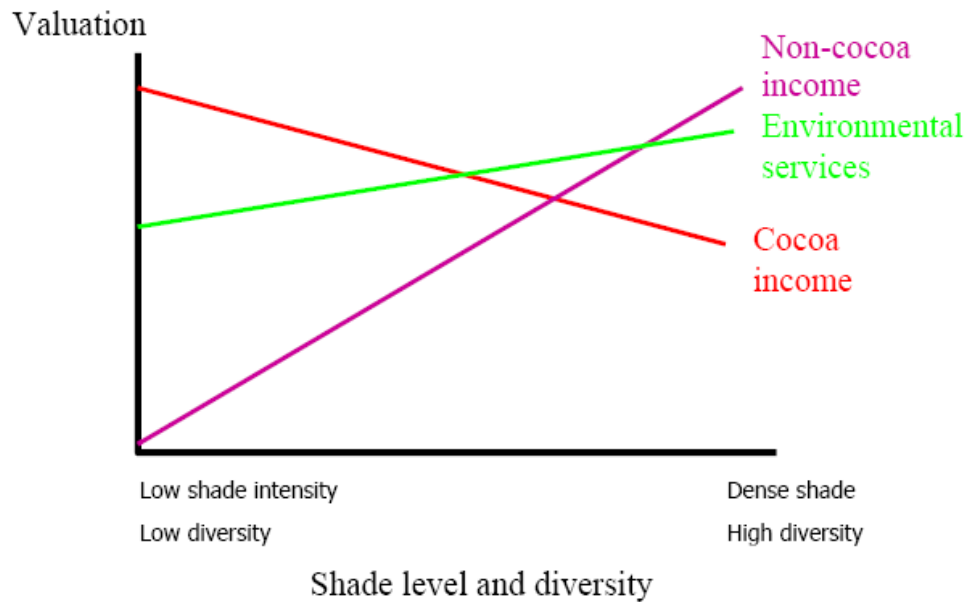
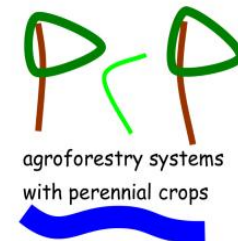
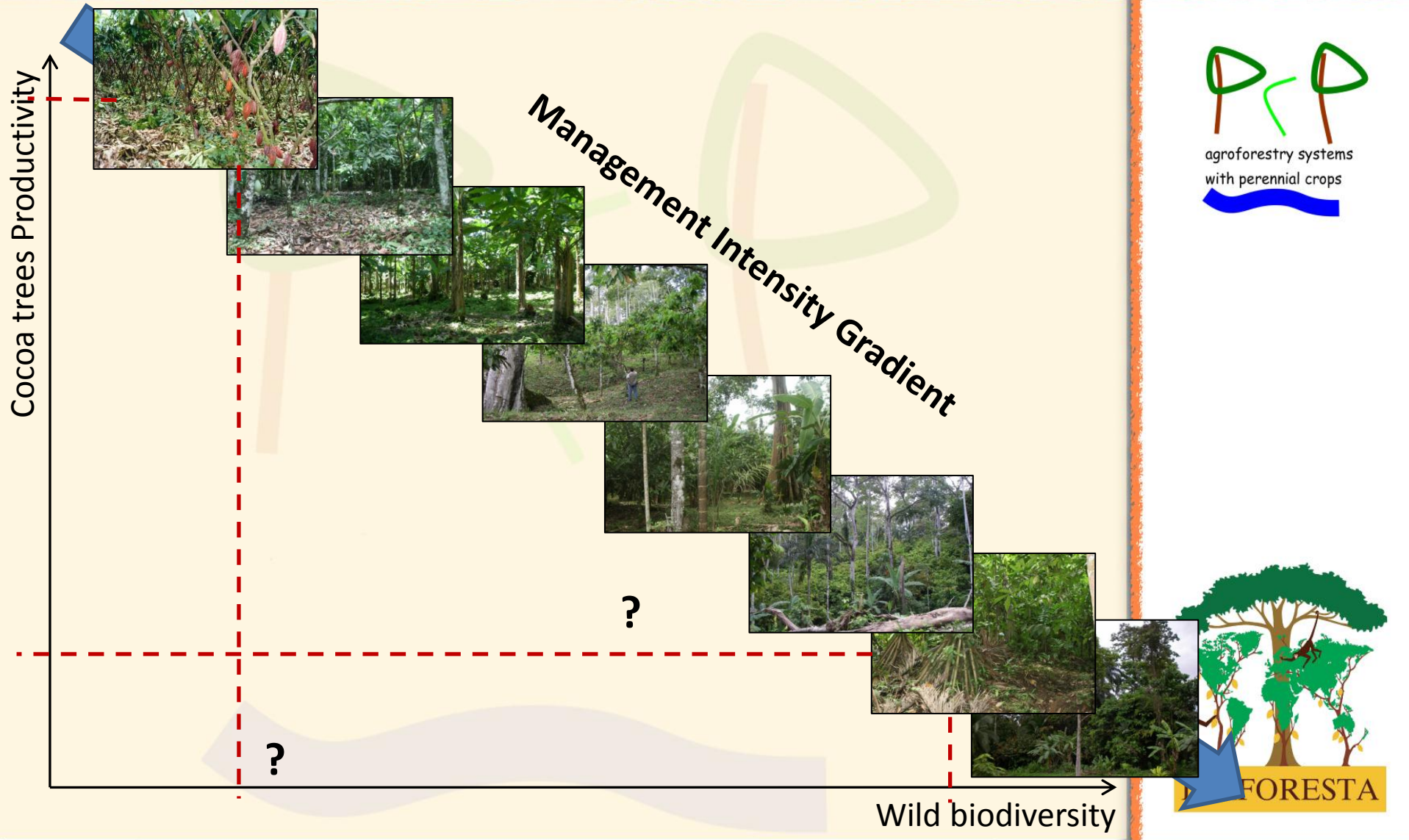


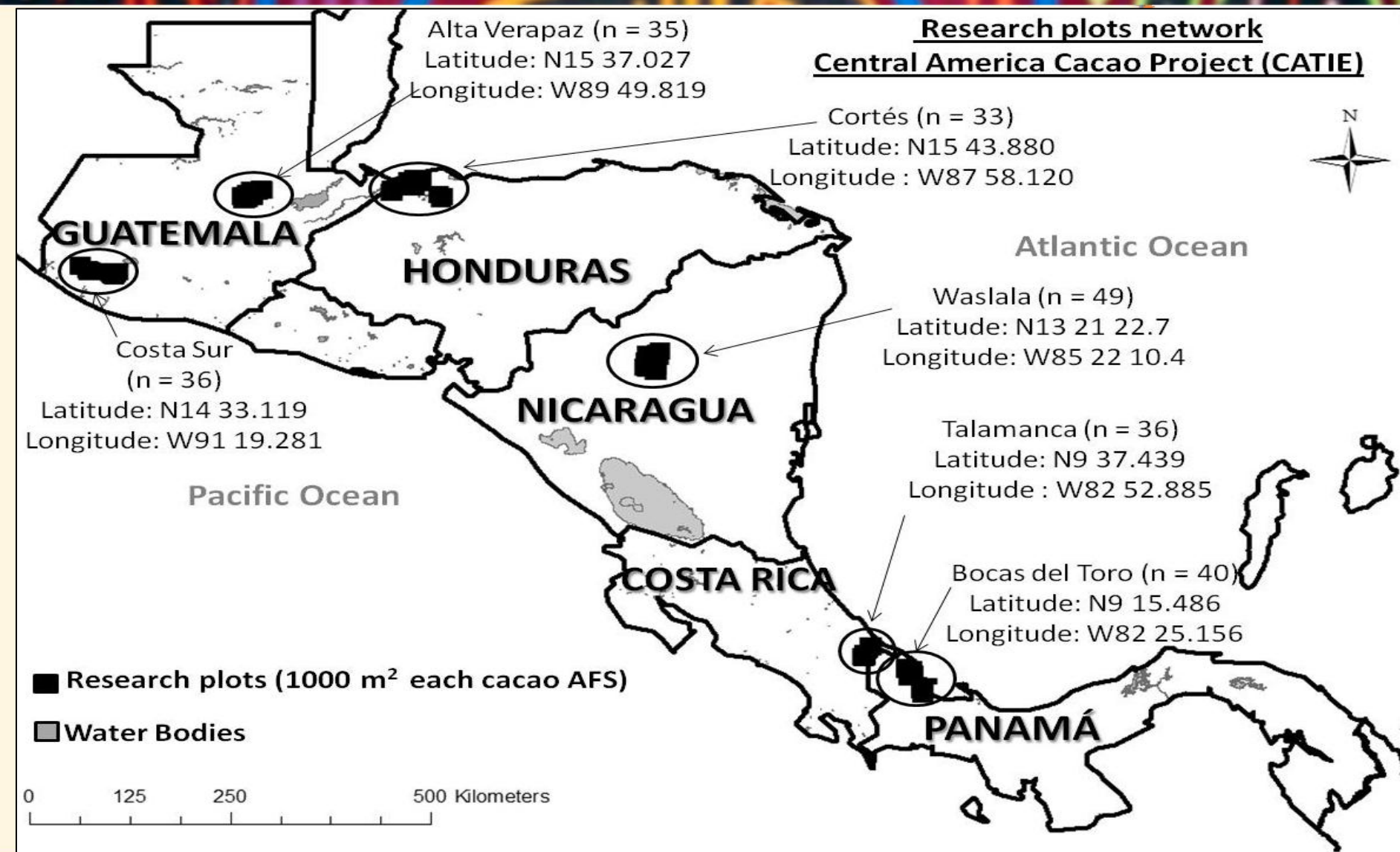
Figure 1. Hypothesized tradeoffs between environmental services, cocoa and non-cocoa income and shade levels in production systems.

