Plant Communities in Field Margins of Agricultural Landscapes: Species Distributions, Functional Traits, and Contributions to Landscape Function

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Abstract: The plant communities of field margins are an important aspect of agroecosystem ecology. A major research challenge is to link studies aiming to understand the determinants of species distribution and community assembly on the one hand and the consequences of resulting biodiversity patterns for ecosystem functioning on the other hand. The main aim of this study is to bridge this gap between species and communtiy distribution models and models of ecosystem function, by addressing the following research questions:
(1) What types of field margins can be identified in Korean agricultural landscapes, and how are they influenced by management? (2) How do local site conditions (margin width, margin management – cut/sprayed/natural, soil type, slope) and landscape context (composition, e.g., %non-crop area, %forest within several buffer distances, and configuration, i.e., spatial arrangement of landscape elements) affect plant communities and plant functional diversity? (3) Can species' traits and resulting functional diversity explain the observed distribution of species in the landscape? (4) How do plant communities, species diversity, and plant functional traits distribution relate to ecosystem services (e.g. food provisioning, reduction of local soil erosion, or soil carbon accumulation)?

Keywords: *field margins, biodiversity, plant functional traits, ecosystem services, community ecology, species distributions, erosion*

1. Introduction

Field margins are a key feature of agricultural landscapes, present in some form at the edges of all agricultural fields (Marshall, 1989). These margins can be separated technically into a number of elements as illustrated in Figure 1. The traditional roles played by field margins in farming systems have been reviewed by Marshall (1993, 1995). Hedges and walls were maintained to keep farm stock in or out. In arable land, field margins delineate the field edge and land ownership. Local topography, geology, land-ownership, and farming enterprises influenced the form of field boundaries, resulting in a diversity of agricultural landscapes. For example, land enclosures in England during the 18th and 19th centuries were accompanied by the planting of many hedges (Pollard et al., 1974). In modern times, agriculture has seen major changes, with intensification of production, developments in machinery, crop protection and the need for larger field sizes. Land re-allotment programmes, in which ownership has been rationalised, have also been implemented in many countries. These developments have been accompanied by changes in field boundaries, often with the removal of features illustrated in Figure 1.

However, a series of extremely important roles for field margins have been identified, reflecting agricultural, environmental, conservation, recreational, and cultural or historical interests. New approaches to creating and managing field margins have shown the importance of these functions. Udo de Haes (1995) and de Snoo (1995) summarize four major concerns involved in field margin management as shown in Table 1.
The effectiveness of field margins in contributing positively to landscape functions by reducing environmental impacts of human activities and providing the services indicated in Table 1 depends on biological community composition, i.e., the establishment, presence and resilience of organisms occupying these niches. The planned research focuses on understanding plant community dynamics at these important interface locations in an agricultural landscape of South Korea. Traditionally, much research on field margins has been conducted in Europe; the role of field margins in other ecosystems, like South Korean agricultural landscapes characterized by monsoon-rainfalls, are comparatively less studied.

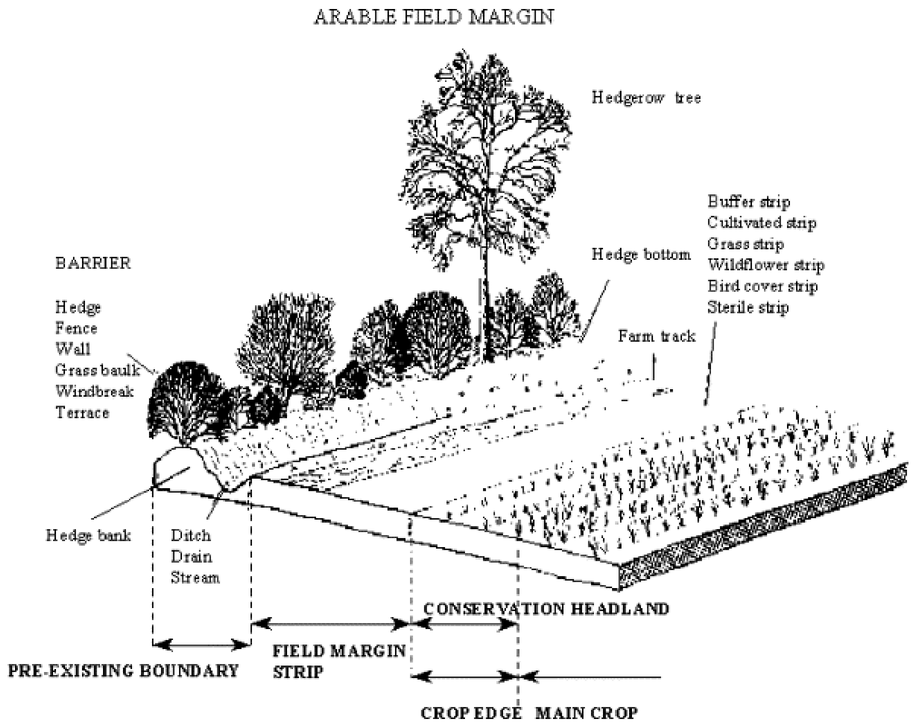

Figure 1. Principal elements of a field margin (after Greaves and Marshall, 1987)

