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Cultural drivers of reforestation in tropical forest groves of the Western Ghats of India

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ABSTRACT

Sacred forest groves in the Western Ghats of India are small fragments of tropical forest that have received protection due to religious beliefs and cultural practices. These forest fragments are an example of community-based conservation and they serve as refugia for many forest-dwelling species in otherwise highly anthropogenic tropical forest-agriculture landscapes of the Indian Western Ghats. Many of these sacred forest groves are considered ancient woodlands, but there is very little information on their origins. For instance: How old are these sacred groves? Are they relics of forest that was once continuous or are they patches of regenerated vegetation? How do changes in the surrounding landscape influence the vegetation in these groves? Based on palaeoecological reconstruction in two such sacred forest groves, we determined the age of these forest fragments. Both reconstructions indicate transition from non-forest open landscape to tree-covered landscape at these sites. These finding from two sacred groves challenge the common perception that sacred forest groves are remnants of once-continuous forest; instead, some sacred groves such as those studied might be regenerated forest patches that are approximately 400 years old. This further raises a number of questions about the drivers of reforestation in these groves. What were the social and cultural circumstances which led to the recovery of forest within these patches? How did land tenure influence forest recovery? What role did religious beliefs play in forest restoration? Using Wallace's (1956) framework of 'cultural revitalization' and based on historical literature and palaeoecological analysis of the two sacred groves, this paper examines the drivers of reforestation in the Western Ghats of India. It suggests various social, ecological and economic drivers of such revitalization, recognizing strong linkages between the 'social' and the 'ecological' within the social–ecological system of sacred forest groves. This example of reforestation suggests that contemporary restoration of forests needs to operate at a landscape scale and look at restoration as a social–ecological intervention in forest management.

1. Introduction

Many forest groves in the tropics are considered sacred by local communities (Bhagwat and Rutte, 2006). Examples of such groves can be found across the world, in Africa (Sheridan and Nyamweru, 2008; Wassie et al., 2009), South Asia (Bhagwat et al., 2005a,b; Malhotra et al., 2007) and Southeast Asia (Wadley and Colfer, 2004; Massey et al., 2012). Many studies have assumed that these groves are remnants of once-continuous forest, which was lost with the onset of agriculture and subsequent large-scale land use transformation (Gadgil and Vartak, 1976; Chandran, 1997, 1998; Chandran and Mesta, 2001). Others have highlighted the threats to these forest fragments in the rapidly changing social, economic and environmental settings (e.g. Chandrakanth et al., 2004). Studies of sacred groves in South Asia are based on reviews of historical literature (e.g. Chandran and Hughes, 1997), ecological surveys of forest fragments (e.g. Chandrashekara and Sankar, 1998; Jamir and Pandey, 2003) or anthropological studies aimed at understanding cultural practices within these groves (e.g. Arora, 2006). While most studies examine time scales of years to decades, there is as yet no study which investigates the dynamics of natural and cultural settings of tropical sacred forest groves over time periods of centuries or millennia. This study contributes to that significant knowledge gap.

Sacred forest groves vary widely in their size; some of them are small fragments of forest (<1 ha) while others are more extensive, spanning >100 ha. Despite variation in size, one common feature of

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all sacred forest groves is their association with gods and goddesses (Chandrakanth et al., 2004), which often results in their protection by local communities on religious or spiritual grounds. India is known to have a high number of sacred forests, many of them protected due to religious or spiritual beliefs of local communities. Estimates suggest that there might be between 100,000 and 150,000 sacred forests in the country (Malhotra et al., 2007). Furthermore, this conservation tradition has a long history in India and therefore sacred forest groves of the Western Ghats of India provide an ideal opportunity to investigate the dynamics of this social–ecological system over centuries. The Western Ghats region in India has a relatively well-documented history thanks to the detailed records of forest resources kept during the British colonial period. These records go back to the 1800s and some of them make explicit mention of the presence of sacred forest groves throughout India (e.g. Brandis, 1897).

The reconstruction of the history of this social–ecological system before 1800s requires a combination of archaeological and palaeoecological methods. Although there are very few archaeological records on sacred forest groves, the ecological history of some of these groves is preserved in layers of sediment deposited over centuries or even millennia. Where groves contain marshy or swampy areas, such historical layers of sediment deposits can provide an unprecedented insight into the vegetation history of sacred forest groves. A comparison between this vegetation history with existing archeological and historical records can therefore enable a nuanced understanding of the social–ecological system of sacred forest groves.

There are, as yet, no studies on sediment archives from sacred forest groves that attempt to understand the past history of these groves. In this study, we use a combination of documented history, anthropological and archaeological literature and palaeoecological sediment archives to reconstruct the vegetation in these sacred groves over long time periods. We use this information to examine their social–ecological characteristics over 1000 years. The main aim of this paper is to ask: Are sacred forest groves relics of once-continuous forest or are they patches of regenerated vegetation? How do changes in social and cultural settings influence the vegetation within sacred forest groves? How can the long-term history of sacred groves provide information for future management of increasingly fragmented tropical forest landscapes?