From Gockowski et al., 2004.



**4- The trade-offs between the productivity of the main crop and biodiversity are affected both by the vegetation structure and the specie considered.**





## COCOA AFS Network

5 countries

6 cocoa growing areas

220 cocoa AFS

26 forest patches

### COCOA FIELD

#### VEGETATION

Botanical  
composition and  
Structure

## MAIN STUDIES (5 countries)

### CARBON CAPTURE

### PROVISION of HABITAT

- Amphibians
- Reptiles
- Soil and litterfall  
invertebrates
- Cocoa pollinators

### CALIDAD FISICA, QUIMICA y BIOLOGICA DEL SUELO

### PRODUCTIVITY

- Cocoa
- Fruit and Timber Trees

## DERIVATED STUDIES

### C FOOTPRINT Nicaragua

### BIRDS Nicaragua

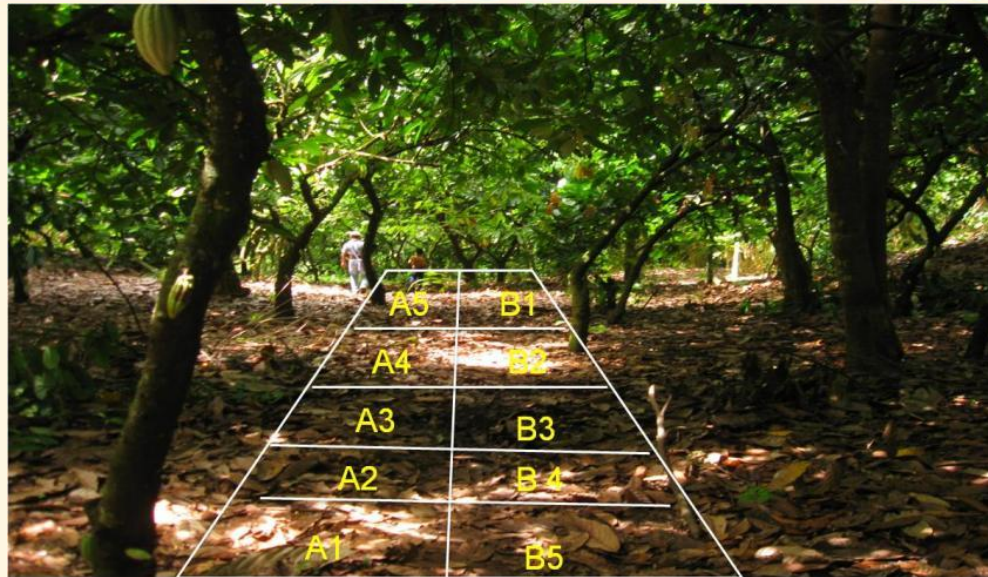
### IMPACT ON COCOA YIELD Panama

### FERTILIZATION Nicaragua

### BIOCARBON Costa Rica

### HOUSEHOLD ECONOMY

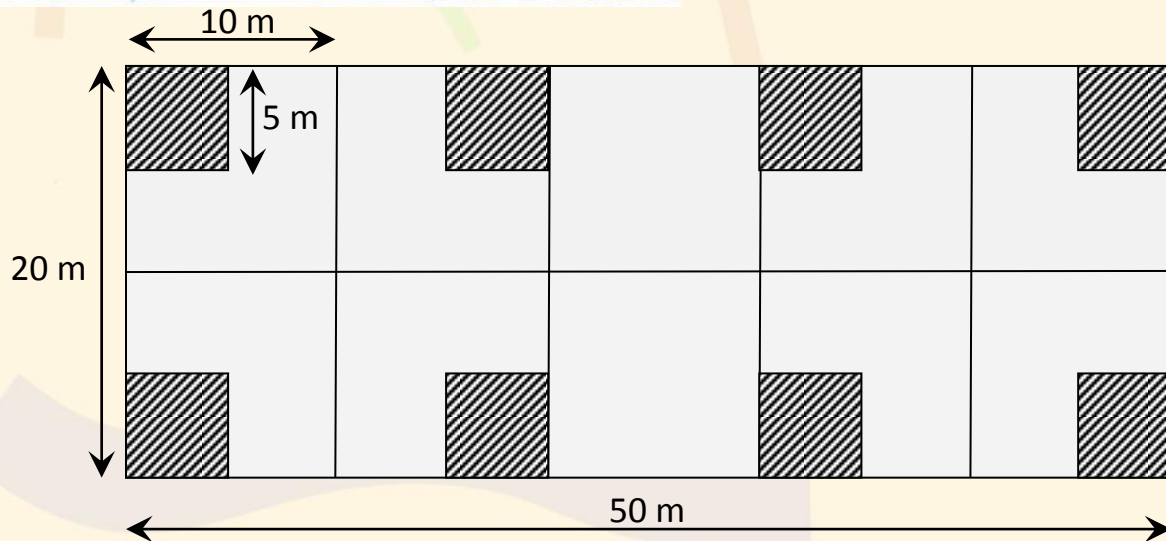
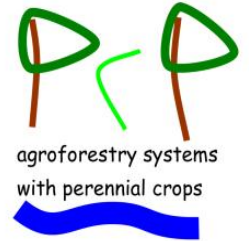




## Methods

36-40 SAF cacao and 3-8 forest patches (control) in 6 central american cocoa producing areas .

Data collected on 1000 m<sup>2</sup> Plots (vegetation) and 8 x 25 m<sup>2</sup> sub-plots (animals)





**Above Cocoa Trees**

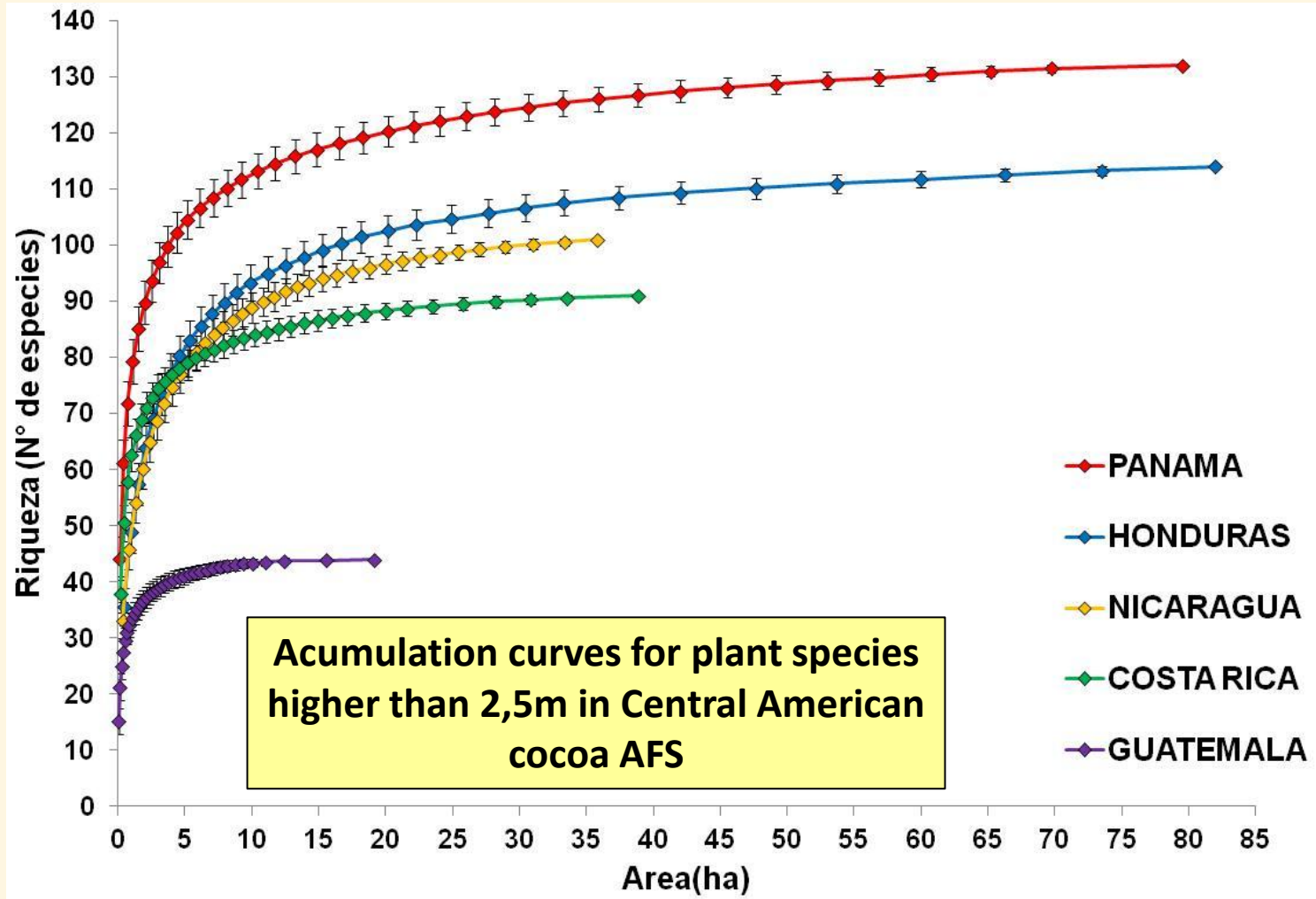
- Identification, Total height and dbh.
- Shade % at 1m height, in dry and rainy seasons.

