Applied Soil Ecology 47 (2011) 119–132

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Soil macrofauna in agricultural landscapes dominated by the Quesungual Slash-and-Mulch Agroforestry System, western Honduras

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ARTICLE INFO

Article history:
Received 24 June 2010
Received in revised form 3 November 2010
Accepted 4 November 2010

Keywords:
Soil macrofauna
Soil ecology
Smallholder agriculture
Land use change
Quesungual Slash-and-Mulch Agroforestry System
Central America

ABSTRACT

Smallholder agroforestry systems often incorporate features that are associated with abundant, diverse soil macrofauna populations. This study sampled soil macrofauna communities across four major land uses present within agricultural landscapes where the Quesungual Slash-and-Mulch Agroforestry System (QSMAS) has been increasingly adopted by smallholder farmers in western Honduras. The four land uses were: secondary forest (*F*), agroforestry plots of less than two years of age (AF < 2), agroforestry plots of more than 10 years of age (AF > 10), and silvipastoral fields (SP). Transect-based sampling of soil macrofauna using the standard Tropical Soil Biology and Fertility Institute (TSBF) method was employed in both the dry season and wet season. All four land uses sampled in this study harboured diverse, abundant and highly variable soil macrofauna populations. In the dry season, total density of soil macrofauna ranged from 1265 ± 308 individuals m^{-2} in *F* sites to 1924 ± 436 individuals m^{-2} in AF < 2 sites. In the wet season, total density ranged from 907 ± 294 individuals m^{-2} in *F*, to 1637 ± 358 individuals m^{-2} in AF < 2. Biomass values followed a similar pattern, ranging from 4.3 ± 1.1 g m^{-2} to 24.8 ± 8.2 g m^{-2} in the dry season and from 13.1 ± 3.0 g m^{-2} to 41.9 ± 11.1 g m^{-2} in the wet season. In order of decreasing strength of statistical relationship, soil depth, land use and season were all related to some aspects of soil macrofauna density, biomass and community composition. At a broad functional group level, soil macrofauna community composition was very similar across all four land uses. The results suggest that the agricultural practices associated with the 'Quesungual' agroforestry system may promote a relatively abundant, diverse soil macrofauna community. The presence of an abundant soil macrofauna community may have important effects on aspects of soil quality that are particularly important to resource-limited smallholder farmers.

1. Introduction

Land use can exert a strong influence on the overall abundance, biomass, diversity and community composition of soil macrofauna (Lavelle and Pashanasi, 1989; Giller et al., 1997; Barros et al., 2002; Barrios et al., 2005). Soil macrofauna have long been recognised for their influence on soil physical, chemical and biological properties and processes (Lobry de Bruyn and Conacher, 1990; Lee and Foster, 1991; Lavelle et al., 1997; Six et al., 2004; Barrios, 2007). The influence of soil macrofauna on soil properties may be particularly important for resource-limited smallholder farmers, who depend on the biological productivity of the soil for their livelihoods (Swift et al., 1994; Giller et al., 1997). However, relatively few of the comparative studies of the effects of different land uses on soil macrofauna abundance have included smallholder or traditional agriculture.

Several agricultural practices that appear to be associated with abundant, diverse soil macrofauna communities, many of which are incorporated within smallholder agricultural systems. These include: the presence of continuous soil cover (Loranger et al., 1998; Vohland and Schroth, 1999; Barros et al., 2003); the addition of high quality mulch (Tian et al., 1993, 1997; Wardle et al., 2006); the inclusion of structurally and taxonomically diverse vegetation within fields (Roth et al., 1994; Perfecto and Snelling, 1995; Bestelmeyer and Wiens, 1996; Birang, 2004; Pauli et al., 2010); and the presence of a mosaic of habitat types in the surrounding area (Lavelle and Pashanasi, 1989; Dangerfield, 1990; Thomas et al., 2004). Conversely, tillage disrupts termites and earthworms, and burning leads to drastic reductions in species density over the

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0929-1393/$ – see front matter
doi:10.1016/j.apsoil.2010.11.005