2. Materials and methods

To reconstruct forest vegetation within sacred groves, we obtained continuous sediment archives from two sacred groves in Kodagu district of the Western Ghats, India. At each site two replicate sediment sequences 100-cm long were collected from small swamps (approximately 10-m diameter and surface area of *c.* 100 m^2) situated within the sacred forest groves, each with area of *c.* 1 ha (latitude *c.* 12°17′N, longitude *c.* 75°13′E, altitude *c.* 900 m asl) and surrounded by a mosaic of arable agriculture and coffee plantations. The nearest continuous forest is at a distance of approximately 10-km from both sacred groves. The dominant canopy species in sacred groves include many heavy-seeded, animal-dispersed trees which are also found in the continuous forest: *Artocarpus hirsutus*; *Caryota urens*; *Diospyros sylvatica*; *Drypetes oblongifolia*; *Elaeocarpus serratus* and *Syzygium hemisphericum* (a fuller checklist of species found in sacred forest groves in the study area is given in Bhagwat et al., 2005a; an analysis of seed weight and historical forest fragmentation in the wider landscape is presented in Bhagwat et al., 2012). We obtained 1-m long sediment sequences at both sites using GeoCore sediment coring system (http://www.geo-core.com). At the sites of sediment coring, the present-day forest is composed of native trees with shrub understory formed by monocot plants from family Pandanaceae, typical of tropical forests in this part of the world. The ecological history of these sites is not known, but anecdotal information from the local people indicates that these sacred forest groves have existed for several of their ancestral generations. These groves are representative of the mid-elevation (500–1500 m asl) forest landscape (Pascal, 1988) and riparian vegetation formations situated within swampy areas around the flood plains of small rivulets. The two forest fragments in question (as well as most others in the study area), however, are surrounded by paddy fields and are therefore subject to the influence of farming practices such as seasonal burning and land clearing. Therefore, this forest–agriculture landscape is a representative example of 'cultural landscape' produced by the interaction between social and ecological drivers of landscape development.

The two sites situated approximately 40-km apart were found suitable for coring due to the presence of swampy areas within these fragments. We obtained sediment sequences in two replicates at each site. An ideal landscape–ecological study would have several replicate samples covering a latitudinal gradient, geological features, soil types and a wide range of anthropogenic disturbances (Sutherland, 2006). However, long-term ecological studies, particularly those in tropical landscapes, are compromised by the availability of 'intact' sediment sequences spanning such gradients. This is particularly true in anthropogenic landscapes, where sedimentary depositional environments such as low-lying valleys are susceptible to disturbance and anthropogenic alteration, making it hard to obtain continuous sediment sequences (Jacobson and Bradshaw, 1981; Overballe-Petersen and Bradshaw, 2011). Furthermore, some soil types such as calcium-rich or alkaline soils, factors such as aridity, and geomorphological contexts such as hill slopes do not provide suitable depositional environments, thus restricting the availability of sediment sequences even further. As such, many influential long-term ecological studies from the tropics have been based on interpretation of sediment sequences from a small number of sites, sometimes even one site (Hodell et al., 2001; Bakker et al., 2008; Barker et al., 2011). Our intact sequences from two tropical forest groves in the Western Ghats afford a unique opportunity to understand the long-term history of these social–ecological systems and to investigate the drivers of vegetation changes in the groves.

We established the chronology of the two sediment sequences by obtaining radiocarbon dates on each (Reimer et al., 2004) (Table 1). Samples were measured at the Oxford Radiocarbon Accelerator Unit and ^{14}CHRONO Centre at Queens University Belfast. Radiocarbon dates were calibrated according to Reimer et al. (2004) using CALIB 6.01 and the IntCal04.14c database. The age–depth relationship was modeled using linear interpolation (Bennett, 1994) in PSIMPOLL version 4.26 (Bennett, 2005). Such chronology is important for a temporal analysis of changes in vegetation in sacred forest groves.

To obtain information on fossilized pollen grains, we sub-sampled sediment sequences from both sites at every 4-cm interval. Standard palynological methods (Bennett and Willis, 2001) were used to reconstruct forest: non-forest ratios and to examine the relationship between environmental and anthropogenic factors and changes in tree cover over time. A total of *c.* 50 pollen morphotypes were identified in each core and they were divided into woody taxa (trees and shrubs) belonging to forest vegetation and non-woody taxa (grasses, sedges and herbs) belonging to non-forest vegetation (Appendix A). We also identified two further pollen morphotypes: domesticated and cultivated plants and miscellaneous types such as understory ferns (listed in Appendix A). We obtained information on the present-day plant taxa recorded in sacred groves (Appendix B). In addition to pollen data, charcoal particles (>150 μm), which indicate the local occurrence of fire,

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