**Cocoa Trees**

- Identification, Total height and dbh
- N° of pods every 2 month during 2 years

**Under cocoa Trees' canopy**

- % Ground cover: 10 x 1 m<sup>2</sup>, 4 times a year (ligneous, grasses, mosses, ferns, litterfall)



## VARIABLES DISCRIMINANTES

### Above cocoa trees

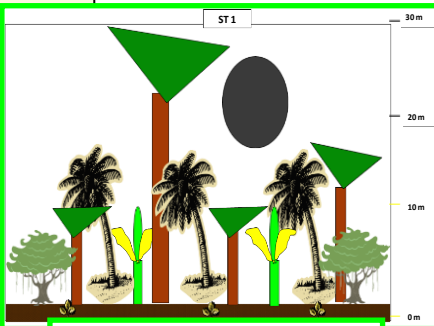
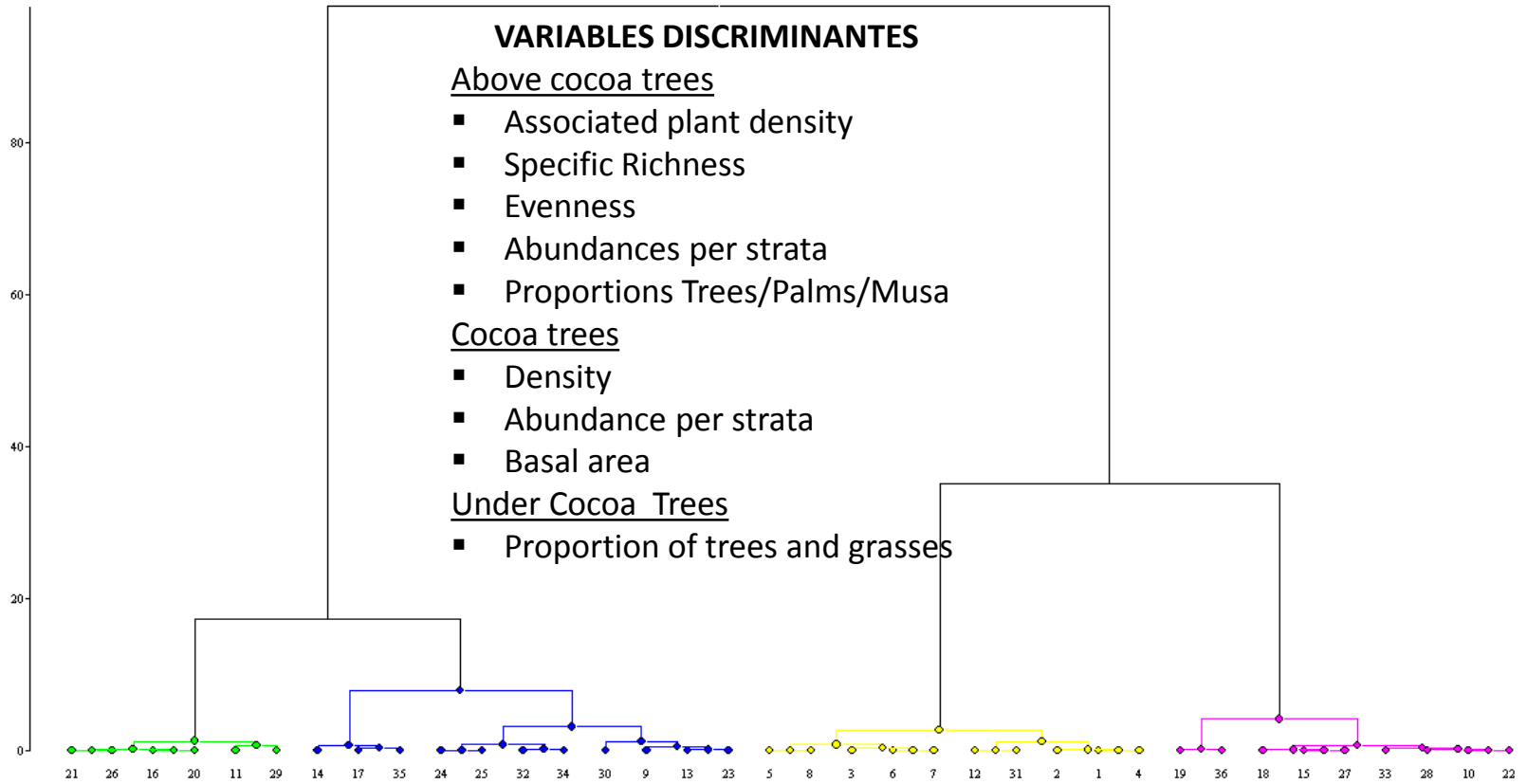
- Associated plant density
- Specific Richness
- Evenness
- Abundances per strata
- Proportions Trees/Palms/Musa

### Cocoa trees

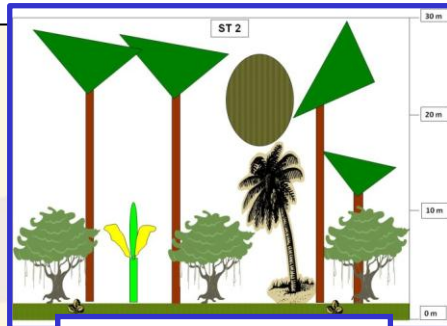
- Density
- Abundance per strata
- Basal area

### Under Cocoa Trees

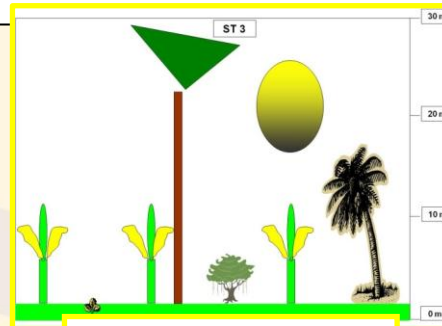
- Proportion of trees and grasses



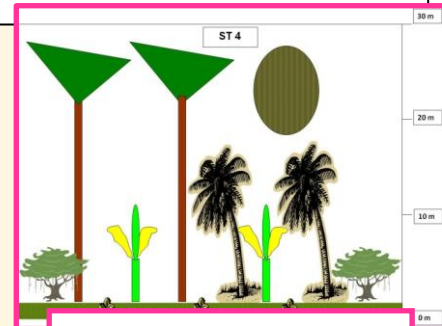
1-canopée dense et complexe (n=6)



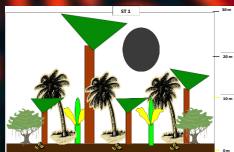
2-haute densité de cacaoyers (n=11)



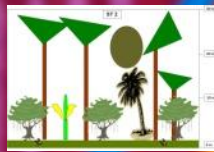
3-haute densité de Musacées (n=10)



4-canopée complexe et peu dense (n=9)



1



2

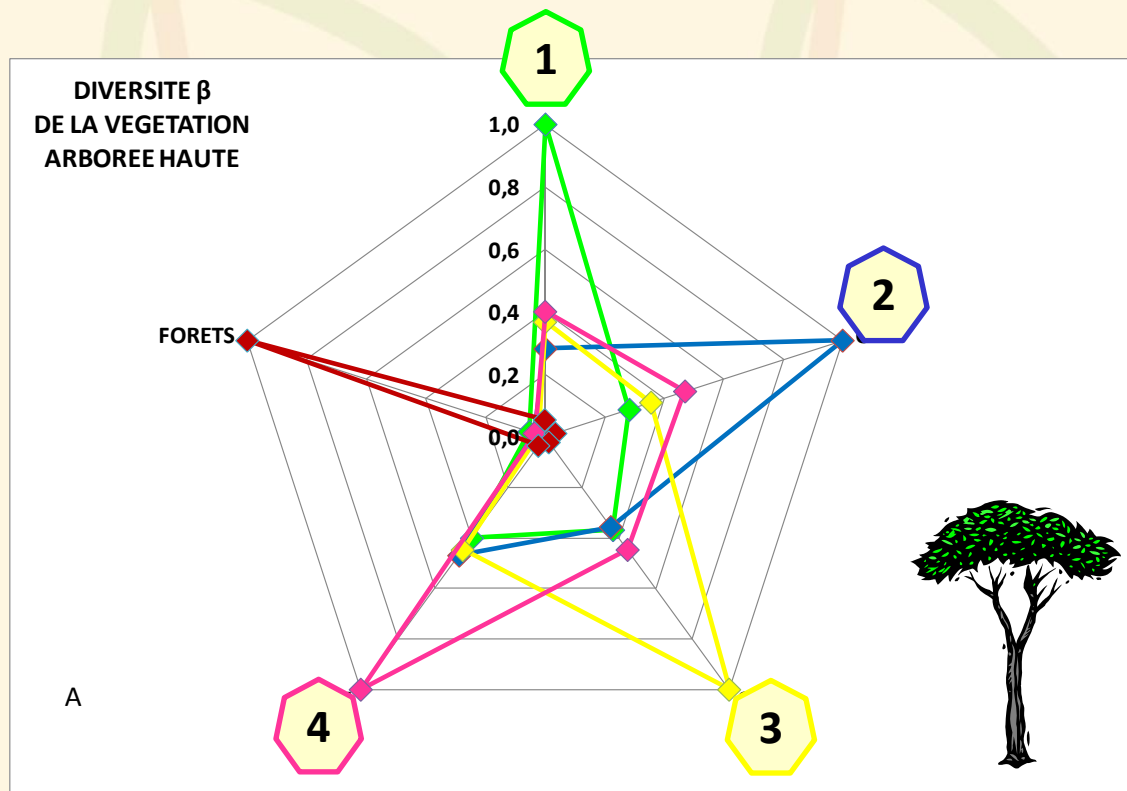


3



4

## Beta diversity of associated plants between 4 groups of cocoa-based AFS and 1 group of forest patches (control) in Talamanca (COSTA RICA)



