Agriculture, Ecosystems and Environment 189 (2014) 154–163

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

The role of coffee agroforestry in the conservation of tree diversity and community composition of native forests in a Biosphere Reserve

Vivian Valencia[a,*], Luis García-Barrios[b], Paige West[c], Eleanor J. Sterling[d], Shahid Naeem[a]

[a] Department of Ecology, Evolution, and Environmental Biology, Columbia University, New York, NY 10027, USA
[b] El Colegio de la Frontera Sur, Apartado Postal 63, San Cristóbal de las Casas, Chiapas 29200, Mexico
[c] Department of Anthropology, Barnard College, Columbia University, New York, NY 10027, USA
[d] Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, USA

ARTICLE INFO

Article history:
Received 23 November 2013
Received in revised form 27 February 2014
Accepted 7 March 2014
Available online 16 April 2014

Keywords:
Coffee
Agroforestry
Agroecology
Tree biodiversity
Conservation

ABSTRACT

Agroforestry is considered a promising alternative to conventional agriculture that can both conserve biodiversity and support local livelihoods. Coffee agroforestry may be particularly important for sustaining trees of conservation concern and late-successional stage, but this possibility remains unclear. Here, we examined whether coffee agroforestry systems can serve as conservation reservoirs of tree species native to nearby forests. We compared tree diversity, composition and structure between coffee agroforests and forests in La Sepultura Biosphere Reserve in Chiapas, Mexico. We found that, although at the landscape level the full set of coffee agroforests appears to conserve comparable tree species richness to nearby native forests, the species composition that is being conserved is different. Coffee agroforests had a lower proportion of trees of conservation concern, a higher proportion of pioneer trees, were dominated by *Inga* spp., harbored lower tree species diversity at the plot level, and were composed of different tree species compared to native forests. We suggest that conservation practitioners and policy makers seeking to promote coffee agroforestry as a conservation strategy should consider how such agroforestry systems differ in species diversity and composition from the native forests of conservation interest. Further, promoting different coffee agroforest management strategies, such as discouraging the replacement of diverse agroforest canopies with *Inga*-dominated canopies, would help improve the conservation value of coffee agroforests through more sustainable practices.

1. Introduction

Agroforestry systems, where crops such as coffee and cacao are grown under the canopy of shade trees, are considered a promising alternative to conventional agriculture in that, in addition to supporting local livelihoods in rural and remote areas, they may also serve to conserve biodiversity (Ashley et al., 2006; Bhagwat et al., 2008; Harvey et al., 2008; Perfecto and Vandermeer, 2008; Perfecto et al., 2007; Schroth et al., 2004). Research has shown that shade coffee agroforestry improves the quality of the landscape matrix and plays an important role as a buffer zone around protected areas and forest patches (Perfecto and Vandermeer, 2002; Perfecto et al., 1996). Studies in the last 20 years have documented the importance of shade coffee as habitat for arthropods (Mas and Dietsch, 2004, 2003; Perfecto and Snelling, 1995; Pineda et al., 2005), birds (Dietsch et al., 2007; Florian et al., 2008; Greenberg et al., 1997; Hernandez et al., 2013; Tejeda-Cruz and Sutherland, 2004), amphibians (Murrieta-Galindo et al., 2013; Rathod and Rathod, 2013), and mammals (Cruz-Lara et al., 2004; Gallina et al., 1996; Williams-Guillen and Perfecto, 2011; Williams-Guillen et al., 2006) outside of protected areas, in otherwise highly human-dominated landscapes (Bhagwat et al., 2008; McNeely and Schroth, 2006; Schroth and Harvey, 2007; Schroth et al., 2004).

Coffee growing areas fall largely within regions considered biodiversity rich (Myers et al., 2000). Thus, although the area devoted to coffee cultivation on a global scale is relatively small, the impact of coffee cultivation on biodiversity is disproportionately large (Donald, 2004). Economically, coffee represents a source of vital income for 25 million farmers around the world, mostly smallholders (Donald, 2004; West, 2012) and it is the second most traded commodity after crude oil (O'Brien and Kinnaird, 2003). Economic incentives may be promoting the expansion of shade coffee into forests that are too remote or steep to be converted profitably to other forms of agriculture (Ambinakudige and Choi, 2009; Rappole

* Corresponding author at: Department of Ecology, Evolution, and Environmental Biology, Columbia University, 1200 Amsterdam Avenue, New York, NY 10027, USA. Tel.: +1 786 510 0714; fax: +1 212 854 8188.
E-mail address: vv2188@columbia.edu (V. Valencia).

