GIS for planning conservation actions in viticulture landscapes

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Abstract GIS is increasingly used for the implementation of conservation programs. Before setting up concrete conservation actions, stakeholders use GIS to analyze the landscape that regulates main ecological processes. The Life + BioDiVine project relies on a large use of GIS for the implementation of conservation actions into European vineyards. GIS is used for the analysis of the landscape's composition, structure and diversity at several scales. It allows calculating landscape variables that are correlated to biodiversity values in order to highlight a possible link between landscape and biodiversity. Specific maps help locating areas of interest for conservation actions and represent a useful tool for communication with farmers or general public.

Key Words: GIS**,** viticulture landscape, conservation actions, biodiversity.

Introduction

Over the past 15 years, conservation plans have emerged as a major tool in biodiversity and sustainable landscape management. Actions for the preservation of biodiversity largely rely on Geographic Information Systems (GIS) that allow multiple data analysis and display. Mapping done with GIS is a basic tool for the study and the understanding of landscapes and habitats functioning (Burel & Baudry, 1999). Management plans frequently seek to adapt the structure of a landscape to achieve particular conservation goals, because the spatial arrangement of elements in a land cover mosaic controls its ecological processes and services (Haines-Young & Chopping, 1996). By allowing a precise analysis of the land cover composition, structure, diversity and by considering multiple additional parameters, GIS is often used as a guide for biodiversity conservation measures.

The Life + BioDiVine project (2011-2014) aims to implement different conservation actions in seven European vineyards. GIS is an indispensable tool for several phases of the project.

Material and methods

The GIS tool for the Life + BioDiVine project

From 2011 to 2014 the BioDiVine project aims to set up conservations actions in 7 European vineyards located in France (4 sites), Spain (2) and Portugal (1). Biodiversity measures focused on several taxa – arthropods, plants, soil microorganisms, birds and mammals – are implemented. To highlight a possible effect of the landscape on biodiversity, the vineyard landscape is analysed with the GIS software ArcGIS 10. The conservation actions will be done according to the results of these experiments.

Organizing and mapping data

Considering the numerous partners involved in the BioDiVine project, information from different sources and formats is processed (quantitative or qualitative data, maps, satellite images and aerial photographs). GIS is used for data storage, modification, analysis, exploration and mapping. Maps represent a support tool for landscape monitoring, conservation actions planning and communication.

The landscape pre-analysis at the "appellation" scale

Before setting up sampling protocols, GIS is used to get an overview of each area (partner sites) by studying land cover maps. The detailed land cover of each area was characterized according to the Corine Land Cover (CLC) typology and relative proportion of each land cover type was calculated. By overlaying several maps regarding different data – i.e. habitat type, protected areas, topography, water and communication networks – GIS locates sampling areas that cover overall landscape variability. On the other hand, the analysis at the "appellation" scale doesn't allow identifying specific habitats and interstitial space, important for ecological connectivity.

The landscape analysis at the multi-plot scale

More precise data are needed to link biodiversity observations to landscape structure.

GPS coordinates of each sampling location are entered into the GIS software. Within 4 different radiuses around each sampling point (50, 100, 150, 200m), polygons (habitat patches), linear (hedgerows, walls, watercourses …) and punctual elements (isolated trees) were identified and characterized according to a more precise typology than CLC's (figure 2), using aerial photographs and groundthruthing.

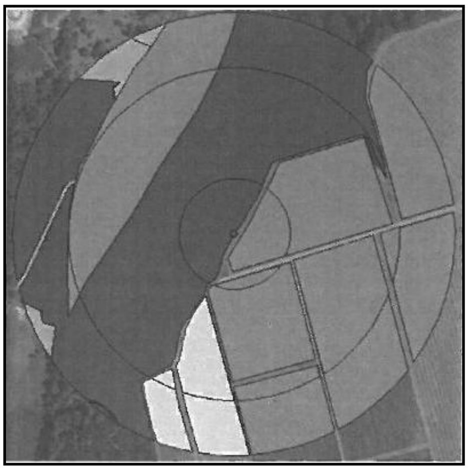

Figure 2: An example of 200m radius area showing detailed land cover characterization. Resolution: 1/4000. (Central point = sampling location; Black = forest; dark grey = vine; light grey = scrubland; white = fallow). (Source: Porte, 2011).

Results and Discussion

Obtaining variables of landscape characterization

Land cover digitalization allows generating several values characterizing the landscape composition (relative proportion of each land cover type), structure (heterogeneity and variability indexes) and diversity (Shannon index). These variables will be correlated to biodiversity variables (Richness, Shannon diversity index) in order to highlight a possible effect of landscape on biodiversity. Table 1 summarizes all of these variables for the sampling point n°2 in "Costières de Nîmes".

For all radiuses, table 1 highlights a large dominance of vines over the other land cover types.

Identification of areas adapted for the implementation of conservations actions

Correlations between landscape variables and biodiversity highlight some specific effects of

Table 1: Landscape variables, for the sampling point n°2 in "Costières de Nîmes" (Heterogeneity index = number of plots; Variability index = number of land cover type).