agroforestry systems  
with perennial crops

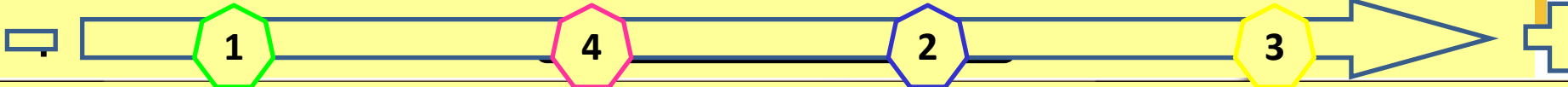
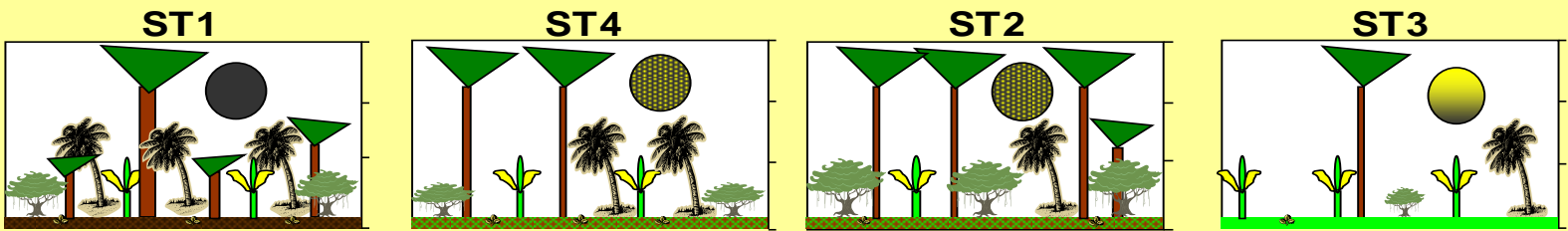
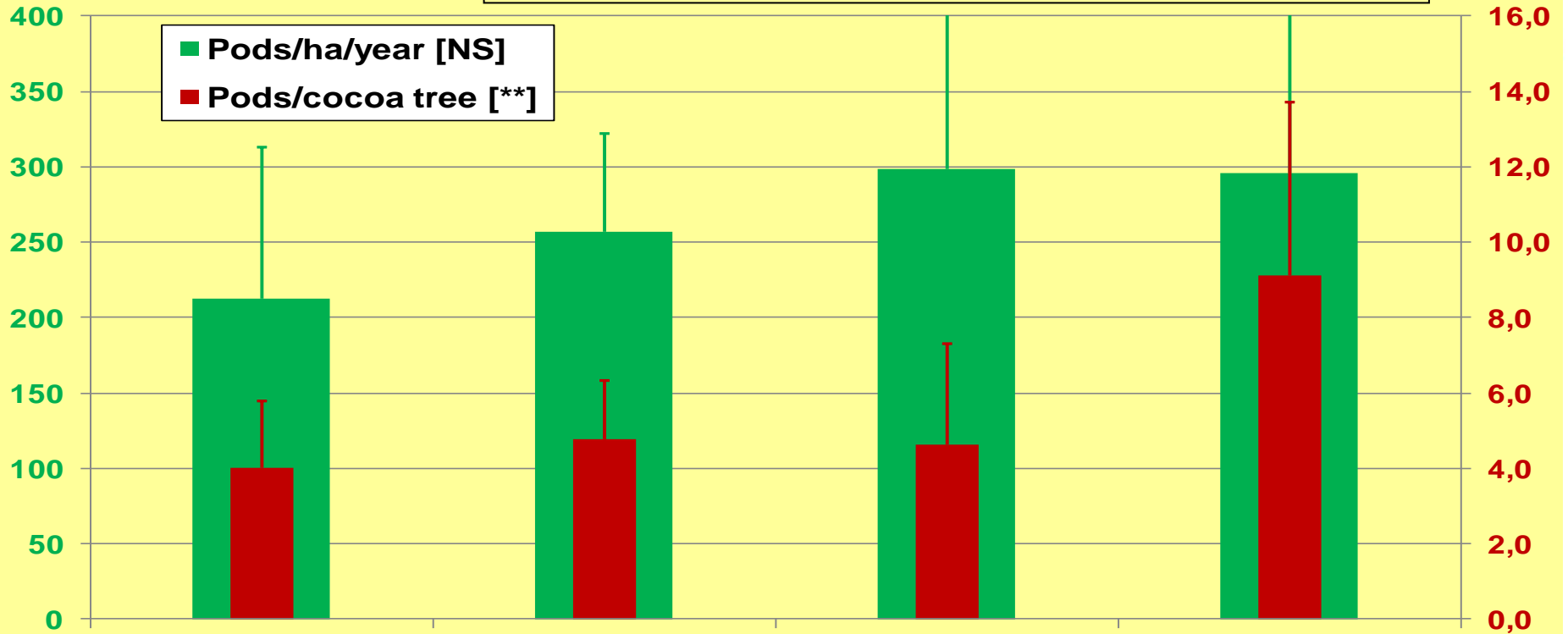


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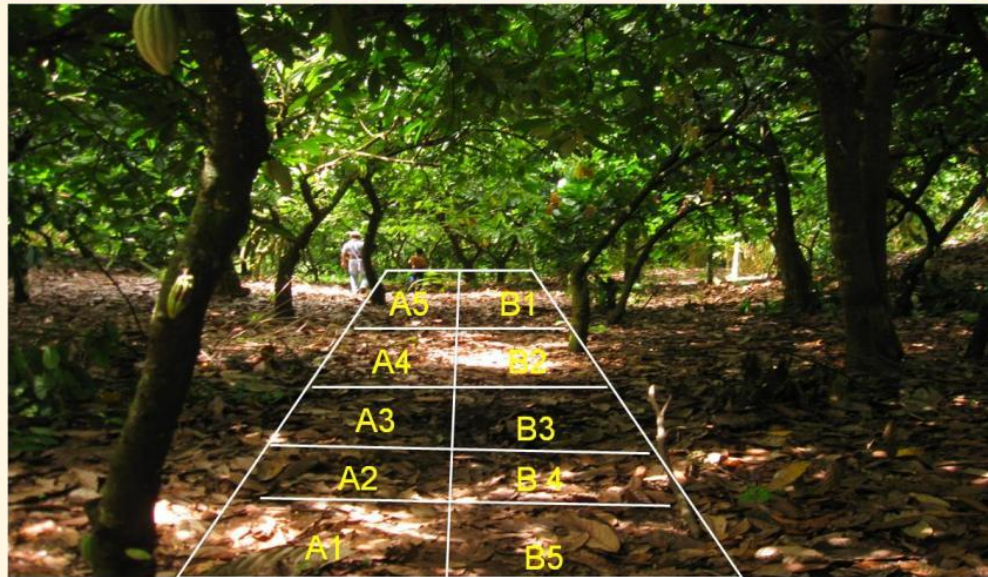
Sørensen's similarity coefficients calculated between four cocoa-based AFS clusters and one forest cluster (control) based on vegetation structure and produced from a sample of 36 cocoa-based AFS and 8 forest patches.

Results are shown for associated plants >2.5 m height (a), reptiles (b) and amphibians (c).

