4. A proposed tool to discern how farming activities contribute to environmental functions in a landscape

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Abstract

In areas where a large proportion of the land is used for farming, such as in European countries, evaluating links between farming activities and landscape multifunctionality is delicate and complex. In the last 15 years, social demands and policy orientation have evolved and now voice greater and more varied expectations concerning landscape characteristics, which are frequently linked to farming activity. However, it is still difficult to clearly identify and understand the contribution of farming to landscape multifunctionality because of the many interlocking forms of farm activities and land uses present in a given landscape. In assessing the contributions of farming land use to multifunctionality, research focuses most often on farm units and less frequently on landscape units, and rarely takes into account the complementarity of different farm types. In addition, it usually ignores combinations of non-productive functions in a landscape. Our research objective was thus to devise a framework that could successfully take into account and appraise complementarities among different farms and multiple functions in a landscape entity. We chose a geo-agronomic viewpoint to address the spatial organisation and complementarities of farming practices in a landscape. After methodological proposals an exploratory practical case study was developed in a small diversified livestock farming area on two sensitive environmental functions (preservation of surface water resources and preservation of a mosaic pattern of vegetation).

The main finding of this study was the multiform contribution of the farms to these two environmental functions, both in the overall landscape and on each farm. Two main spatial configurations appeared: 1) large farms with a spatially limited and disseminated contribution to the two landscape functions, and 2) medium and small farms with a relatively large localised contribution to the two functions.

Improvements are now necessary, e.g. in the identification of land users expectations, in the identification of the fulfilment conditions of various function sets, and in the simplification needed to make comparisons between many and larger landscapes. The ultimate aim is to produce tools and references at landscape scale for policy and decision making concerning agriculture and multifunctionality.

Key words
Multifunctionality, method, case study, farm, spatial pattern

4.1 Introduction

In the last 15 years social demand and policy orientation in rural areas have evolved; more varied and extended functions are required of landscapes, especially those with a large proportion of farming area, such as in European countries: preserving water resources, helping vegetation and land maintenance, supplying and preserving long-term employment, etc. These social and policy trends generally bring changes in the conditions of farming (rules, subsidies, user conflicts, etc.). Because of the often large and long-standing farming land uses in rural areas, farmers are considered essential actors in the fulfilment of these functions. However, precise qualitative and quantitative assessment of their contributions is generally complex because of their close dependence on other environmental and local conditions, and the resultant variability (Benoit *et al*., 1998; Hayo *et al*., 2002; Monestiez *et al*., 2004). Such assessment has also become a very sensitive issue owing to its increasing importance for subsidy entitlement.

Recent research on land use contributions to multifunctionality focuses more frequently on the farm unit and less frequently on the landscape unit, and rarely takes into account the complementarity of different farm types (Lardon *et al*., 2004). In addition, this research usually concentrates on the link between the farm productive function and a single non-productive function for the landscape concerned, with a methodology suited to this function, but ignores the varied interactions of non-productive components in the landscape. Evaluating the links between farm activities and landscape multifunctionality is thus currently a delicate and complex issue, requiring new tools, new references, and a new approach in agriculture (OCDE, 2001; Hervieu, 2002; INRA, CEMAGREF, CIRAD, 2002).

Accordingly, our present research objective was to develop a tool that takes into account and evaluates complementarities among different farms and multiple functions in a landscape entity marked by the diversity of farm land users, and of biotic and abiotic conditions (Rapey *et al*., 2004).

Because of our agronomic experience, we first centred our approach on the functions that are most directly linked to farm practices on land, such as environmental and productive functions. We chose a geo-agronomic viewpoint that considered the spatial pattern of farming practices in a landscape, and we were attentive to the location of the different farming areas and practices. Using references from the environmental sciences, we undertook an enlarged agronomic characterisation of the farming area with data on the ecological status of practices and environmental vulnerability of the land support. We tested this approach on a small landscape case study, and we propose a methodological framework for the qualitative assessment and comparison of agricultural contributions to landscape multifunctionality.

4.2 Framework of the data collection

Our principal working hypothesis was that the fulfilment of the environmental functions for a land unit depends on the 'patchwork' of farm practices and natural conditions in that land unit.