Buffer's radius (m)	50	100	150	200
Total surface (ha)	0,785	3,14	7,065	12,56
Variables of landscape characterization				
Shannon-Weaver Index for landscape	0,26	0,66	1,04	1,4
Landscape heterogeneity Index	1	6	13	21
Landscape variability Index	1	2	2	4
Relative % of land cover type				
Vineyards	95,55	75,4	68,1	70,2
Orchards	0	0	0	0,13
Forests	0	0	0	0,24
Urban sites	0	0	0,52	1,56
Scrubland	0	0	0,44	2,83
Gardens	0	17,68	22,67	17,43
Hedgerows	0	0,05	0,22	0,27
Dirt roads	0	2,71	3,17	3,34
Interstitial spaces	0,45	4,16	4,97	4

the landscape on biodiversity. For example, in "Costières de Nîmes" where agrosystems are dominated by vineyards and orchards, the first results highlight the negative effect of orchards on biodiversity (table 2). No significant effect of vines on biodiversity is identified.

According to these results, GIS identifies on the plot scale map, areas dominated by orchards with a specific lack of semi natural habitats, in which conservation actions should be implemented in priority.

Table 2: Significant Spearman correlation coefficients r (α = 0,05) found among arthropods abundance and richness and landscape parameters at 4 buffer sizes.

Buffer size	**200m**			**150m**		**100m**	**50m**	
Habitat	**Orchard**	**Roads**	**Shannon**	**Orchard**	**Roads**	**Orchard**	**Orchard**	**Interst.**
Abundance	-0,521	-0,539	-0,456	-0,450	-0,402	-0,431	ns	0,437
Richness	-0,480	-0,450	ns	-0,414	ns	-0,462	-0,455	0,420

Precise localization of areas in need of landscaping

Significant results (correlations) combined with map analysis (land cover, topography, geology …) allow GIS to locate strategic areas for conservations actions. These actions have to be more precisely located to be efficient and not to disturb the farmer activity.

The figure 3a illustrates a 200m radius area, representative of the "Costières de Nîmes" site (area dominated with vines, orchards and fallows). Fine scale GIS mapping allowed locating very precise locations for conservation actions (3b).

In order to improve ecologic connectivity at the multi plot scale without disturbing the farming practices, strategic conservations actions are decided with the farmer.

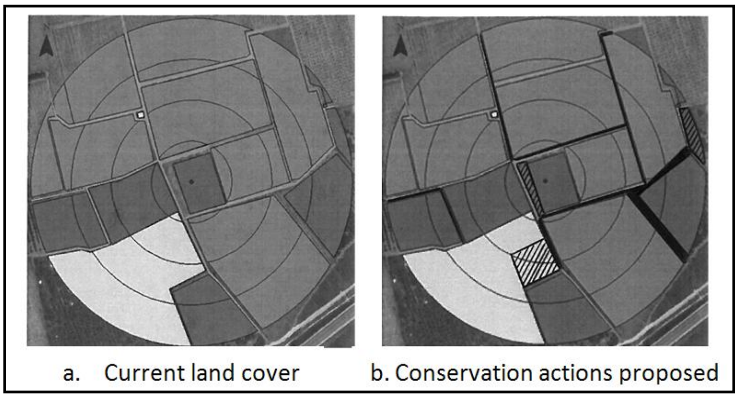

Figure 3: Proposition of conservation actions on a 200m radius in "Costières de Nîmes". Resolution: 1/4000.

(Color Code: 1. Polygon elements: dark grey = orchard; light grey = vine; white = fallow; 2. Linear elements: dark line = mixed hedgerow; dark surface = ground cover; hatched surface = wood). (Source: B. Porte, 2011).

In this case, proposed actions are 1) woodlots implemented on an abandoned orchard, part of a fallow and a free space; 2) ground covers on large plot edges around an orchard; 3) mixed hedgerows for connectivity between these two semi-natural habitats. The type of action and its location were chosen according to a land cover analysis at the plot scale, in addition to the results of the correlations obtained previously. GIS map allows locating non-characterized surfaces that represent the interstitial spaces (plot's edges, headlands, roadsides...). These are strategic areas for conservation actions that can be set up without impeding the passage of agricultural machinery. In some "appellation", these areas cover important surfaces. For example, they represent 7 % of the total surface in Saint Emilion (Bonnet *et al.*, 2011) and 4% of the 12 ha of the sampling point n°2 of "Costières" (table 1).
Using GIS maps at different scales, the landscape manager can discuss several conservation strategies with the farmer. GIS maps are communication tool that help farmers getting involved in conservation actions. The progressive involvement of farmers, possible especially thanks to GIS maps, promotes a common impulse for the valorisation of the appellation landscapes and indirectly, of the product "wine".

Thanks to its versatility and its many functions, GIS is a useful tool in the fight against unsustainable resources' use and biodiversity decline. It transforms raw data into very explicit ones that are easily understood by a wider public and then, helps raise awareness for this urgent cause. Through the colour outputs (essentially maps), the GIS software conveys a sense of reality, regardless of the data used for its creation. It is an efficient tool to support and illustrate the explanations of experts to the general public.

As the use of GIS is increasing strongly, precautions should be taken not to overcome the limit of this tool in order to map ecological phenomena as close as they really are.

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