Table 1. Major functions of field margins in agricultural landscapes

Function	Role
Agronomy and animal husbandry	Define land ownership, provide stock fencing and shelter, provide windbreak for crops, enhance pollination, provide wood and wild game
Environmental	Control transport of pesticides, herbicides and nutrients; prevent erosion and siltation, influence snow and water distribution
Nature conservation	Provide species refugia, complement biodiversity by providing habitat, feeding and breeding locations, and movement corridors
Recreation and rural development	Provide field access, and areas for walking, driving, hunting; promote tourism via aesthetics, maintain culture and heritage

1.1 Biodiversity in Field Margins

Global change and its consequences present one of the most important threats to biological diversity and the functions of ecosystems (Wilson 1985, MEA 2010). Faced with this problem, it is highly desirable to develop effective conservation strategies that maximize the contribution of managed areas (Westman 1990). In agricultural landscapes, this includes the refugia of field margins.

Conservation strategies have largely focused on patterns of diversity, specifically how to maximize the number of species that can be protected or maintained within a particular geographic region. The criteria for identifying areas of highest conservation value is wide-ranging and includes high species richness (Ricketts et al., 1999), endemism (Meyers et al., 2000; Hobohm, 2003), rarity (Prendergast et al., 1993), endangerment (Dobson et al., 1997), unique phylogenies (Mace et al., 2003) and evolutionary histories (Sechrest et al., 2002), and degree of threat (Wilcove et al., 1998; Abbitt et al., 2000). A high diversity within the plant community of an ecosystem is considered an important indicator of the overall quality of that system for biological conservation (Soulé 1986; Primack 1998). The proposed research will bring these biodiversity perspectives together with an understanding of the distribution of plant growth forms in field margin communities. Thus, it is intended to quantify landscape biodiversity components in field margins, but also to begin relating this diversity to functional traits of the field margins that may influence the important functions described in Table 1.

1.2 Plant Functional Traits

The high diversity of species makes a functional analysis of the importance of individual species challenging. The concept of plant functional traits promises to be a powerful approach in this context (Wellstein et al. in press). 'Plant functional trait' is a currently widely used expression in plant ecology (Díaz and Cabido 2001, Lavorel and Garnier 2002, Hooper et al. 2005), but its actual meaning still varies among authors. A plant functional trait is generally defined as any morphological, physiological or phenological feature measured at the individual level that impacts fitness (Violle et al. 2007). It may be understood as a surrogate of a function (e.g. specific leaf area) or as this function itself (e.g. photosynthesis), with the difficulty to agree on the actual meaning of function (Calow 1987, Jax 2005). It may also be considered as a trait that strongly influences organismal performance (McGill et al. 2006) and/or individual fitness (Geber and Griffen 2003, Reich et al. 2003). Finally, it may be defined with respect to ecosystem functioning (McIntyre et al. 1999): this is the case of functional effect traits, defined as those traits that have an impact on ecosystem functioning (Díaz and Cabido 2001, Lavorel and Garnier 2002). Plant functional traits promise to allow for a process-based understanding plant community patterns at a manageable level of complexity. They provide a link between organism-centred and matter-flux-oriented perspectives on ecosystem ecology.

1.3 Aims and Research Questions

The proposed research is designed to understand how particular plant communities develop at field margins; where and how individual elements of these communities spread and become established. The main aim of the study is to further our understanding of the processes governing plant community structure and resulting functioning in agricultural field margins. The research is structured by the following research questions:

- What types of field margins can be identified, and how are they influenced by management?
- How do local site conditions (margin width, margin management – cut/sprayed/natural, soil type, slope) and landscape context (composition, e.g. %non-crop area, %forest within several buffer distances, and configuration, i.e. spatial arrangement of landscape elements) affect plant communities and plant species' diversity?
- Can species' traits explain the observed distribution of species in the landscape? At what spatial scales are these community and trait patterns best predictable?
- How do plant communities, species diversity, and plant functional traits distribution relate to ecosystem services (e.g. food provisioning, reduction of local soil erosion, or soil carbon accumulation)?
- What management guidelines can be derived in order to preserve and possibly enhance the ecosystem services provided by the plant communities in the field margins?

This planned research focuses on describing naturally occurring plant communities of the field margins in the agricultural landscape of Haean Catchment in S. Korea. It will build on and expand research by Kang et al. (2011). The study is well integrated within the TERRECO project. TERRECO provides an outstanding interdisciplinary environment for linking biodiversity-oriented studies with matter-flux oriented studies of ecosystem functioning.

