Ecological Indicators 85 (2018) 832–840

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Ecobordure: A flora-based indicator to assess vegetation patterns of field margins and infer its local drivers. Design in Brittany (France)

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ARTICLE INFO

Keywords:
Indicator
Vegetation
Field margin
Management practice
Agricultural adviser
Agroecology

ABSTRACT

Field margins are key landscape elements contributing to maintain biodiversity in agricultural landscapes. Yet, their ecological value is often poorly assessed and restricted to landscape descriptors, e.g. density or structure of hedgerows. We introduce Ecobordure, a flora-based indicator designed to describe vegetation patterns of field margins and infer on drivers leading to these patterns, i.e. structure and management practices of field margins. Ecobordure first targets agricultural teachers and advisers, who want to learn and help students and farmers to learn about patterns and drivers of field margin vegetation, for promoting management practices favorable to this biodiversity. Here, we present the stages of the Ecobordure design and output validation. The first stage consisted of elucidating the relationship between vegetation composition and structural and management characteristics of field margins. Canonical Correspondence Analyses were performed on empirical datasets derived from field work in bocage regions of Brittany (north-western France). This first stage led to the selection of 31 reference species, quite common, easy-to-recognize and representative of i) the whole community and ii) a wide range of ecological attributes. The 31 reference species were classified in three groups sharing similar life history traits and ecological attributes: "forest-edge", "grassland" and "weed" species. The second stage consisted of the graphical representation of field margins in a triplot diagram, the "Ecobordure triangle", according to the relative percentage of the three species groups. The representation of the Ecobordure triangle was then refined through segmentation in seven sectors to facilitate the reading and interpretation of results. Finally, the output validation of the indicator was performed by testing the consistency between Ecobordure outputs and structural and management characteristics of field margins, using an independent dataset. Our results demonstrate that Ecobordure is a simple, efficient and reliable indicator allowing users to characterize vegetation patterns of field margins and identify potential drivers leading to these patterns. In its original form, Ecobordure can be applied to a broad spectrum of field margins in European bocage regions with temperate oceanic climate, on acidic to neutral soil. However, its use can be extended to other agricultural regions through adaptation of the species list. We conclude by giving some information about Ecobordure use and appropriation by end users.

1. Introduction

Biodiversity in agricultural landscapes is associated with both semi-natural elements, e.g. woodland and hedgerows, and productive even intensively-managed elements such as crop and grassland fields (Fahrig et al., 2011). All these elements are interspersed in landscapes and inter-related by structural relationships, ecological processes and agricultural management decisions (Burel and Baudry, 1999). Therefore, segregating areas for conservation cannot be the only way to manage and maintain biodiversity in agricultural landscapes (Fisher et al., 2009). A more integrative approach is needed to understand the relationships between semi-natural elements and productive landscape elements and thus, to contribute to a more sustainable agriculture.

Among landscape elements, field margins are the narrow perennial, non-cropped strips bordering fields that differ from agriculture land by their ground structure (e.g. a bank) and/or their vegetation structure

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https://doi.org/10.1016/j.ecolind.2017.11.046
Received 30 May 2017; Received in revised form 27 October 2017; Accepted 21 November 2017
1470-160X/

(from herbaceous vegetation to bushes and trees or combinations) (Fig. A.1 in Supplementary material). They are important for maintaining biodiversity and associated ecosystem services (Kleijn and Verbeek, 2000; Olson and Wäckers, 2007). Field margins can benefit crop growth by serving as windbreak if planted with trees (Forman and Baudry, 1984), and by reducing soil erosion, floods and pesticide drift (Marshall and Moonen, 2002). Field margin vegetation can also provide resources and refugia for farmland wildlife (Meek et al., 2002). In the last decades, studies were conducted to elucidate drivers of vegetation patterns of field margins. They showed that field margin vegetation is related to environmental conditions, adjacent land use, landscape context and, management practices and their history (de Blois et al., 2002; Le Coeur et al., 2002; Marshall and Moonen, 2002; Alignier and Baudry, 2015). Despite the effort made to prioritize the drivers of vegetation dynamics (e.g. de Blois et al., 2002) and reduce their number in models (e.g. Schippers and Joenje, 2002), models still remain too complex for most agricultural professionals and other land managers.

Indicators are simple and operational tools that increase the ability of users to describe complex phenomena or systems (Girardin et al., 2000). They are key tools for assessing the effects of agricultural management on biodiversity and environment (van der Werf and Petit, 2002) in the perspective of agricultural sustainability. Frequently used indicators are based upon physical or landscape descriptors. Feld et al. (2009) pinpointed that efforts should be made for the development of indicators based upon biological (e.g. species richness) and functional (e.g. species traits) attributes. But, such indicators are generally based upon an exhaustive view of the identity of species in communities such as total species richness of plants, number of rare and/or endangered species (e.g. Alard et al., 1994; Matthews et al., 2009), information which is often laborious and time intensive to collect for non-expert users. To overcome these limitations, the development of simple indicators based upon biological attributes and enabling users to assess the complexity and multifaceted components of biodiversity remains an issue.

