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A mapping method of crop composition and configuration to study their effect on biodiversity of European agricultural landscapes

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Abstract

Agricultural landscapes approximately occupy 40% of available land surface. As such they constitute a keystone in biodiversity conservation programs. In return, biodiversity contributes to production through ecosystem services as pollination or pest control. In this perspective, deciphering the role of agricultural landscape heterogeneity in maintaining biodiversity may be a promising research direction. In most agricultural regions, the trend is to increase field size dedicated to a decreasing cover type number. What are the effects on biodiversity of such a changeover in rural landscapes spatial patterns? May new policies involving a modification of this trend be envisaged? The FARMLAND project precisely aims at giving an answer to these questions combining tools from geomatics, remote sensing and geostatistics associated to ecological research on biodiversity. Based on spatial indexes from landscape metrics, this work proposes a mapping method for sampling quadrats and constituting an experiment design in order to dissociate the influence of composition (the number and probability of occurrence of the different cover types) and configuration landscape heterogeneity (the spatial display of cover types) on biodiversity. After the sampling of 40 quadrats in each of the 7 European sites, multi-taxa biodiversity records and ecosystem services identification will be undertaken.

We present here the different steps of the adaptation of the initial methodology from [1, 2] to the French site “Vallées et Coteaux de Gascogne” that constituted a test zone for the other European sites. We discuss the discrepancies and modifications from the Canadian princeps study.

Keywords: Moving window analysis, remote sensing, multicriteria analysis, landscape metrics, heterogeneity, biodiversity.

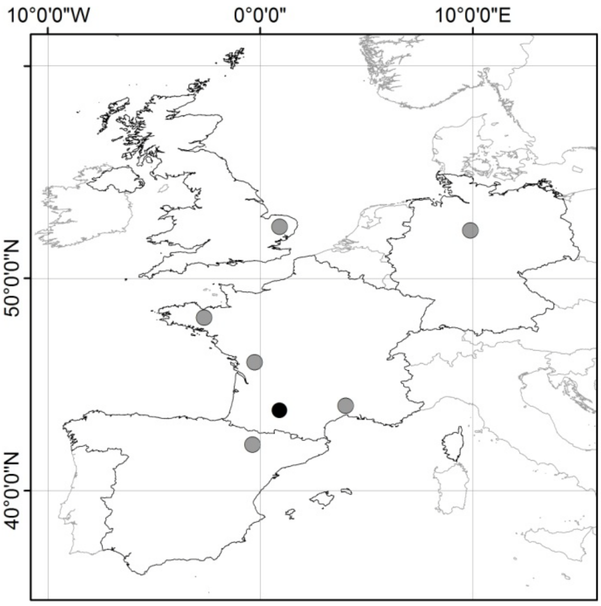
1 Introduction

The present work ascribes to the Farmland project (BiodivERsA2011-66) that aims at studying the relationships between agricultural landscape heterogeneity and biodiversity among seven study sites located in four different European countries. Many recent studies have highlighted this research direction [3, 4, 5, 6] and suggested modifications in agricultural practices that could be accepted by the different actors of the rural space [7]. In that perspective, this European wide project largely inspired in its methodology from recent works in landscape ecology [1, 2]. This methodology proposes a process line that leads, on the basis of land use and cover types, to the selection of quadrats in which biodiversity recording and ecosystemic services could be assessed. Notably, the experimental design has been set up in order to dissociate the influence of two components of landscape heterogeneity: composition heterogeneity - that refers to the number and probability of occurrence of the different cover types, and configuration heterogeneity - the spatial display of cover types [8, 9]. The methodology from the work of [2] first applied to north-american rural landscapes has been conducted and adapted to an european site in the South-West of France. Indeed, the long history of European rural landscape presents huge discrepancies with their North-American homologs.We present here the different steps of the process and the modifications of the princeps study.