This hypothesis generalises the results shown for some of the most frequently studied functions (e.g. soil erosion and its link to the location of tilled fields in a river basin) to sets of environmental functions.

- our approach required a set of specifications for data collection and analysis in a landscape;
- identification and knowledge of the functions that depend locally on the farming activity;
- inclusion of all the farmers present in the land unit, irrespective of their economic role;
- full information on the farming practices on which the fulfilment of the functions depends; and
- consideration of the location of the practices in relation to their bio-physical conditions, and to the surroundings practices.

This approach was implemented in a first case study in a border zone of the French Massif Central. A small entity of 350 ha in the hilly part of a rural commune totalling 1,034 ha of utilised farm area was studied. It displayed a pronounced diversity of farming land uses and land users with mixed crop and livestock farming orientations.

4.2.1 Identification of the functions

This step required defining landscape functions and their links with farming activity. In the literature on multifunctionality, the basis of the function is either the expression of a specific social demand or the statement of a particular impact noted on landscape characteristics. Given our initial hypothesis and our agronomic viewpoint, we assume that a function exists when there is a relation between an expressed expectation of land users, whether farmers or non-farmers, and a spatial entity modified by farming practices. For example, when anglers' expectation of water quality in an area depends on the land cover and practices on the farm fields bordering the rivers in a landscape, then agriculture has a water quality preservation function (fulfilled to varying degrees).

To select the relevant functions for the landscape studied, we used two sources to extract expected effects of agriculture: documents on local environmental regulations for agriculture and the opinions of several members of the commune council. Two main functions emerged for our case study: the preservation of the quality of the surface water resources, and the preservation of the diversity of the mosaic land cover.

4.2.2 An enlarged definition of farmers concerned by the functions

An appraisal of the agriculture functions in a landscape requires to include in the analysis all the farms and fields present, irrespective of their productive or non-productive role. We take this position because some previous studies pointed out the significant impact of concentrations of small non-professional farms in parts of a landscape due to their specific practices and geographical location (Rapey *et al*., 2002). Hence we chose to enlarge the common definition of farmer and farming practice which is generally limited to a productive role (Laurent and Mouriaux, 1999).

In the landscape studied, the 25 farms surveyed, using 94% of their utilised farm area, comprised 54% full-time, 12% part-time, 16% retired, and 16% hobby farms (i.e. with no financial product), accounting for respectively 77%, 6%, 8%, 3% of the entire studied farming area. In a 'classical' approach to farming activity, these last two categories would not have been included, which would have ignored the contribution to landscape functions of 32% of the land users and 11% of the farming area.

4.2.3 Targeted information on farming practices conditioning the function fulfilment

First, this stage required identifying and detailing:
1. the farming practices; and
2. the spatial entity concerned by the functions, because of their potential role in the function fulfilment.

Some points emerged from a literature analysis of agri-environmental studies and measures:
1. types of practices in farm fields with potential effect on each function fulfilment; and
2. criteria and conditions concerning these farming practices that are relevant to their favourable or unfavourable impact on environmental components.

The different practices, criteria, and conditions actually observable in the study landscape were recorded and used as indicators of the ecological status of farm field practices. In this work stage, our objective was to construct tools essential for differentiating farming practices that made favourable or unfavourable contributions to each environmental function, rather than for the evaluation of function fulfilment.

In the study landscape with its functions, the significant practices identified concerned fertilisation and treatments, grazing and land maintenance. For the 'water' function, the selected indicators of the ecological status of practices in each farm field were the estimated annual surpluses of N and P_2O_5 according to the field apparent balance and the declared number of pesticide treatments at certified doses in a year; for the 'landscape' function, the indicators were the observed

FIGURE 4.1. Qualification, in the case of the 'water' function of 1) the favourable or unfavourable character of farming practices on environmental components, 2) environmental vulnerability, and 3) the field contribution to the function fulfilment.

