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# Land sharing vs. land sparing in the dry Caribbean lowlands: A dung beetles' perspective

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ABSTRACT

Extensive cattle ranching is considered to be one of the major causes of environmental degradation particularly in tropical dry forest, one of the most threatened ecosystems worldwide. The transformation of extensive treeless pastures into intensive silvopastoral systems combining pastures, fodder shrubs, and trees has been promoted to rehabilitate degraded lands. This study was conducted to explore the influence of transforming extensive treeless cattle ranches into intensive silvopastoral systems and how this alters dung beetle diversity in a tropical dry forest located at Cesar river valley, Colombia. The study took place in three livestock farms, dung beetles were collected with baited pitfall traps in three land uses: forest, intensive silvopastoral systems and treeless pasture. A total of 5349 beetles belonging to 17 genera and 32 species, were collected. Forests had the highest species richness and abundance values, followed by intensive silvopastoral systems. The latter contained 61% of the native forest species and supported 36% more diversity than treeless pastures. Differences in diversity and composition were related mainly to canopy cover and soil cover. Conserving remaining dry forest fragments is crucial for preserving typical dry forest dung beetle assemblages in this region. Intensive silvopastoral systems complement the role of forests as reservoirs of biodiversity and contribute to the landscape-scale conservation of dung beetles. In this particular landscape and at the spatial scale that is relevant for dung beetles, intensive silvopastoral systems provide the benefits of both land sparing and land sharing.


## 1. Introduction

The expansion of agriculture and livestock production has accelerated the loss of natural habitats and biodiversity, with negative effects on the ecological functions and ecosystem services provided by rural landscapes (Perfecto and Vandermeer, 2008). Much of the debate on how to harmonize food production with biodiversity conservation has focused on two opposing strategies known as land sharing and land sparing (Calle et al., 2014; Fischer et al., 2008; Phalan et al., 2011; Tscharntke et al., 2012). The former proposes that production and conservation should be integrated in complex multifunctional landscapes that include wildlife friendly habitats, while the latter suggests that productive activities be intensified in land areas separated from conservation (Calle et al., 2014; Gilroy et al., 2014; Perfecto and Vandermeer, 2008; Tscharntke et al., 2012).

Although both strategies could play complementary roles in managing biodiversity at the landscape scale (Fischer et al., 2008; Perfecto and Vandermeer, 2008; Tscharntke et al., 2012), much of the literature has treated them as contrary options (Calle et al., 2014; Kremen 2015) and very few researchers have addressed the question of which strategy might be the most appropriate in a specific context (Chandler et al., 2013; Edwards et al., 2010; Gilroy et al., 2014; Hulme et al., 2013; Phalan et al., 2011) or how both could be complemented. However, some researchers believe that certain agricultural practices can contribute simultaneously to the objectives of intensive production and conservation (Calle et al., 2014; Francesconi and Montagnini, 2014; Perfecto and Vandermeer, 2008; Tscharntke et al., 2012). If so, the benefits of land sharing could be combined with those of land sparing. This could be the case of certain agroforestry systems, which integrate agriculture and forestry to achieve higher yields, more sustainable land use, conservation of natural ecosystems, landscape connectivity and biodiversity conservation (Francesconi and Montagnini, 2014).

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In the Americas, the Tropical Dry Forest biome has been the subject of intense deforestation for the establishment of farmland and livestock production (Portillo-Quintero and Sánchez-Azofeifa, 2010). Although the original distribution of this ecosystem in Colombia is unknown, it is estimated that less than only 1.5% of the original cover remains (Etter, 1993; Pizano et al., 2014). In the Cesar river valley, located in the Colombian Caribbean region, the expansion of intensive cotton monoculture in the 60s caused the destruction and fragmentation of tropical dry forests, together with the physical degradation and loss of the productive capacity of soils and the contamination of water sources (UNCCD, 2007). In the 90s extensive cattle ranching systems expanded throughout this landscape. The dominant model of grazing was based on improved pastures such as star grass *Cynodon plectostachyus*, with little or no tree cover, hereafter referred to as treeless pastures. Since then, livestock in the region has compounded the problems of erosion, habitat fragmentation, destruction of water resources, and as a result it is estimated that 27% of the lands are in process of desertification (UNCCD, 2007).

Since 2005, Intensive Silvopastoral Systems have been established successfully in the dry Caribbean region of Colombia with rapid and positive impacts on meat and milk yields, water regulation, greenhouse gas balance and a microclimate that enhances animal welfare (Calle et al., 2012, 2013; Murgueitio et al., 2011). Intensive silvopastoral systems are agroforestry systems for beef and milk production that combine various types of grasses, herbaceous legumes, fodder shrubs, timber and fruit trees and native palms, which together make up a layered grazing system with high plant diversity (Calle et al., 2012; Murgueitio et al., 2011). These ISS could contribute to ecological rehabilitation at a landscape scale. However, to optimize the management of the agricultural landscape and maximize the success of restoration at the regional level, it is necessary to characterize the reference ecosystem, understand how much diversity and functionality exists in the remaining forest fragments and determine to what extent this diversity can be recovered through restoration (SER, 2004).