2. Material and Methods

2.1 Study Area

The main site for initial field studies is the Haean-myun catchment which is located in the Soyang Lake watershed adjacent to the Demilitarized Zone and east of Seoul in Central Korea (38°14' to 38°15' E; 128°09' to 128°10' N) (Fig. 3). Elevation varies from ca. 500 to 750 m a.s.l. The annual precipitation of the study area is 1250 mm and the annual temperature is 6 °C.

2.2 Field Margins Survey

In a first step, a botanical survey for the field margins of Haean-myun area was conducted, covering one hundred sampling sites, covering the whole catchment (Figure 2). Each site was sampled in three plots, each plot was 1 m^2 in size, and plots were spaced 4 m apart. In each plot, the cover percentage of species was estimated, and plant height, plot exposure and slope were measured.

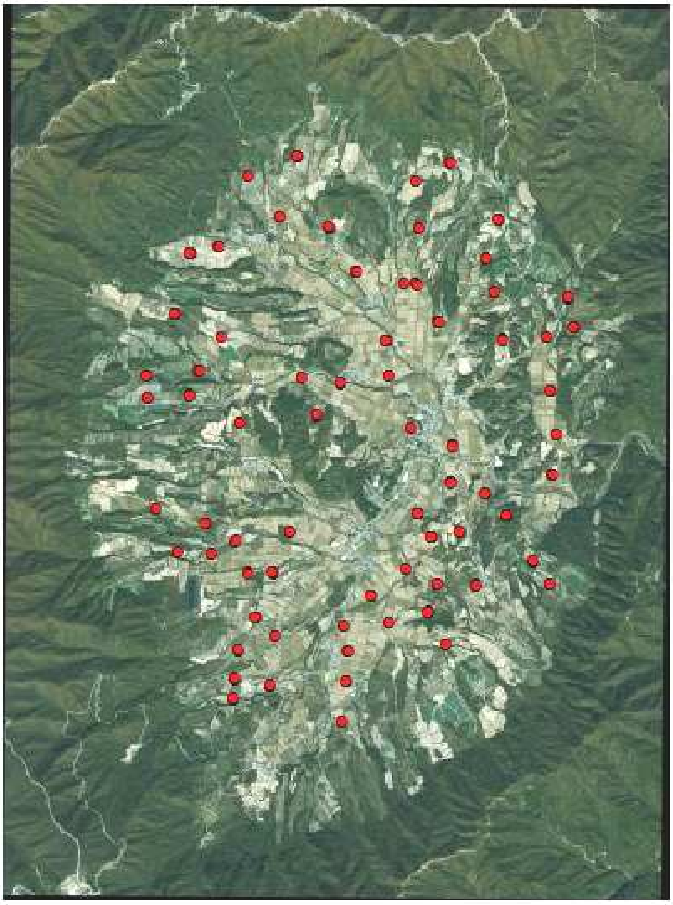

Figure 2: Initial set of sampling sites for plant communities in Haean catchment. In total, 100 sites were sampled.

2.3 Species Distribution Modelling

Species distribution models (SDMs) estimate species responses to environmental gradients, and are used to make spatial predictions of habitat suitability or probability of species occurrence (Franklin 1995; Scott et al. 2002; Guisan et al. 2006). While the ecological underpinning of SDMs is the species–environment relationship, the models are developed using data on the actual distribution of species occurrences, which often reflect the combined influences of multiple interacting biotic and abiotic factors (Pausas 1999; Pausas & Lavorel 2003; Pausas et al. 2004). In this project, species distribution models will be used to identify environmental determinants of the species' distribution, to spatially interpolate the distributions and to assess the consequences of local and landscape scale environmental change.

2.4 Plant Functional Traits

A suitable set of functional traits reflecting response and effect traits will be selected and quantified for common plant species. We will consider intraspecific variation in trait values for a selected subset of species and traits. The set of species and traits will be defined after an initial field survey. Plant traits will be obtained from the literature and databases (PLANTS Database http://plants.usda.gov/, the Global Biodiversity Information Facilities, www.data.gbif.org), and complemented by field measurements.

2.5 Field Experiments

In order to evaluate the ecosystem services provided by the field margin community, experiments will be conducted. We envision to focus on ecosystem services that are particularly salient in Haean, i.e. soil erosion control and soil carbon accumulation. Design decisions will be made using experience from the first phase of TERRECO.

3. Outlook

The plant communities of field margins are an important aspect of agroecosystem ecology. A major research challenge is to link studies aiming to understand the determinants of species distribution on the one hand and the consequences of biodiversity patterns for ecosystem functioning on the other hand. The TERRECO project with its wide interdisciplinary and process-oriented setup offers an outstanding opportunity for addressing this research challenge.

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