In agricultural landscapes, grasslands have received particular attention for the development of indicators (e.g. Alard et al., 1994; Pervanchon et al., 2002; Lewis et al., 2014). Indicators based on species composition or traits have been developed (Wittig et al., 2006) to infer their grazing regime (Höft et al., 2010), their ecological and agronomical values (Plantureux et al., 2010), and their fodder productivity (Duru et al., 2012). By comparison, other semi-natural habitats like field margins received far less attention.

In this paper, we present a flora-based indicator, Ecobordure ('Eco' for ecology and 'bordure' for field margin, in French) designed to describe vegetation patterns of field margin and to infer on local drivers leading to these patterns. By designing Ecobordure, we target agricultural teachers and advisers who seek for tools to increase awareness of agricultural students and farmers and help them to learn about biodiversity patterns and their drivers, i.e. management practices. Doing so, advisers work to increase farmers' ability to identify and develop management practices favorable to vegetation diversity of field margins. Ecobordure was built from a list of 31 reference species, easy-to-recognize and representative of the whole vegetation community encountered in field margins typical of bocage regions with oceanic climate and acidic soils. The suitability of Ecobordure as proxy of vegetation drivers of field margins was tested. In a standard scientific concern, the elaboration of the indicator has undergone a validation process at each stage of its development, i.e. design and output validation *sensu* Bockstaller and Girardin (2003). Finally, some information about the indicator use and appropriation by end-users is provided.

2. Material and methods

2.1. Rationale of Ecobordure

Ecobordure is an indicator empirically designed and validated to describe vegetation patterns of field margins in bocage regions, on acidic to neutral soil, with temperate oceanic climate. Ecobordure is based upon the presence of 31 reference herbaceous species classified into three complementary species groups, i.e. forest-edge, grassland and weed species. The choice to consider only the presence/absence of species was motivated by arguments of minimizing errors in the estimation of plant abundance between users and reducing the time costs of implementation. By this way, all Ecobordure users should find the same results. Each species group is made up of plants with similar life history traits and ecological attributes. The three groups provide distinct responses to structural (e.g. presence of trees on field margins) and management (e.g. crop rotation in the adjacent field, management intensity) drivers. Interpretation of Ecobordure outputs allows inference on the potential drivers leading to observed patterns. Fig. 1 presents the main stages of the Ecobordure design and validation.

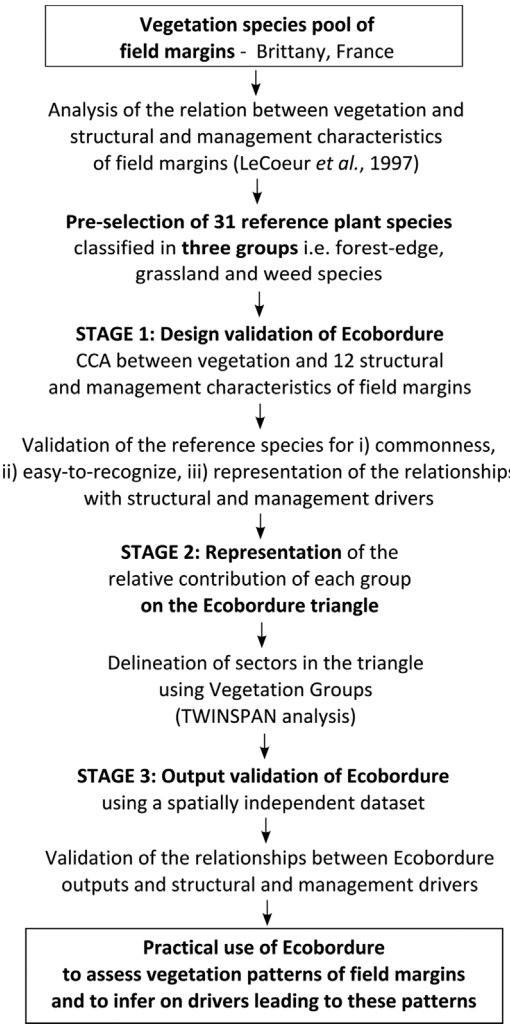

Fig. 1. Framework for the design and validation of Ecobordure.

2.2. Study area for the Ecobordure design

The fieldwork was conducted in Zone Atelier Armorique, a Long Term Ecological Research (LTER) site in northern Brittany, France (48°36′N, 1°32′W). The climate is temperate oceanic with close to 740 mm of annual precipitation. The bedrock is either granite (southern part of the study area) or shale with loam deposits of variable depth. The pH of soils ranges from 6 (on granite bedrock) to 7. The annual precipitation ranges from 700 to 800 mm to 800–900 mm for higher-lying areas on granite bedrock. The study area is located in a region