The sustainable management of livestock requires understanding the role that intensive silvopastoral systems can play in landscape scale restoration and in particular, how intensive silvopastoral systems contribute to the maintenance of dung beetle populations in agricultural landscapes. Dung beetle populations are dependent on vegetation cover (Halffter and Matthews, 1966), require special shelter and nesting sites (Halffter and Edmonds, 1982), and are highly sensitive to the chemical inputs used in conventional livestock production (Lumaret and Martínez, 2005). In this context, dung beetles (Scarabaeinae) are adequate biological indicators of the health of the livestock landscape due to their importance for the dynamics and functioning of the production system (Nichols et al., 2008). They are responsible for soil environmental services such as removal and relocation of cow manure (bioturbation), incorporation of organic matter into the soil and the control of bloodsucking flies and gastrointestinal parasites (Giraldo et al., 2010; Nichols et al., 2008).

This study was aimed at understanding how the productive transformation of extensive treeless cattle ranches into intensive silvopastoral systems influences the diversity of dung beetles in the dry forest region of the Cesar river valley, Colombia. Do intensive silvopastoral systems contribute to the conservation of native beetles within livestock systems by providing complementary habitats? In addition, it sought to understand whether the strategy proposed for the rehabilitation of cattle farmlands in the Cesar river valley may offer an alternative to the land sharing vs.

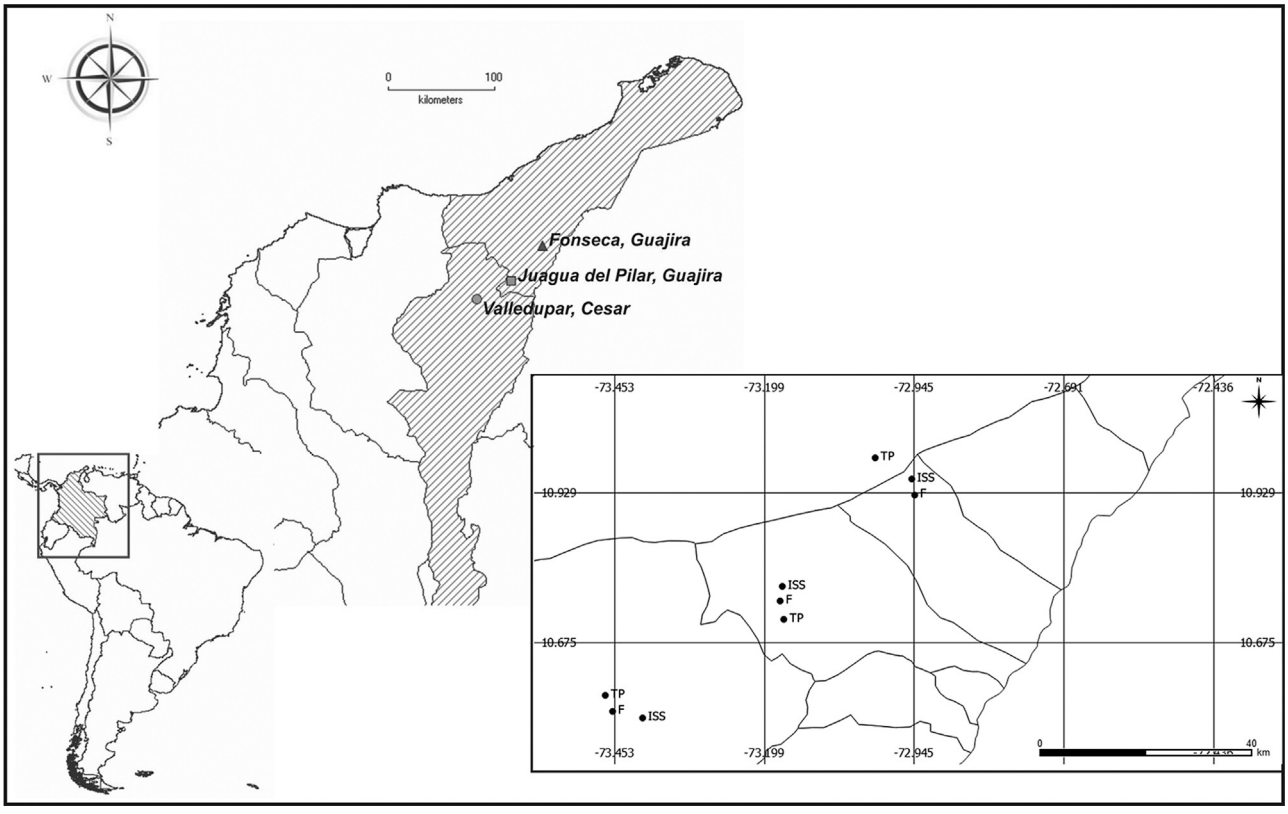


**Fig. 1.** Study area and location of sampling sites in the Cesar river valley (Colombia). Land use systems: F: forest; ISS: intensive silvopastoral system and TP: treeless pasture.