Ecosystem Services Functional Motif
a new concept to analyse and design agroforestry systems

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What is the ESFM concept?

Agroforestry systems (AFS) are multi-species systems comprising cropped and associated (spontaneous or not) species, including trees (Jose, 2009). Those species provide different types of supporting, regulating and provisioning ecosystems services (ES). We propose a new concept called **Ecosystem Service Functional Motif (ESFM)** defined as **the smallest representative spatial unit relevant to understand the provision of a set of targeted ES**, at a given time. The targeted ES can be of different types (habitat or support, production, regulation).

How to represent the ESFM?

For each targeted ES, the smallest unit at which the motif represents the field structural design is drawn. The ESFM is the smallest structural unit **providing ALL the targeted ES** (Fig. 1A & 1B). When the field structural motif has a simple geometric shape, then the ESFM has a simple geometric shape too (Fig. 1C : ESFM2 & ESFM3).

A new concept: what for?

1. To precisely describe a wide range of existing AFS, differing in terms of species richness, structural complexity and spatial organisation (Fig. 1). ESFM allows to determine the smallest scale at which data should be collected for relevant analysis and upscaling of AFS functioning.

2. To design improved AFS according to various types of targeted ES at various stages in the "life cycle" of the AFS (Fig. 1C);

3. To model AFS. Simple AFS (Fig. 1) generally have a simple geometric ESFM (rectangle, hexagon,...) which is easier to represent in models than when the ESFM has an irregular shape. In order to model complex AFS with irregular ESFM shape, we suggest to build simple geometric modelled ESFM based on a simplified structure including functions provided by groups of species (Fig. 2).
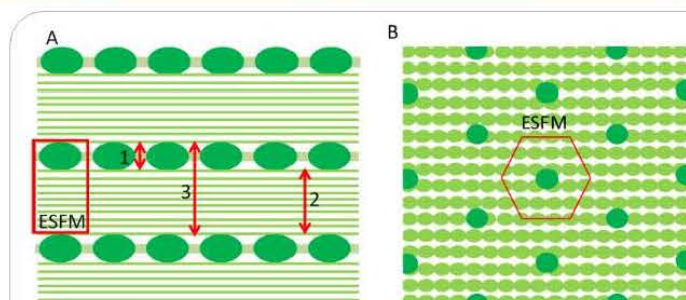
CONCLUSION & PERSPECTIVES

The ESFM concept can be applied to a wide range of AFS from simple to complex ones. The motif defines the structural and functional basic unit to be considered to target a given set of ES, at a given time.

The ESFM concept can be a **tool** for agronomists for (i) **assessing** the functioning of AFS with appropriate experimental design, (ii) **designing** improved agroecological systems explicitly based on ES targeted, and (iii) **modelling** AFS using a motif (or various motifs) adapted to represent the targeted ecosystemic functions and finally the provided services.

Fig. 1: ESFM (Surrounding redlines delimit ESFM in each example) is the smallest spatial unit providing all the targeted ES.
- *Fig. 1A: simple alley cropping AFS in France. ESs = timber production + biodiversity conservation + habitat for natural enemies (1), + food or forage production (2), + soil C storage (3).*
- *Fig. 1B: Arabica coffee trees with erythrines in Costa-Rica. ESs = coffee production + N2 fixation (CC mitigation) + Pests & diseases regulation*
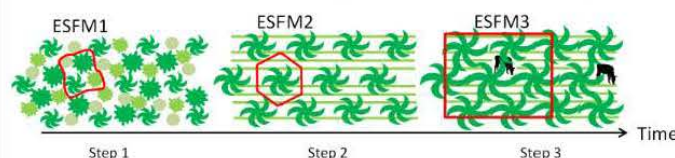

Fig. 1C : from left to right, ESFM transition in one decade: from food crop oil palm AFS to silvopastoral oil palm AFS in Cameroon (Rafflegeau 2008).
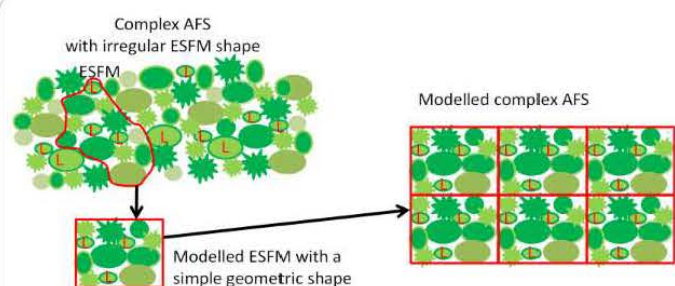

Fig. 2: The ESFM concept can help to model in complex AFS, like i) Melanesian food garden, ii) intensified temperate vegetables and fruits (horticultural) production, iii) African food garden, iv) West-Indies "Jardin créole", v) Cameroonian cocoa AFS (Jagoret et al.,2018), etc.

References

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