1. Qualification of the ecological status of farming practices / field:
/ 'water' function

- High surplus of N apparent balance
- High surplus of P apparent balance
- High number of pesticide treatments at certified doses

→ 'Unfavourable' practices when at least one condition is fulfilled
→ 'Favourable' practices in other cases

X

2. Qualification of the environmental vulnerability / field:
/ 'water' function

- Proximity of rivers (< 35 m from a field border)

→ 'Unfavourable' bio-physical condition when the condition is fulfilled
→ 'Favourable' condition in other cases

3. Practices × Environment Conditions / field	**'Unfavourable environment'**	**'Favourable environment'**
'Unfavourable practices'	Unfavourable conditions ↘ Potential low contribution	Medium conditions ↘ Potential medium contribution
'Favourable practices'	Medium conditions ↘ Potential medium contribution	Favourable conditions ↘ Potential high contribution

Relevant example for the studied area / 'water' function	'Unfavourable environment'	'Favourable environment'
'Unfavourable practices'	Continuously grazed paddock in an alluvial plain	Continuously grazed paddock on a plateau
'Favourable practices'	Rotational grazing paddock unfertilised in an alluvial plain	Rotational grazing paddock unfertilised on a plateau

presence of bush and/ or tree edge in each plot and the degree of similarity of cover type to that of surrounding plots. After data collection, on each farm field in the landscape each indicator value set was inspected and a classification and frequency analysis of the values relative to an indicator were made. This differentiated the favourable or unfavourable status of practices for the function fulfilment and the landscape studied (Figures 4.1 and 4.2).

4.2.4 A specific view of farming practice location

To consider the interactions of the farm practices with the environmental conditions, information on the ecological status of practices must be combined with data on local environmental vulnerability. A literature analysis gave us:

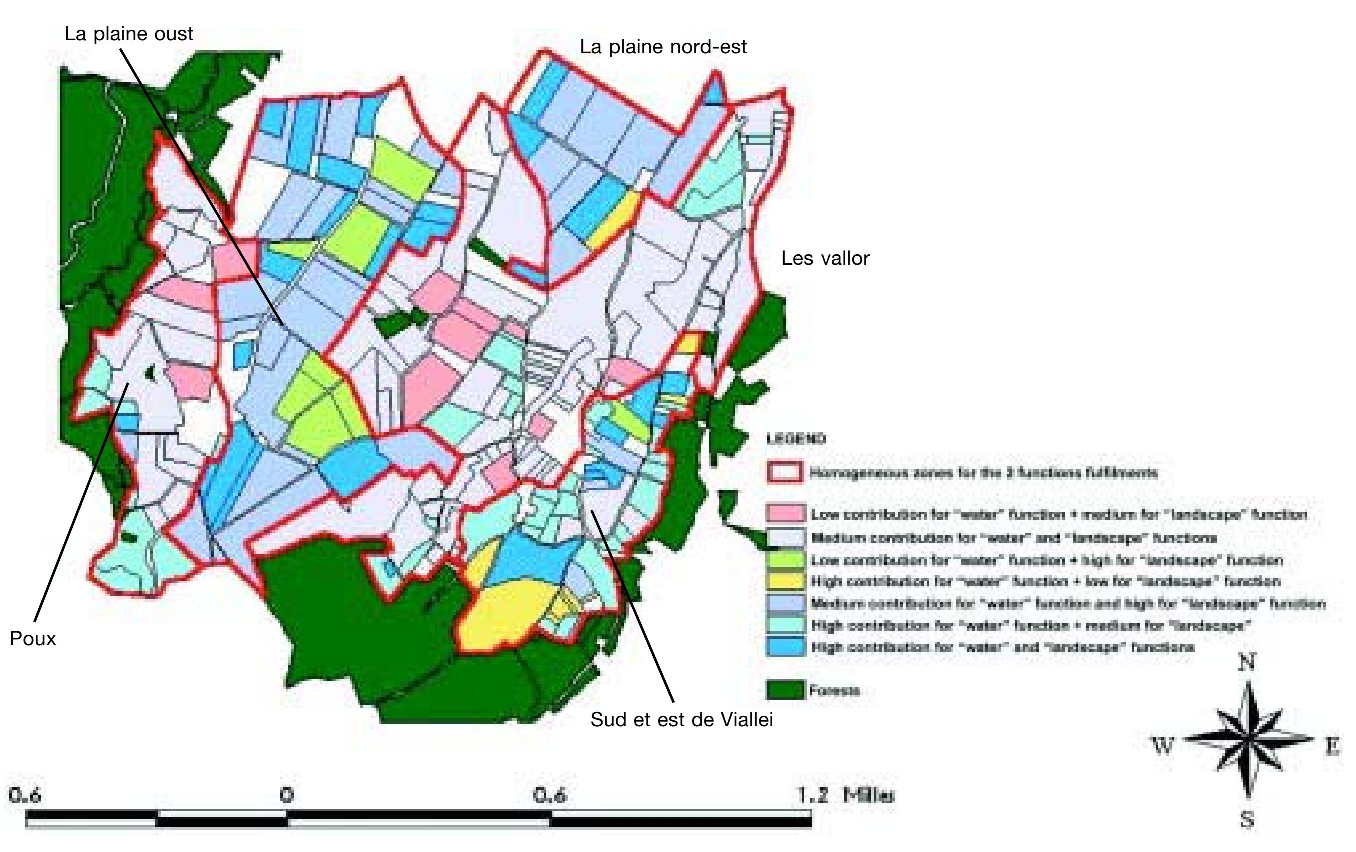
1. certain bio-physical conditions that are determining for the environmental function fulfilment; and
2. criteria and conditions concerning farms fields that are relevant to their environmental vulnerability. The actually observable and variable conditions in the studied landscape were recorded and used as the indicators of environmental vulnerability of farm fields.

