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Why do farmers plant more exotic than native trees? A case study from the Western Ghats, India

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ABSTRACT

Farmers worldwide regularly plant trees to obtain provisioning and other ecosystem services. This practice has come under scrutiny by conservationists who perceive a reduction of biodiversity due to preferential planting of exotic trees. In order to reverse this preference for exotic trees it is necessary to identify the key drivers of exotic species planting and propose alternative species of interest to farmers. We examined this question in a coffee agroforestry landscape of the Western Ghats, India, a global biodiversity hotspot. We interviewed farmers regarding tree planting behaviour, preferences and constraints, and assessed the relative performance and value of native versus exotic species. Multivariate analyses were used with six species-level characteristics and four farm-level characteristics, to reveal the most significant predictors of planting frequency.

The exotic species *Grevillea robusta* was planted 5.4 times more often than native trees. Individual species' planting frequencies were most strongly related to their realised economic values, which was highest for *G. robusta*. Native trees with greater multipurpose utility value and stature were also more likely to be planted. Farm-level characteristics related to increased planting efforts were increasing climatic dryness, increased land area with native tree tenurial rights and farm size. However, farmers with a greater proportion of land under secure tree tenure planted fewer trees.

We conclude that although native trees had higher multipurpose utility and potential economic value than the exotic *G. robusta,* the latter is grown more often due to existing legal frameworks that restrict private ownership and realising monetary value from native species. If current laws were amended to increase the economic benefits obtained from native trees, they are likely to be planted more often by farmers. We propose that our results can help in implementation of the recent National Agroforestry Policy of India, as well as inform agroforestry policies and practice elsewhere.

1. Introduction

Agricultural landscape matrices with multi-strata agroforestry systems are recognised for their contribution to biodiversity conservation outside protected forests, provision of ecosystem services and alleviation of poverty (Perfecto et al., 1996; Schroth et al., 2004, 2011; Bhagwat et al., 2005; McNeely and Schroth, 2006; Vandermeer and Perfecto, 2007; Tscharntke et al., 2011; Dhakal et al., 2012). Farmers worldwide have contributed substantially towards this diversity by planting trees that provide economic value, food security and environmental improvement (Dewees, 1995; Scherr, 1995; Akinnifesi et al., 2006; Takaoka, 2008a; Anglaaere et al., 2011; Kehlenbeck et al., 2011; Goodall et al., 2015; Nyaga et al., 2015). However, a recent globally observed threat to farmland biodiversity is the ongoing transformation of traditional complex agroforests into simpler land use forms dominated by exotic species, which may eventually culminate in unshaded crop monocultures (Siebert, 2002; Peeters et al., 2003; Ruf, 2011; Jha et al., 2014). The increasing dominance of agroforestry canopies by fast growing exotic species is the first step in this landscape-simplification process, and this trend has been recorded across many tropical and subtropical countries. Thus, in southern Bahia, Brazil, farmers often plant non-native rubber (*Hevea brasiliensis*) and jackfruit (*Artocarpus heterophyllus*) trees rather than native timber and fruit trees for shade in their cocoa farms (Schroth et al., 2011); in Costa Rica, *Eucalyptus* species

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have become popular as coffee shade (Tavares et al., 1999; Schaller et al., 2003); and in Ghana, cocoa and coffee farmers wishing to diversify into timber production often prefer South American *Cedrela odorata* or Asian *Tectona grandis* to native species (Ruf, 2011). Similar preferences for planting exotic tree species on farm land have also been observed in other tropical regions (Dewees, 1995; Elouard et al., 2000; Takaoka, 2008a,b; Ambinakudige and Sathish, 2009; Nath et al., 2011; Kehlenbeck et al., 2011; Tefera et al., 2014; Nyaga et al., 2015; Valencia et al., 2015). In addition to the threat of declining environmental quality and ecosystem services caused by exotic species monocultures, diversity and continuity of the tree canopy may be compromised, thus preventing wildlife migration across agroforests and between nearby forest fragments (Perfecto et al., 1996; Vandermeer and Perfecto, 2007; Schroth et al., 2011). Therefore it may be ecologically desirable to halt and reverse this canopy-simplification process. What then, are the main drivers of exotic tree planting by farmers, and what can be done to divert their efforts towards increased retention and planting of native trees?