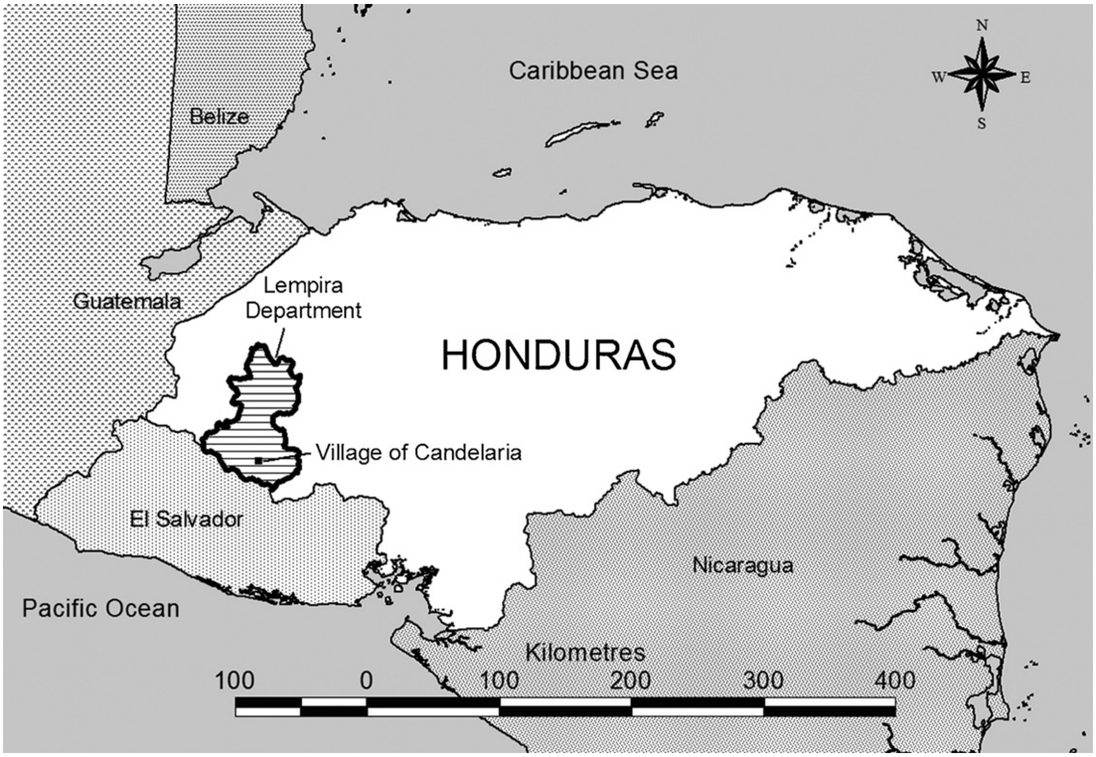

Fig. 1. Location of study area. Study sites were selected from the region surrounding the village of Candelaria in Lempira Department, Honduras.

short term (Critchley et al., 1979; Bhadauria and Ramakrishnan, 1989; Black and Okwakol, 1997; Netuzhilin et al., 1999; Rossi et al., 2010).

A number of long-term monitoring and 'chronosequence' studies indicate that the composition and abundance of soil macrofauna in agricultural fields can change considerably with increasing time under cultivation. Following initial disturbance, soil macrofauna density may decline initially and then increase (Decaëns et al., 1994, 2002; Netuzhilin et al., 1999; Barros et al., 2004), or exhibit variable patterns, such as peaks and troughs in abundance (Bhadauria and Ramakrishnan, 1989; Okwakol, 1994; Sileshi and Mafongoya, 2006a). Many traditional smallholder agricultural systems are based on rotation of plots between native vegetation, cropping and fallowing, so it is likely that the soil macrofauna communities in these systems are dynamic, responding to changes in management, vegetation and soil organic matter input. Because soil macrofauna communities are likely to be dynamic, it is important to sample across seasons and at different successional stages of agricultural use.

The Quesungual Slash-and-Mulch Agroforestry System (also referred to as QSMAS) from western Honduras (Welchez et al., 2008) was used as the case study in this research because it incorporates many features that should promote abundant, diverse soil macrofauna populations, which should in turn improve soil quality for smallholder farmers. The name 'Quesungual' comes from the name of the village where this agroforestry system was first identified (Hellin et al., 1999). The agroforestry system comprises a suite of land management practices used by resource-poor smallholder farmers. It is notable not only for its heterogeneity and incorporation of high levels of plant diversity, but also for the fact that it represents a transition from traditional slash-and-burn agriculture to a reportedly more sustainable method of slash-and-mulch agroforestry (Welchez et al., 2008). The study area has suffered from land degradation and related issues of food insecurity and poverty in the past (Pender, 2001; Ruben and Clercx, 2003; Ordoñez Barragan, 2004; Ayarza et al., 2005). Today, the apparent success of the new system in improving farmers' standard of living while at the same time increasing vegetation cover and diversity (Hellin et al., 1999; Ayarza et al., 2005) allows for the examination of relationships between above- and below-ground biodiversity in the context of land management practices.

The overall aim of the study was to explore the associations of land use, season and soil depth with soil macrofauna density, biomass and community composition across four land uses found within an agricultural landscape dominated by the Quesungual agroforestry system, including secondary forest, agroforestry plots of two distinct ages, and silvipasture plots. The first objective of the study was to test the assumption that the land uses represent a gradient of change in tree density, vegetation diversity and soil organic carbon content. The second objective was to compare soil macrofauna biomass and abundance among different land uses. The third objective was to characterise seasonal distribution patterns of soil macrofauna abundance and biomass in both the dry and wet season. The fourth objective was to investigate the vertical distribution of soil macrofauna biomass and abundance within the soil pedon. The final objective was to assess changes in soil macrofauna community composition according to land use, season and soil sampling depth. Prior to this study, no systematic information had been collected on the soil macrofauna of the study area.

2. Materials and methods

2.1. Study area and study sites

The study area was located in the zone surrounding the village of Candelaria, in the southern region of Lempira Department in southwestern Honduras (Fig. 1). The climate of the study area is classified as equatorial winter dry (Aw) according to the Köppen–Geiger classification (Kottek et al., 2006). Annual rainfall, which falls primarily between May and October, averages 1200–1400 mm (Cherrett, 1999). Average daily temperatures range between 17 and 25 °C (Hellin et al., 1999). The study area falls within the Central