As previously for the practices, the differentiation of the environmental vulnerability in all the farm fields in the landscape aimed to show the relative role of bio-physical conditions in the fulfilment of each environmental function, rather than to evaluate the function fulfilment.

On the landscape studied, the bio-physical condition for the 'water' function was proximity of a river to the field; for the 'landscape' function, the condition was the frequency of visibility from the highest points around the studied perimeter. All these indicators were estimated from GIS data bases and tools. After the estimation for each farm field in the landscape, the indicator value set was inspected. As previously done for practice characterisation, a classification and a frequency analysis of the values for each indicator was made to differentiate favourable and unfavourable bio-physical conditions for the function fulfilment in the landscape studied (Figures 4.1, 4.2).

Finally, the collected and used data in this approach to landscape functions covered a larger domain than the more usual field in the farm approach used by agronomists:

FIGURE 4.2. Map of the potential fields contributions to the two function fulfilments in the case of the 'water' and 'landscape' functions for the studied area.



- for the data sources: farms surveys, landscape maps and photographs, etc.;
- for the data: observed values and indicators;
- for the farming activities: full-time and part-time farmers, professional and hobby farmers, crops and livestock, etc.; and
- for the environmental characteristics: topography, hydrography, etc.

These data covered and allowed linkage within various spatial determinants of the function fulfilment.

4.3 Main results

Because of the limited extension of the study area and non-comparison with other landscapes, the findings emerging from the data analysis have no generic scope. Nevertheless, the various agricultural conditions inside the landscape enable us to make certain comparisons and discern certain linkages between function fulfilment and farms and to test the operability and utility of the methodological framework described above.

4.3.1 Inside the landscape; varied conditions for function fulfilment

The 350 ha of farming area studied presented a wide diversity of land-cover: 219 ha of grassland, 93 ha of arable land, 14 ha of fallow and bush, and 2 ha of garden and orchard spread over 240 farm plots. The land users varied in terms of farming labour force and capital invested in farming activity: full-time farmers with more than 100 ha of average total Utilised Area, part-time with about 20 ha of UA, retired with about 20 ha of UA, and hobby farmers with less than 5 ha of UA. Thus, the farming land uses and practices presented a complex pattern in the landscape studied.

After collecting and combining the environmental and practice characteristics of each field (Figure 4.1), we found that the conditions for the function fulfilment were highly varied in the landscape. However, it was possible to discern homogeneous parts of the landscape that formed new spatial and specific entities with similar contributions to the environmental functions (Figure 4.2).