# Cocoa yield/ha/year and /tree in each cluster



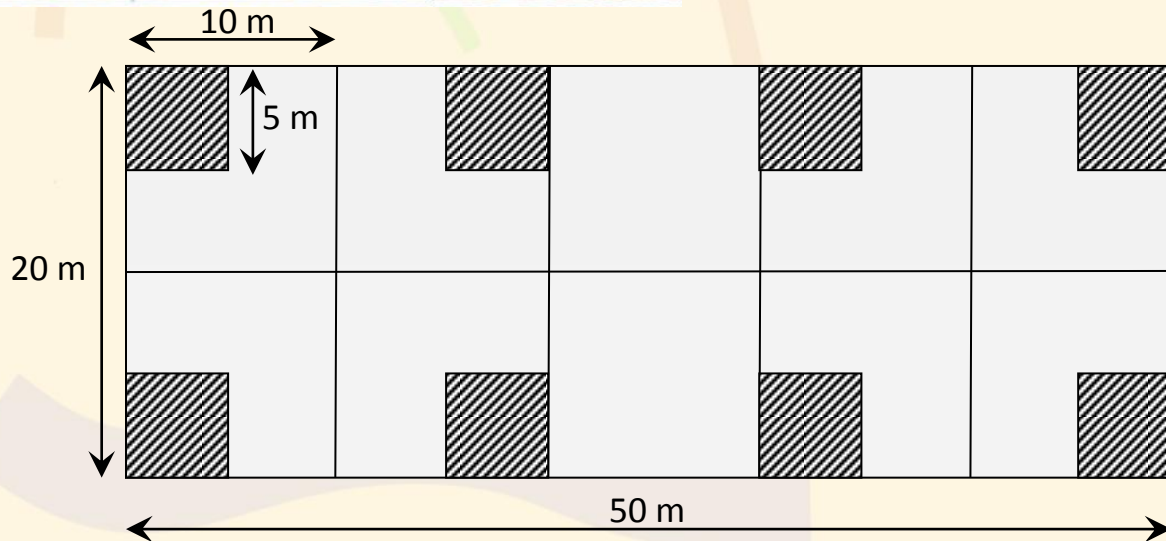
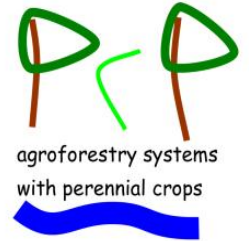
Management intensity



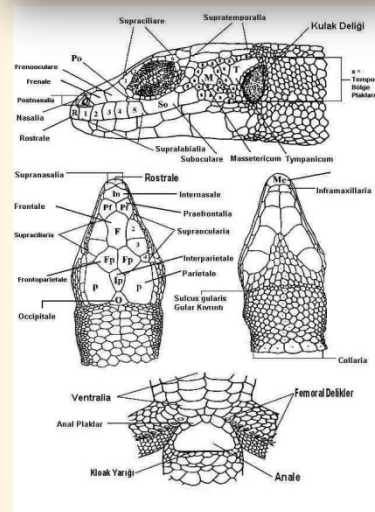
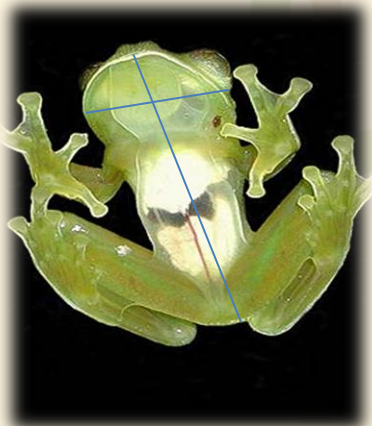
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# AMPHIBIANS and REPTILES capture



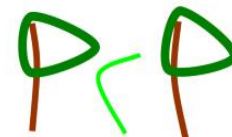
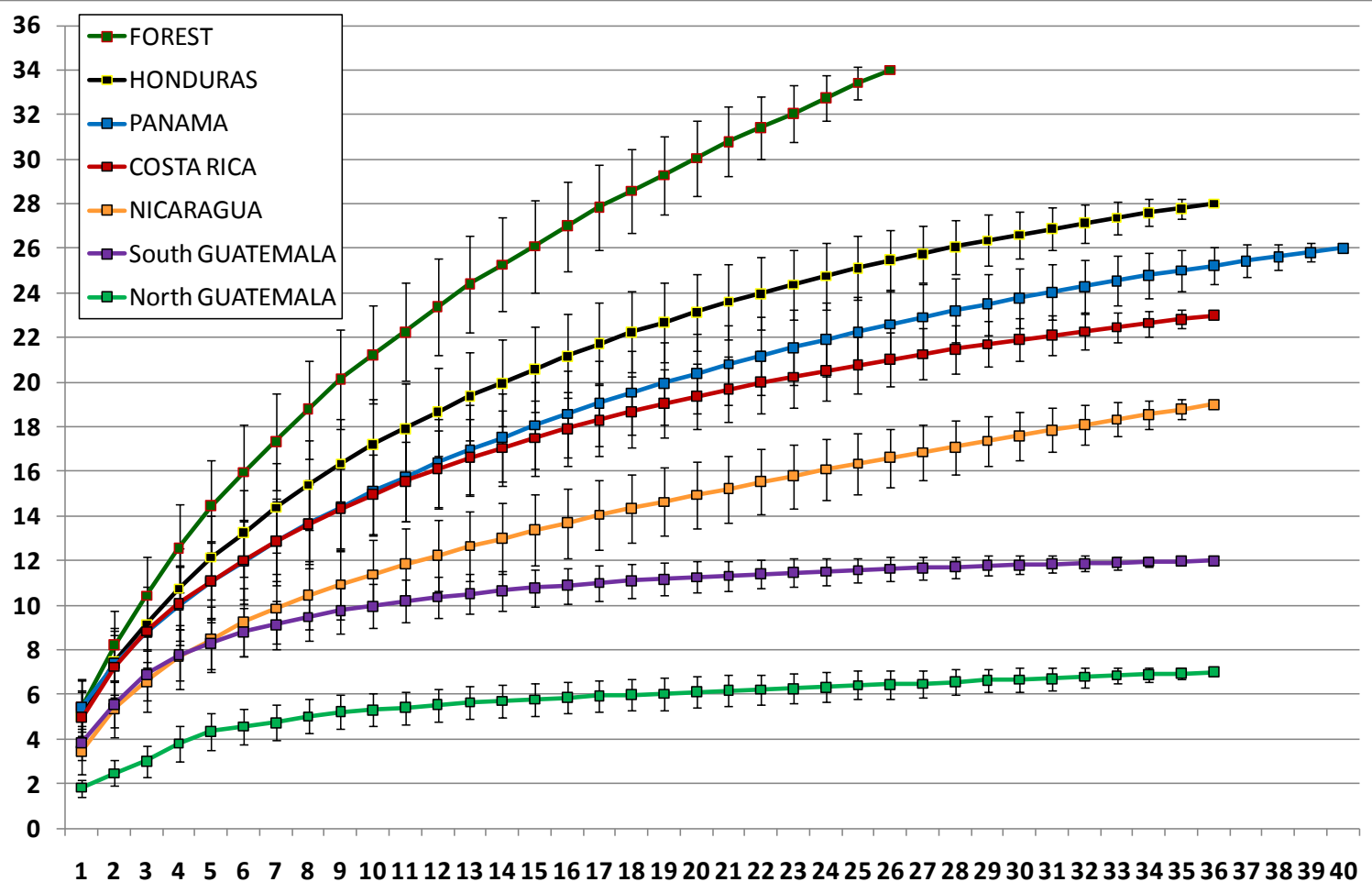
agroforestry systems with perennial crops



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## REPTILES accumulation curves in COCOA AFS from 6 Central American cocoa growing regions and forest controls

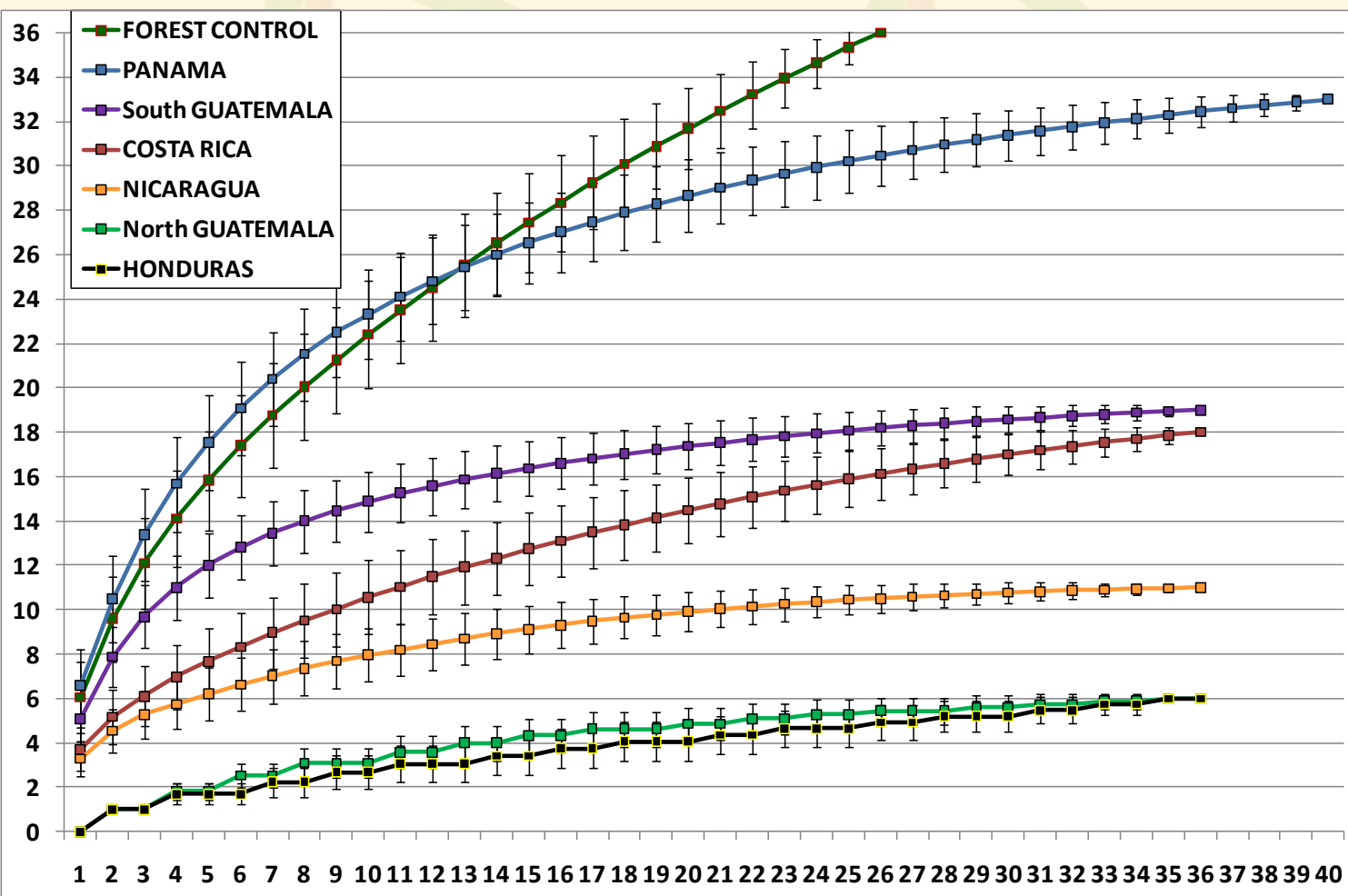
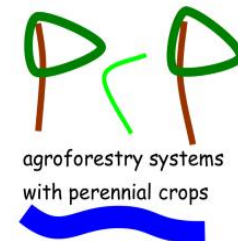


