

# Vegetation-based indicators for assessing ecosystem services of cacao agroforestry systems, buffer zone of Abiseo River National Park, Peru

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# Introduction

Agroforestry systems with less intensive management and high canopy cover, resembling neighboring natural forests, are capable of hosting a high number of species (Ashley et al., 2006).

This can be a promising approach when defining intervention strategies in the buffer zone of the National Park "Rio Abiseo" - NPRA, in the Peruvian Amazon. The PNRA buffer zone is dominated by cacao agroforestry systems and cacao plantations (SERNANP, 2015), which can potentially provide connecting habitat to many wild species, at the same time guarantee the provision of goods and services to the local farmers.

## Results

- Five attributes were identified as significant vegetation structural attributes (table 1) for the assessment of the provisioning services (table 2).
- The attributes related to the vertical structure of the vegetation are highly significant.
- The natural forests presented five vertical layers, while the cacao agroforestry systems and the cacao plantations presented three and two layers respectively (figure 2 and 3).

**Table 2.** Assessment of the provision of ecosystem services by
 agroforestry systems in the buffer zone of the NPRA. + = positive relation/influence; - = negative relation / influence.

|     |   | Supportir  | Provisioning   |                     |
|-----|---|--|--|---------------------|
|     |   | (habitat p   | Service  |                     |
| No. | Vegetation<br>structural<br>attributes                  | jaguar<br>(Panthera<br>onca)<br>(Arroyo-Arce, et<br>al., 2014) | San<br>Martin's titi<br>monkey<br>(Callicebus<br>oenanthe)<br>(DeLuycker,<br>2007) | Cacao<br>production |
|     | Tall trees<br>with dense<br>canopy                      | +++  | +++  | _                   |
| ]   | Tall trees<br>with gaps or<br>openings in<br>the canopy | ++   | +  | +                   |
|     | Small trees<br>/many                                    | -  | -  | +++                 |

#### Goal

We aimed to identify attributes capable of performing as indicators for the assessment of the supporting and provisioning services of the cacao agroforestry systems. The supporting services focused on the provision of suitable habitat for the jaguar (*Panthera onca*) and the San Martin's titi monkey (*Callicebus oenanthe*), while the provisioning services focused on the average monthly income (USD per ha) from cacao.

# **Methods and Materials**

A comparison was done between the vegetation structural attributes of the cacao agroforestry systems, the cacao plantations and the natural forests in the buffer zone of the NPRA (table 1).

CCA was able to identify the attributes capable of explaining the variance found between the natural forests and the cacao agroforestry systems and the cacao plantations.

**Table 1.** List of significant attributes tested for the CCA.

| Key Attributes   | Df | ChiSq | F    | Pr (>F)   |  |  |
|--|----|-------|------|-----------|--|--|
| Shrub layer  | 1  | 0.86  | 5.95 | 0.001 *** |  |  |
| A layer of trees<br>between 16 and 20m<br>tall (extra medium<br>layer) | 1  | 0.39  | 2.69 | 0.001 *** |  |  |
| Presence of snags  | 1  | 0.35  | 2.45 | 0.014 *   |  |  |
| Average tree height  | 1  | 0.29  | 1.99 | 0.004 **  |  |  |
| A layer of trees<br>between 5 and 15m<br>tall (medium layer)           | 1  | 0.29  | 1.99 | 0.006 **  |  |  |
| Residual   | 54 | 7.82  |      |           |  |  |
| Significance codes: 0 '***' 0.001 '**' 0.01 '*'                        |    |       |      |           |  |  |

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# Conclusions

- The tree layer of 16 to 20 m high, the shrub/tree layer of 5 to 15 m high and the presence of snags, are structural attributes of the vegetation that can be indicative of the supporting service provided by the cacao agroforestry plot.
- The provisioning service of the cacao agroforestry system can be assessed by the average monthly income (USD per ha).

These attributes were measured and compared in modified Whittaker plots (0,1 ha), set in the cacao agroforestry systems (19 plots), cacao plantations (21), and natural forests (20) (figure 1).

A principal component analysis- PCA and a constrained correspondence analysis- CCA (with a permutation test) were used to compare the structural attributes in the different systems.





Figure 2. Vegetation profile showing the structure and vertical layers of a cacao agroforestry system sample plot located near the park ranger station "El Churo", buffer zone of the NPRA. Tree species: 1. Tornillo - *Cedrelinga cateniformis* (Ducke) Ducke; 2. Caraña – Burseraceae; 3. Croton sp.; 4. Cacao - Theobroma cacao L.; 5. Coffee - *Coffea arabica* L.; 6. Coca - *Erythroxylum coca* Lam.



In the buffer zone of the National Park "Rio Abiseo", the farmer's need for a constant cacao production has to be balanced with the need of habitat provision for the wildlife. This entails the incorporation of some of the identified vegetation structural attributes to the cacao agroforestry plot.

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**Figure 1.** Sampling plots location in the buffer zone of the NPRA. Cacao agroforestry systems (yellow circles), cacao plantations (red) and natural forests (green). The brown polygons highlight the areas suitable for cacao cultivation (300 to 700 masl with slopes less than 30%). Source: own elaboration based on the San Martin Government Cartography information.

layers of a natural forest sample plot, buffer zone of the NPRA.

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