2 Study site

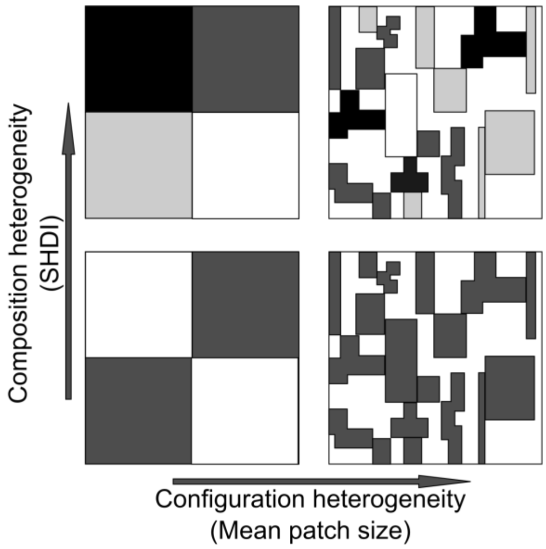
Figure 1 gives the study site “Vallées et Coteaux de Gascogne” which is located 50 kilometers West from Toulouse across the Haute-Garonne and Gers French departments. Its spatial range covers up to 1820 km² and land use and cover types mainly refer to mixed crop-livestock system with crop fields, woodlands and pastures.

Figure 1: Localization of our study site (black dot) among the six other European sites (grey dots).



Source: ESRI

Figure 2: Illustration of axes of spatial heterogeneity: composition and configuration heterogeneity.



Source: Fahrig *et al.*, 2011 [1].

3 Material and method

3.1 Data

According to the cropping schedule, a SPOT 4 and SPOT 5 multi-temporal image stack has been created with a 10 meters resolution. It pools images from February, June, July, August and September 2009. Other geographic data such as IGN BD TOPO (building cover) and BD ORTHO (recent aerial photographs) have also been used. Graphic land use from CAP data that pools input on agricultural practices during 2009 has been used as regions of interest for supervised classifications.

3.2 Description of the process line

The experimental design aims at sampling forty 1km² quadrats ascribing to four modalities (i.e. the crossing of two modalities low/high of the two heterogeneity indexes) (figure 2). In that perspective, these heterogeneity indexes must be calculated from Land Use and Cover Types and their statistical independence should be assessed to ensure their dissociation in further statistical analyses. Once spatial autocorrelation has been taken into account, indicating the minimum distance between quadrats, a sampling of forty quadrats can be performed.

3.3 Land Use and Cover Types

Land Use and Cover Types have been established through a 4 steps process involving ArcGIS 9.3, ENVI 4.7 and ENVI EX softwares. First, an urban agglomeration buffer zone has been determined and masked off from the SPOT images metafile according to a function of the habitation density (50 times the square root of the surface of zone that have a habitation density greater than 100 by km² and a surface greater than 1 hectare). Second, a supervised classification based on maximum likelihood has been used to discriminate six crop types (cereals, rape, corn, oilseeds, hays and pastures, sunflower) and a background class including all non-agricultural elements (woodlots, water, building area). Third, feature segmentation has been performed to distinguish the edge of the different fields and assess the fragmentation of habitat. Fourth, a procedure including suppression of fields smaller than 1 hectare, majority analysis and 8 meters internal buffer zone within the different fields has been performed in order to reduce the classification errors.

3.4 Landscape metrics and heterogeneity indexes

A moving window analysis has been performed on Land Use and Cover Types raster with FRAGSTATS 3.3 in order to determine two rasters based on heterogeneity indexes (Shannon Diversity Index and Mean Patch Size respectively for composition and configuration heterogeneity). A similar procedure has been undertaken to identify the areas that contain from 60 to 90% of their surface dedicated to agriculture. This last raster has been used as a mask on both heterogeneity indexes in order to focus the study on the agricultural component of the landscape.