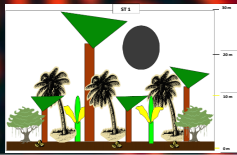
agroforestry systems  
with perennial crops



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## AMPHIBIANS accumulation curves in COCOA AFS from 6 Central American cocoa growing regions and forest controls





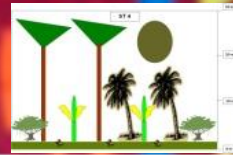
1



2

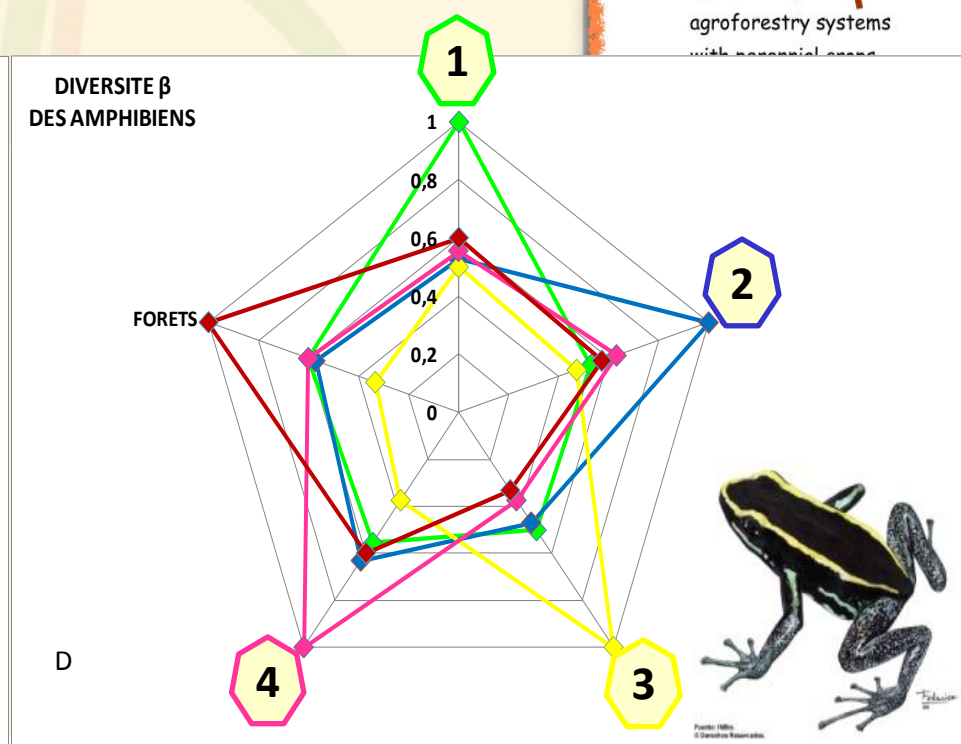
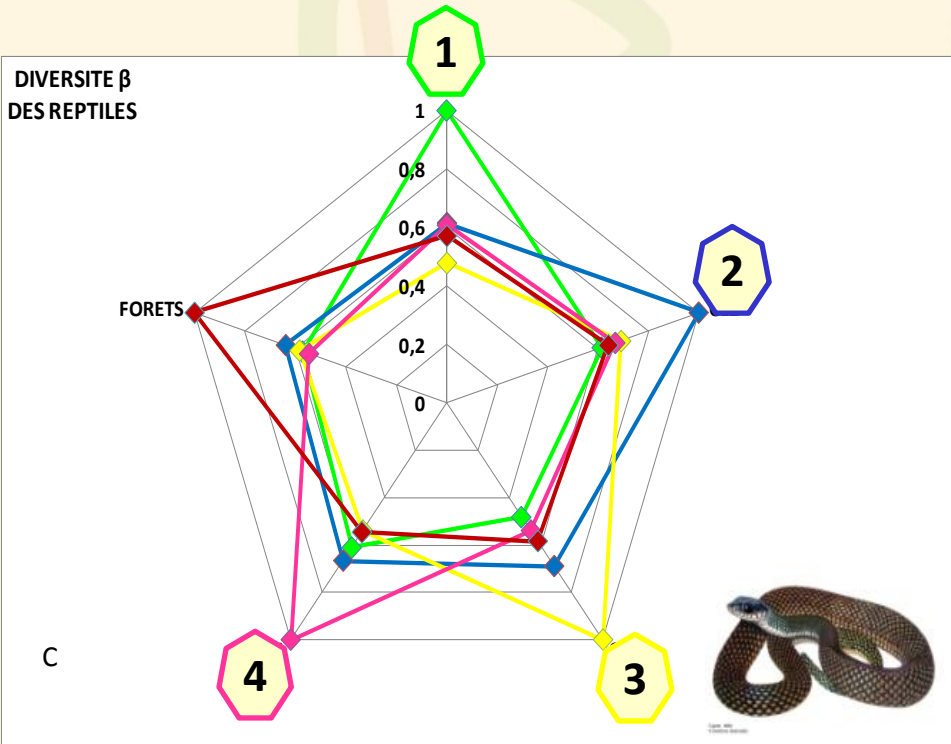
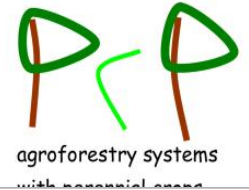


3



4

## Beta diversity AMPHIBIANS and REPTILES between 4 clusters of cocoa-based AFS and 1 cluster of forest patches (control) in Talamanca (COSTA RICA)



Sørensen's similarity coefficients calculated between four cocoa-based AFS clusters and one forest cluster (control) based on vegetation structure and produced from a sample of 36 cocoa-based AFS and 8 forest patches.

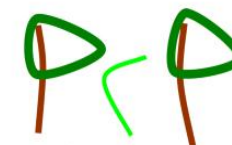
Results are shown for reptiles (C) and amphibians (D).



## AMPHIBIAN species found in Central American cocoa AFS and reported on the UICN red list

### AMPHIBIANS

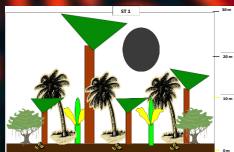
		PA	CR	NC	GN	GS	H
<i>Caecilia volcani</i>	Data deficient	■					
<i>Strabomantis biporcatus</i>	Vulnerable			■			
<i>Incilius campbelli</i>	Vulnerable				■	■	
<i>Dermophis mexicanus</i>	Vulnerable					■	
<i>Craugastor chac</i>	Vulnerable						■
<i>Craugastor charadra</i>	Vulnerable						■
<i>Incilius campbelli</i>	Vulnerable						■
<i>Lithobates brownorum</i>	Data deficient						■
<i>Ptychohyala hypomykter</i>	Endangered						■



