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# Impact of farming systems on agricultural landscapes and biodiversity: from plot to farm and landscape.

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## 1 Introduction

Green-way policies in agricultural landscapes focus on ecological continuities between semi-natural elements (hedgerows, permanent grasslands, woods). These policies assume that annual crops and temporary grasslands have a negative or neutral impact on biodiversity. However, some works have shown that the presence of annual crops with dense cover and spatial continuities between different crops could also have a positive impact on biodiversity, either on woody species (see e.g. Ouin et al 2000) or on crop species (see e.g. Burel et al 2013). These landscape patterns are directly linked to farmers' decisions about the choice of crops they cultivate and their allocation on the farm fields. These decisions are related to fields characteristics and crop management requirements. In livestock farms, these decisions are also linked to animal management, particularly the way they are fed and the way fodder is produced (on-farm or bought) (Garcia et al, 2005). The aim of this study was to evaluate the impact of contrasted livestock farming systems management on landscape patterns related to cultivated covers and potential biodiversity, here carabid beetles in bocage landscapes in Brittany, France. We achieved this goal through a multi-level modelling framework in order to combine field, farm and landscape level analysis.

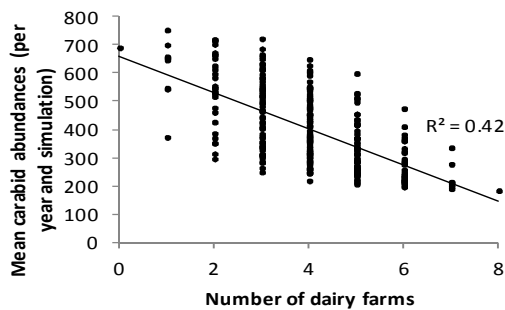
## 2 Materials and Methods

We developed a methodology combining farmers' decision making analysis, ecological observations and modelling. Modelling has been done at the field, farm and landscape levels. We applied our methodology to a case study in Brittany, France. We compared two livestock systems, swine and dairy, in one bocage landscape (circle of 1 km diameter) which fields were farmed by 8 farms. A farm decision-based model was first built from farmers' interviews to simulate cropping patterns at the field and farm levels. Land-use patterns were then simulated at the landscape level by aggregating predicted cropping patterns of the 8 farms. Ecological statistical models were built from empirical data on carabid beetles, to predict carabid abundances at the field level in (i) annual crops and (ii) in semi-natural (woody) elements in simulated landscapes. Each farm were either simulated as a dairy or a swine farm, leading to a total of 256 landscape scenarios, each repeated 250 times, one scenario corresponding to 10 years of rotation. We used APland library dedicated to landscape modelling (Boussard et al, 2010).

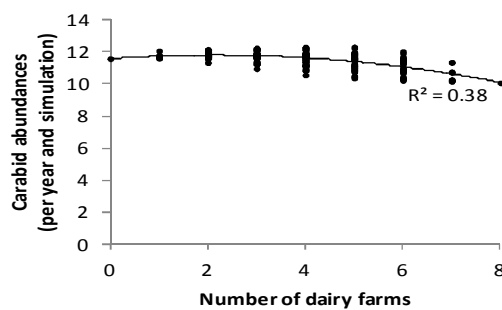
## 3 Results and Discussion

From an ecological point of view we predicted that carabid species of annual crops were more abundant in swine production landscapes due to increased spatial continuities (edge length) between maize and winter cereals, whereas abundances of species of woody elements were enhanced in mixed landscapes (dairy and swine) because of higher land-use diversity (figure 1).

(a) Carabid species of annual crops



(b) Carabid species of woody elements



**Figure 1.** Predicted abundances of (a) carabid species of annual crops and (b) species of woody according to the number of farms in dairy vs. swine production systems.

On table 1 we can observe that there is a relation between farms' farming system and crop areas within the simulated landscape. This is particularly true for wheat and grassland, while maize area is relatively less variable. As a result we can see a significant relation between farms' farming systems and spatial continuities between maize and winter cereals. A second result is that the intra-scenario variability is rather high (S.D. between 4.4 and 8.7 ha except for grassland in the swine scenario; from 288 to 466 meters of spatial continuities), which points out some flexibility to manage landscape to promote crop acreage and spatial continuities that would enhance carabid abundances.

**Table 1:** Mean and S.D. of land-uses areas and spatial continuities (edge length) between winter cereals and maize for 3 contrasted scenarios out of the 256 simulated (2500 landscapes per scenario: 10 years and 250 repetitions).

Scenarios	Wheat (ha)		Maize (ha)		Grassland (ha)		Spatial continuities (m)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Swine only	27.6	8.7	16.8	7.2	0.4	0	2246	466
Mixed	14.9	5.9	15.1	6.7	27.9	5.1	1095	433
Dairy only	5.8	4.4	21.6	6.8	37.4	6.2	339	288

Relative contribution of each farm to carabid beetles abundances was then calculated (table 2). It corresponds to the increase in the mean number of carabid beetles predicted when converting a farm from dairy to swine farming system. Farm size is the main factor explaining this contribution (see farms 1,2 and 4). But, it is not a general rule, since farm 2 and 9 contributions are respectively higher than the ones of farm 4 and 8. Potential grassland area in the landscape, related to the position of milking facilities (within, close or far from the landscape), and the edge length between fields are two other factors to consider. Indeed, they favor the increase of spatial continuities between maize and winter cereals when shifting from dairy to swine farming systems.

**Table 2:** Farm relative contribution (case of annual crops carabid beetles)

	Areas and edges length calculated for each farm				Relative contribution
	Arable land (ha)	Edges (m)	Min grassland area (ha)	Max grassland area (ha)	
F2	16.6	2 544	1.9	16.6	230.1
F4	20.5	2 829	0.0	20.5	122.9
F1	14.3	1 484	0.0	14.2	72.7
F9	4.7	1115	0.0	4.7	42.2
F6	2.5	345	0.0	2.5	16.4
F3	1.2	222	0.0	1.2	16.2
F7	3.2	1177	0.0	3.2	14.1
F8	7.3	713	0.0	0.0	0.1

#### 4 Conclusion

Our multi-level and agro-ecological modeling framework allowed to evaluate the impact of different farming systems (dairy and swine) on landscapes patterns and abundances of carabid beetles. We showed that over-representation of swine farming system leads to increased edge length between maize and winter cereals and so favoring crop carabid beetles. On the contrary, a diversity of farming systems seems to be required in order to favor woody carabid beetles. Moreover we showed that for a given set of farming systems in a landscape there was a variability of crop patterns and edge length between cultivated covers. This indicates that there are some rooms to maneuver crop allocation to fields in agricultural landscapes. But these rooms for maneuver have to be thought at a collective level since they result from several farmers decisions, some farms having a higher contribution to the landscape pattern and resulting biodiversity.

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