3.5 Determination of the sampling zones

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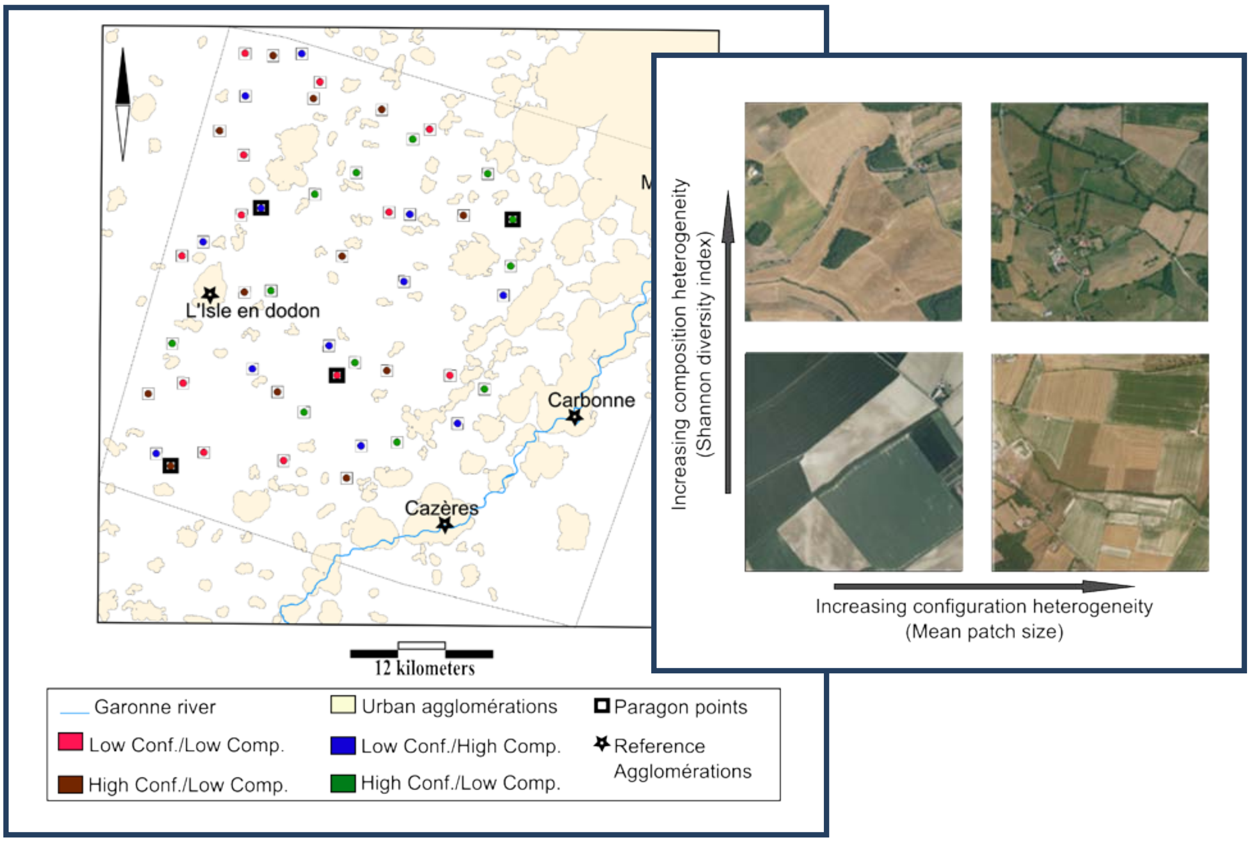
20000 dots have been sampled with the two masked rasters extents and their values crossed in a bivariate dot-plot. Then value intervals corresponding to low/high modalities for each index has been determined while maintaining statistical independence between indexes (assessed through non-parametric spearman correlation). This step allowed us to obtain four combinations of value intervals and to give a spatial representation of their corresponding areas in which sampling the quadrats. Afterwards, spatial autocorrelation has been evaluated and a minimum distance between quadrats has been estimated (1.5 km).

4 Results and discussion

While landscape history and structure is radically different in the princeps [2] and the present study, many of the steps of the process line have been adapted. The main innovations consists in taking into account most of land use and land cover classes to represent agricultural landscape complexity and masking urban agglomerations and small villages. Indeed, the classification process can easily confound hays and pastures with grass around habitations. The use of a buffer zone that takes into account the size of the agglomeration greatly improves the process line and prevented errors in the final sampling step (e.g. a quadrat in a urban agglomeration).
Though the original procedure from [2] has been adapted entirely to our site (figure 3), the whole project will require the coordination of the different laboratories involved in the project in order to fit with the peculiarity of each study site. The kick-off meeting of the project that will take place in spring 2012 will be the opportunity of such a focus.

Figure 3: Example of selected quadrats in four combinations of Low/High configuration (Comp.) and configuration (Conf.) heterogeneity. Black box refers to extract of recent aerial photographs at the right.



Source: BD ORTHO et TOPO (IGN).

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