There also appeared a complex mix of conditions for the function fulfilment within and between farms (Table 4.1). A large number of farms were included in the 'favourable' or 'medium' conditions for function fulfilment. In 'unfavourable' conditions, the number was lower. Hence, a large proportion of the farms made different contributions to the functions inside the limited study perimeter and inside their own farm area.

These findings suggest a hierarchy of areas and farmers in terms of aptitude to preserve or increase function fulfilment.

4.3.2 Farm groups with common characteristics in terms of contribution to functions

The conditions for the two function fulfilments in each farm present in the landscape showed some similarities, apparently correlated with common characteristics on farming activity and structure. The 'full-time' and 'part-time' farmers presented the widest-ranging conditions for the function fulfilment (respectively 7/7 and 6/7 of the configurations listed in Table 4.1), the 'retired' and 'hobby' farmers were less widely diversified in their conditions for the function fulfilment (respectively 5/7 and 3/7 of the configurations listed in Table 4.1). The qualities of the conditions were also different: 'retired' and 'hobby' farmers stood out with no unfavourable conditions for the 'water' function, and with favourable conditions for this function for a significant part of their area (> 1/3 of the UA); for the 'landscape' function, most of their used area presented favourable conditions. On closer examination, this high environmental 'performance' was seen to derive not only from extensive practices but from the close fit between the field practices and bio-physical conditions. At the landscape level, these favourable conditions for function fulfilment were not extensive, but were still important because of their relative extension over small sensitive parts of the landscape.

These first findings revealed links between the function fulfilments and the farm type: full-time farmers with a large extension and various locations of their fields ➔ varied conditions and contributions to the function fulfilments with irregular fit between the field practices and bio-physical conditions; retired and hobby farmers with a small extension and similar location of their fields ➔ similar conditions and contributions to the function fulfilments, with frequent fit between the field practices and bio-physical conditions.

Further close inspection of the differences between farms revealed another important factor concerning their potential impact on function fulfilment: recent changes in farm sizes and practices. As regards practices and farms a few years before the CAP 2000 changes (year of survey -8), the 'full-time' farmers contrasted with the others; they presented large changes in farm size (area and livestock) and practices. Concerning their former conditions for function fulfilment, 69% of their area underwent changes during the period 1994–2002, in contrast to the relative stability of the 'part-time', 'retired' and 'hobby' farmers (respectively 24%, 34%, 42% of their area changed during the period 1994–2002).

Thus, spatial and temporal variability were the characteristics of the 'full-time' farmers as regards their contribution to the environmental functions studied. This shows the need to survey full-time and non-full-time farmers specifically and differently to understand and act on function fulfilment in a landscape.

4.4 Discussion and conclusion

This partial approach to landscape multifunctionality, based on a geo-agronomic viewpoint, displays some major strengths and limits.

It proposes a first basis for a structured and operational approach to the characterisation and comparison of the agricultural contribution to landscape multifunctionality. Some improvements are necessary, in particular on the following points: identification of land user expectations conditioned by farming practices, definition and characterisation of the main conditions for the different function fulfilments, a method for combining multiple indicators for practices and bio-physical conditions, and reasoned methodological simplification to allow comparisons between many and larger landscapes.

This proposed approach reveals and can be used to appraise the role of the regulation of diverse practices and farm locations inside a landscape. This viewpoint also discerns and helps to understand how size, complementarities and changes in the different type of farms influences function fulfilment; in the case-study presented, the full-time farmers displayed a high variability in their practices and environmental conditions that induced a wide variability in their contributions to function fulfilment.

TABLE 4.1. Qualification of the global conditions for the 'water' and 'landscape' function fulfilment in all fields in the study area.

Field conditions for 'landscape' function fulfilment	Field conditions for 'water' function fulfilment	Area concerned (ha)	Number of farmers concerned
Favourable	Favourable	37	17
	Medium	75	11
	Unfavourable	17	4
Medium	Favourable	37	16
	Medium	128	20
	Unfavourable	19	5
Unfavourable	Favourable	12	6
	Medium	0	0
	Unfavourable	0	0

The next steps in our approach will be to transpose this framework to larger areas corresponding to administrative and political units of management in order to produce tools and references to support public policy decisions on agriculture and multifunctionality.

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