agroforestry systems with perennial crops



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1



2

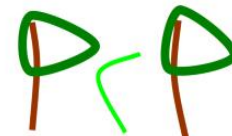
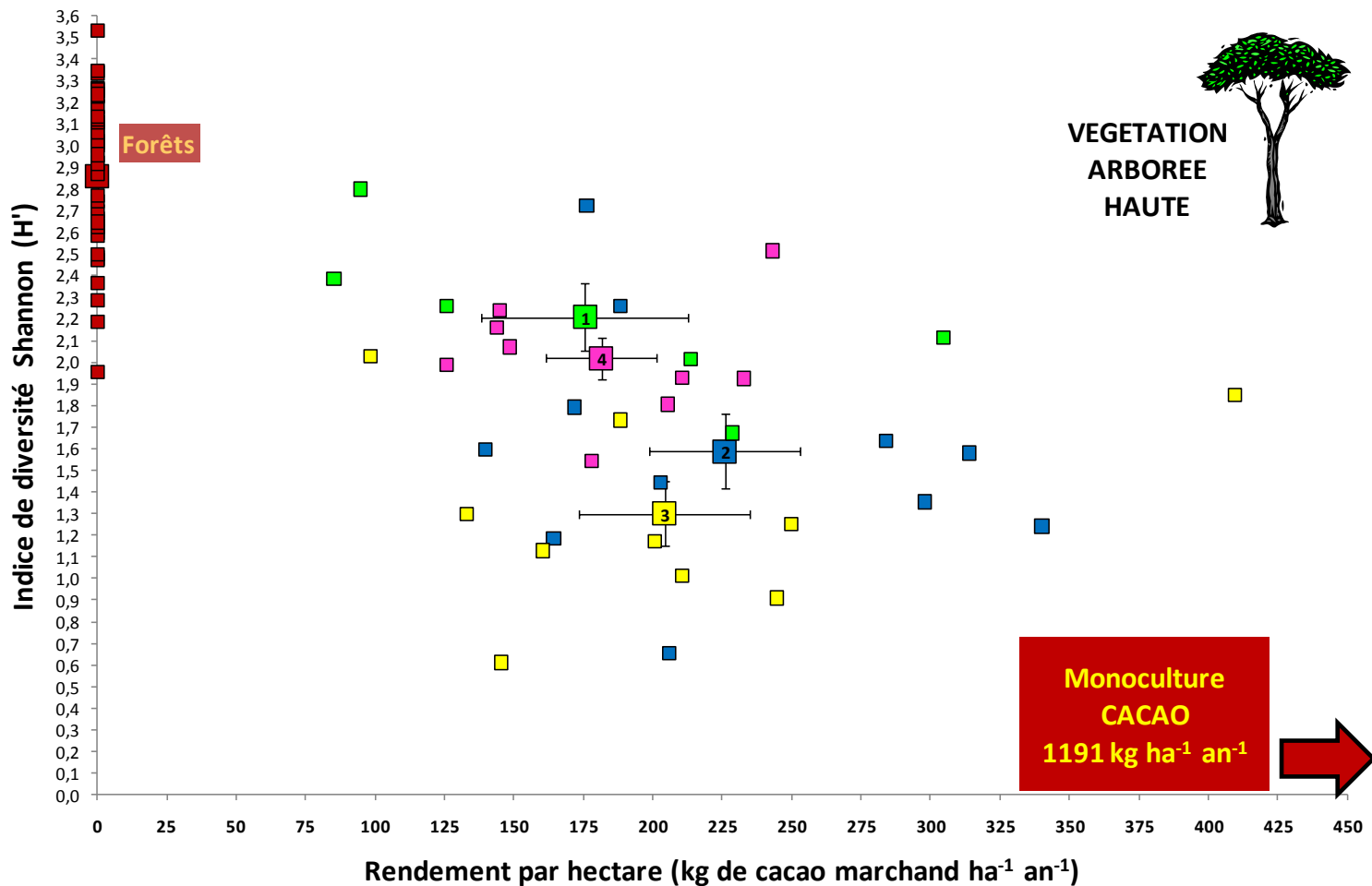


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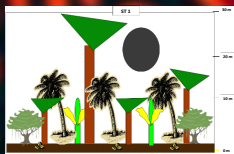
## Trade-off between plant diversity and cocoa yield



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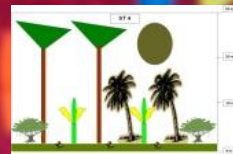
1



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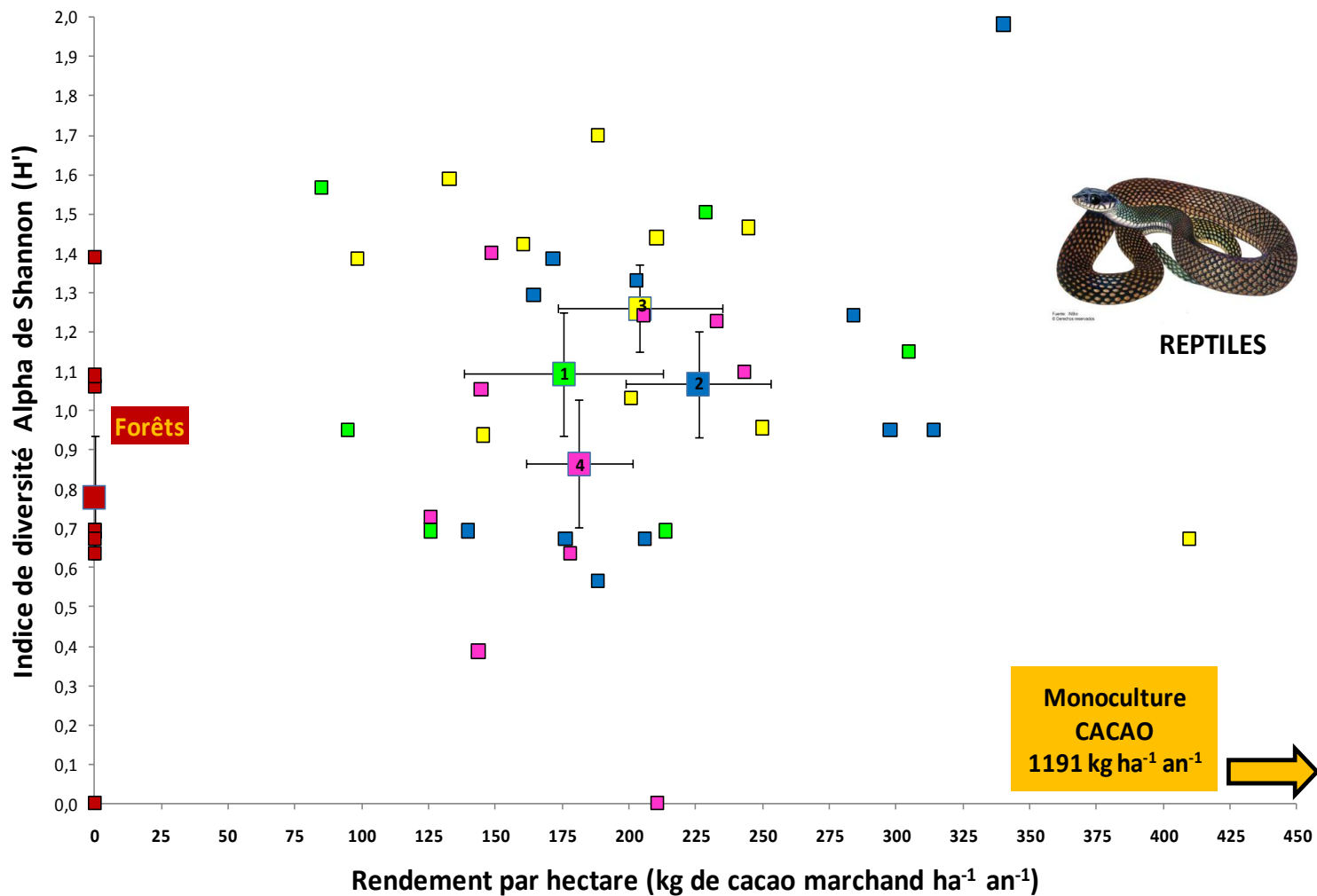


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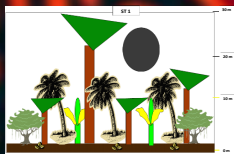
## Trade-off between Reptile diversity and cocoa yield



agroforestry systems with perennial crops



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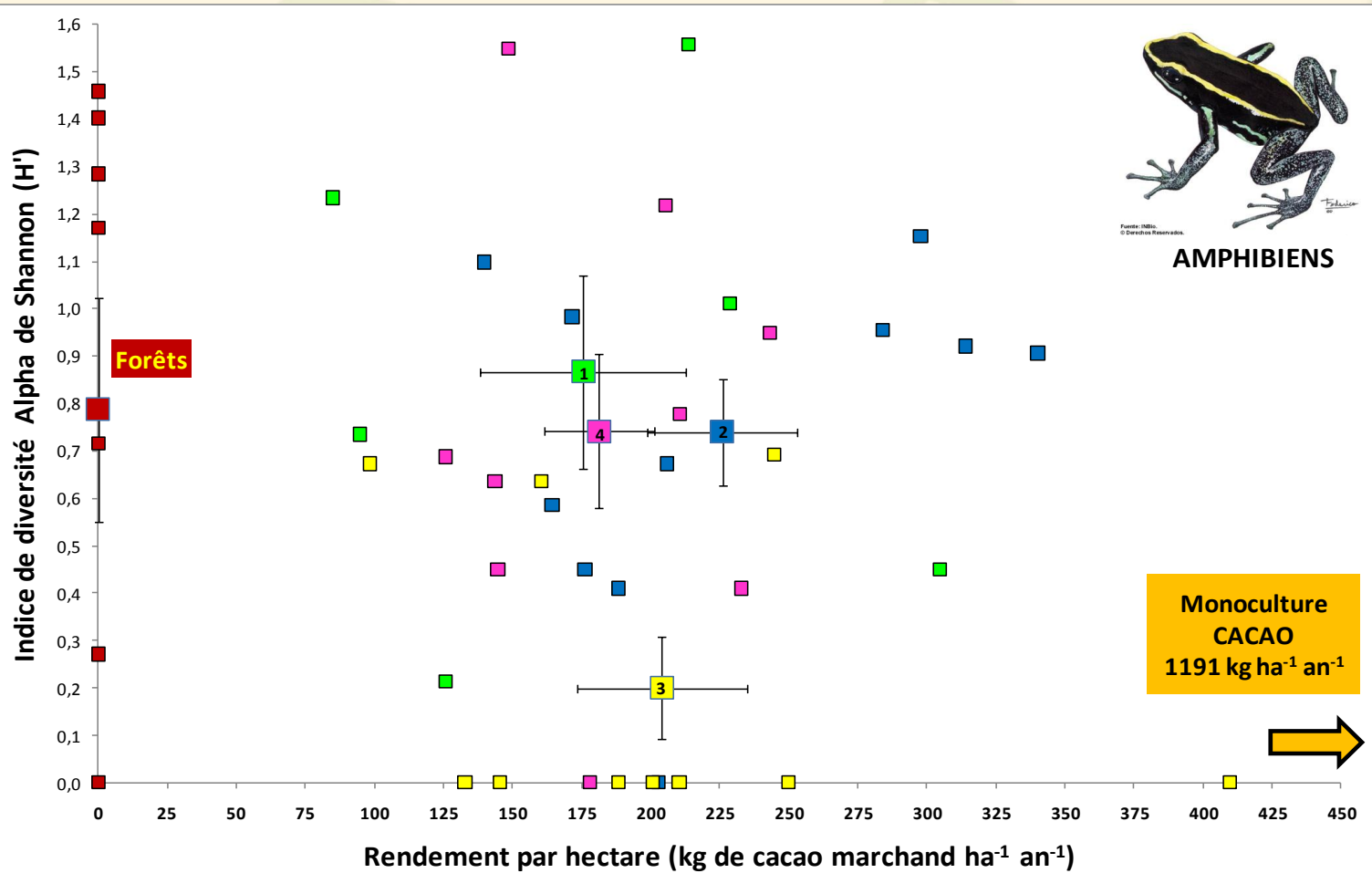