http://dx.doi.org/10.1016/j.agee.2014.03.024
0167-8809/

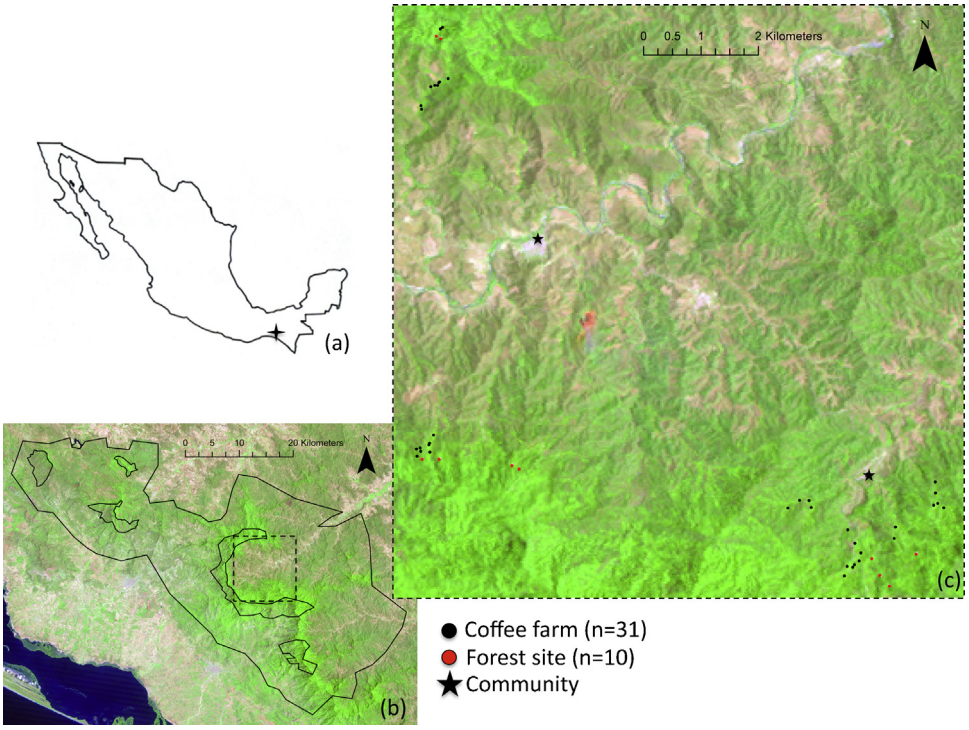

Fig. 1. (A) Map of Mexico showing the location of La Sepultura Biosphere Reserve. (B) Map of the reserve; inner polygons delimit core area and dotted square corresponds to study area. (C) Enlargement of study area that shows the distribution of coffee farms (black dots), forest sites (red dots), and the two communities (stars). Maps B and C were created using data from a Landsat satellite. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

et al., 2003; Silva Rivera, 2006; Tejeda-Cruz et al., 2010). In addition, conservation organizations have been actively promoting shade coffee as conservation strategy compatible with local livelihoods (Conservation International, 2001; Philpott and Dietsch, 2003).

Although coffee agroforests harbor high species richness for most taxa examined, it is strongly debated whether species community composition is similar to that of nearby forests (Philpott and Dietsch, 2003; Rappole et al., 2003). Because different species exhibit different levels of susceptibility to disturbances, agroforests may lose rare, specialist, endemic, and mature-forest species (García-Fernández et al., 2003; O'Dea and Whittaker, 2007; Scales and Marsden, 2008; Tejeda-Cruz and Sutherland, 2004). While coffee agroforestry systems have been found to harbor levels of tree species richness similar to surrounding native forests (Bandeira et al., 2005; López-Gómez et al., 2008) and higher levels of tree diversity in the more "traditionally" managed systems (López-Gómez et al., 2008; Méndez et al., 2007; Moguel and Toledo, 1999; Philpott et al., 2007, 2008; Reynoso, 2004), studies have not examined tree relative abundance and composition which are susceptible to change. Thus, though farmers commonly retain adult trees of many native species when the understories of forests are planted with coffee, it is unclear to what extent coffee agroforests may, in the long run, conserve tree species found in native forests, including late-successional species and those considered of conservation concern.

In order to successfully incorporate coffee agroforestry into conservation strategies, it is important to understand the extent to which agroforests may be a suitable permanent habitat for mature forest-dwelling species. The current study examined the role of coffee agroforests in conserving tree diversity and community composition found in nearby native forests in La Sepultura Biosphere Reserve in Chiapas, Mexico. The objectives are to characterize and compare coffee agroforests and forests in terms of (1) floristic richness and vegetative structure, (2) tree community composition, (3) composition by traits of succession, and (4) the presence and abundance of tree species of conservation concern.

2. Methods

2.1. Study site

This study was conducted in two *ejido* communities in La Sepultura Biosphere Reserve (SBR) in Chiapas, Mexico (167,309 ha; 16°00′18″–16°29′01″ N and 93°24′34″–94°07′35″ W; Fig. 1). Topographic and edaphic conditions give rise to multiple ecosystems such as evergreen pine forest, evergreen forest, mesophyte mountain forest, low deciduous tropical forest, medium semievergreen and semideciduous tropical forest, foggy chaparral and savannas (INE, 1999). In the area encompassing sampled coffee agroforests and forests, annual rainfall varies between 2000 and 2500 mm, rainy season lasts from May through October, and mean annual temperature fluctuates between 20 and 22 °C at altitudes between 970 and 2550 m.a.s.l. (INE, 1999). Shade coffee cultivation is most common between 800 and 1500 m.a.s.l., while corn, bean, and cattle are most common at low altitudes (Rico García-Amado et al., 2013); at higher than 1500 m.a.s.l. forest is the dominant cover.

2.2. Sampling design

We selected a sample of thirty-one coffee agroforests (herein also referred to as farms) characterized by a wide range of farm sizes, ages, and elevations. We adopted a sampling methodology employed in previous studies on floristic richness in Chiapas (Perez-Ferrera and Tejeda-Cruz, 2011; Ramírez-Marcial et al., 2001; Rocha-Loredo et al., 2010), which consists of establishing one circular plot composed of three concentric circles (radii of 5, 12, and 17 m) at the center of each farm. We identified, counted, and measured the diameter at breast height (DBH) of adult shade trees