Farmers tend to be risk averse when deciding whether or not to adopt new farming practices (Pannell et al., 2014; Stevenson et al., 2014), which suggests that their decision to adopt new exotic species may be linked to reduction of economic, environmental and/or policy risks. In some countries, the introduction of fast growing exotic species has been promoted by government-supported agricultural extension workers who expect exotic species to be more efficient than native species in improving farm productivity and reducing poverty (Dunn, 1991; Dewees, 1995; Schneider et al., 2014). In addition, the exotic tree species themselves often possess (or may be perceived to possess) more useful attributes than native species, such as faster growth rates, higher economic value, fewer pests, and reduced competition with the main crop (Kalinganire, 1996; Tavares et al., 1999; Lott et al., 2000; Takaoka, 2008b; Anglaaere et al., 2011; Tefera et al., 2014). Finally, the local legal frameworks may also play a role in promoting exotic species by withholding farmers' rights of ownership over native trees, thus making the latter trees less attractive to propagate for the future (Van Noordwijk et al., 2003; Ruf, 2011; Schroth et al., 2011). In this paper we examine whether such global patterns are occurring in agroforestry landscapes of the Western Ghats, India, a key international biodiversity hotspot (Myers et al., 2000), and if so whether there are commonalities or unique features in the underlying drivers.

The Western Ghats is a mountain chain in southern India where biodiversity remains high despite a long history of human occupation and forest manipulation (Elouard et al., 2000; Bhagwat et al., 2005; Ranganathan et al., 2008). The focal area of our study in this region is the coffee agroforestry (CAF) dominated district of Kodagu in Karnataka State, which contains higher tree diversity than many other coffee landscapes worldwide (Table 1). The rustic CAF environment in this district has enabled migration of endangered wild fauna between protected forests, including large mammals such as elephants (Bal et al., 2011; Fig. 1A). The high tree diversity in Kodagu is mainly a result of retention and supplementation of naturally grown native trees within the CAFs for over 150 years (Haller, 1910). However, intensification of coffee production since the 1990s has resulted in gradual reduction and simplification of the complex multispecies tree cover to impoverished mixtures, sometimes dominated by fast-growing exotic species, especially *Grevillea robusta* (Proteaceae, Australian Silky oak or Silver oak, Fig. 1B) (Elouard et al., 2000; Moppert, 2000). With respect to shade management *G. robusta* costs less for maintenance than the densely leaved, thickly branched and spreading native trees (farmers' information). Previous studies have highlighted the increasing dominance of *G. robusta* in CAFs of the Western Ghats (Elouard et al., 2000; Moppert 2000; Bali et al., 2007; Garcia et al., 2010), and some possible drivers of shade tree dynamics have been proposed (Ambinakudige and Sathish, 2009; Guillerme et al., 2011; Nath et al., 2011).

G. robusta is an evergreen species native to Australia that was first introduced to South Asia in 1862 (Harwood, 1989) and promoted in India by British owners of tea and coffee estates. Although present in India for over 150 years, it is only in recent decades that concern has been raised about the increasing dominance of *G. robusta* in CAFs of the Western Ghats (Moppert 2000; Bali et al., 2007; Garcia et al., 2010). In order to reduce the current dominance of *G. robusta* in this region, a clear understanding is first required of how farmers value and utilise this species in order to suggest alternatives that they could easily adopt. In Kodagu, *G. robusta* grows faster than at least three popular native timber species (Nath et al., 2011). In addition, the lack of tenurial rights over native trees grown by farmers in the Western Ghats has been cited as a possible reason for their preference of exotic species

Table 1
Tree species richness values reported from various coffee agroforestry systems around the world.

Location	#farms/plots/sites	Min. tree size (cm dbh)	Area sampled (ha)	Total # species	Species ha^{-1}	Reference
GLOBAL						
Chinantec, Mexico	22 farms	2.5	2.2	45	20.5	Bandeira et al., 2005
Northern Chiapas, Mexico	61 farms	1	0.61	52	85	Soto-Pinto et al. (2001)
Mabira Forest Reserve, Uganda	105 farms	NA	210	238	1.1	Boffa et al. (2008)
Aberdare Mountains, Kenya	62 farms	≤ 2	39	59	1.5	Pinard et al. (2014)
East Usambara Mountains,	22 farms	2.5	13.2	139	10.5	Hall et al. (2011)
Tanzania						
West Java, Indonesia	148 farms	NA	(0.5–10 ha farms)	64 (inclu. bamboo)	NA	Parikesit et al. (2004)
Sumatra, Indonesia	3 sites/120 plots	NA	23.6	105	4.61	Philpott et al. (2008)
WESTERN GHATS, INDIA						
Chikmagalur	14 farms	3.18	1.26	49	38.9	Bali et al. (2007)
Kodagu	23 farms	10	NA	162	NA	Bhagwat et al. (2005)
Kodagu	14 plots	10	1.75	58	33.1	Ambinakudige and Sathish (2009)
Kodagu	7 farms	9.55	5.76	67	11.6	Nath et al. (2010)
Kodagu	20 farms	NA	10	129	12.9	Caudill et al. (2014)

NA = data not available.