3

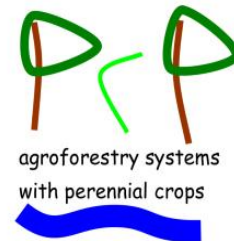


4

# Trade-off between Amphibian diversity and cocoa yield



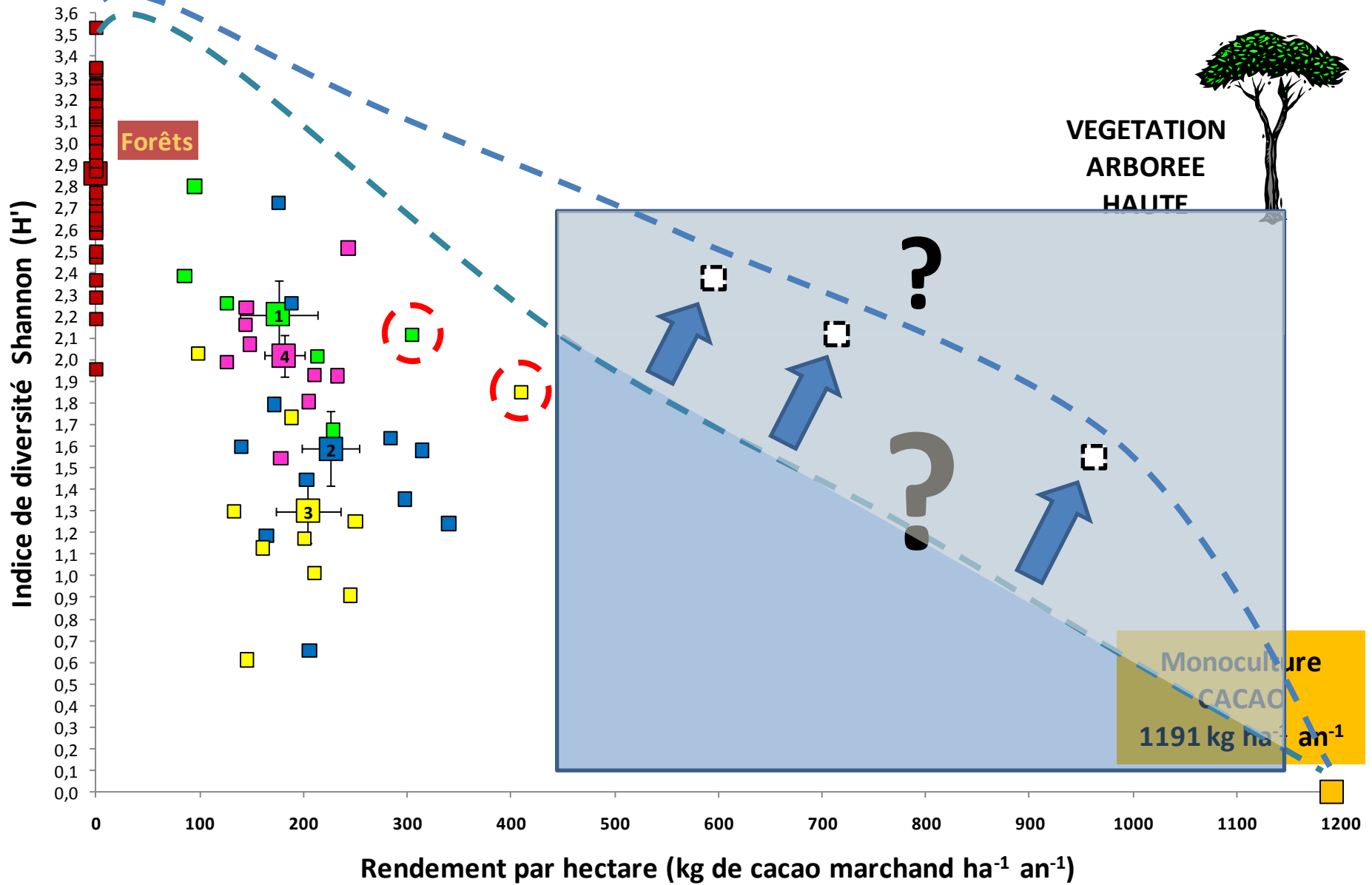
AMPHIBIENS



agroforestry systems with perennial crops



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MAURICIO RIVERA  
MHUA ©



agroforestry systems  
with perennial crops

# Thank you



*Centrolene ilex*



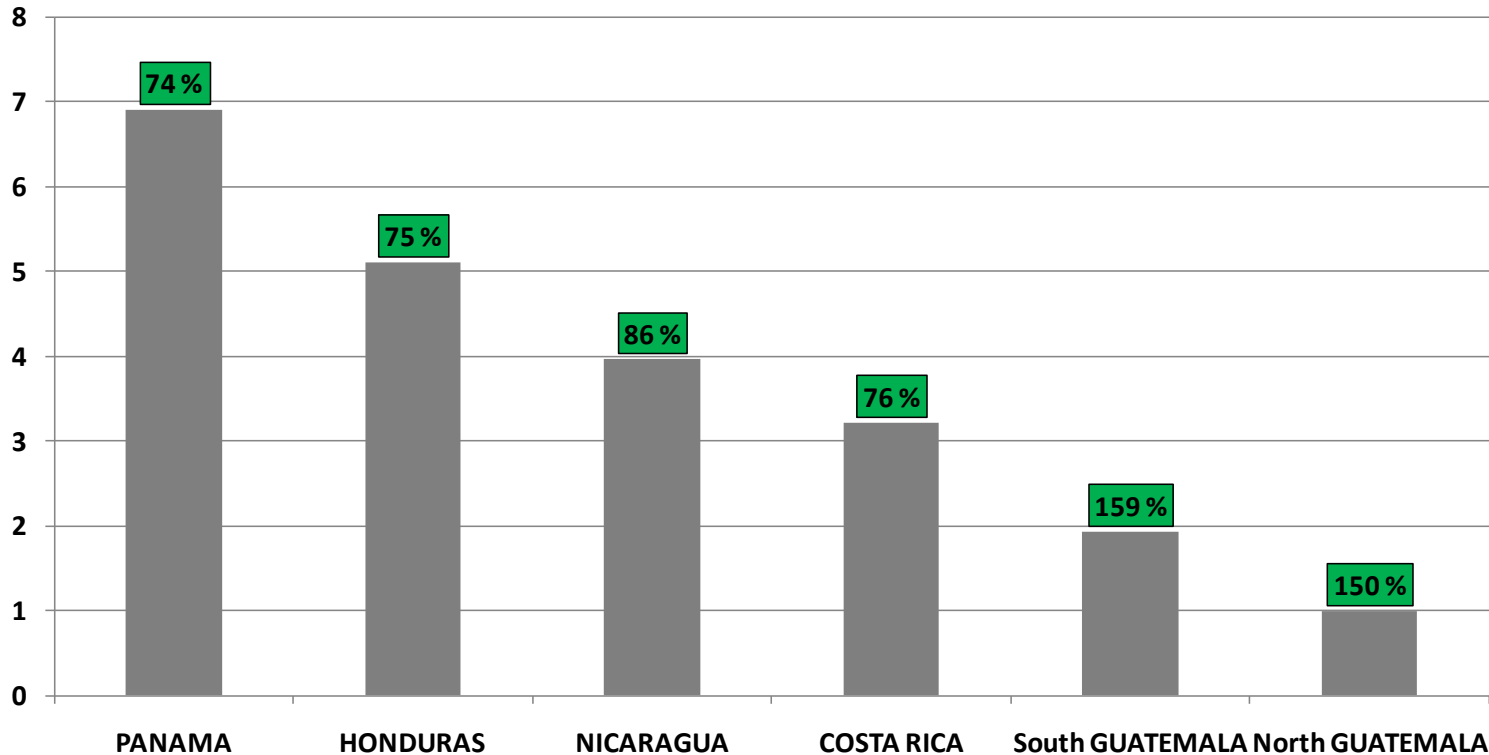
*Atelopus varius*



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# FORESTS

Estimated number of REPTILE species captured on the first FOREST PLOT and accumulation rate calculated on the first 3 plots



# FORESTS

Estimated number of AMPHIBIAN species captured on the first FOREST PLOT and accumulation rate calculated on the first 3 plots

