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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,

Table 1
^{14}C Radiocarbon dates for two sacred groves.

Sacred grove	Laboratory code for radiocarbon date	Depth (cm)	Uncalibrated years BP	Calibrated years BP
Sacred grove a	UBA-14928	24	210 ± 26	176
Sacred grove a	OxA-16771	44	987 ± 27	912
Sacred grove b	UBA-14926	36	330 ± 23	386
Sacred grove b	OxA-16754	65	1014 ± 34	935

were also counted in the sediment sequence at 4-cm intervals corresponding with the fossil pollen data. The abundance of charcoal particles and their concentration provides a suitable proxy for the reconstruction of landscape-scale burning (Whitlock and Larsen, 2001).

3. Results

The study sites are located in a typical cultural landscape of the Western Ghats of India (Fig. 1), where sacred forest groves interspersed with cultivated land are a common feature. Hundreds of these groves are present throughout the region and the two study sites provide examples representative of sacred groves in the wider study area. Both sacred forest groves show similar trends in vegetation change over time. Throughout the 1000-year sequence, the prevalent trend is that of increasing tree cover and decreasing grass cover. Pollen from domesticated plants and ferns are present at both sites throughout the 1000-year sequence, but in low proportion in comparison with tree and grass pollen. At around 400 years before present (BP) a sharp increase in forest and a simultaneous sharp decrease in non-forest vegetation is observed at both sites indicating the occurrence of an important 'regime shift' in both sacred forest groves at the same time. Today, 400 years later, the proportion of woody plant pollen is between 80% and 90% and the proportion of non-forest pollen is between 5% and 20% indicating a well-wooded landscape (Fig. 2). This vegetation change also corresponds with a decrease in the presence of fire indicated by decreasing abundance of charcoal particles (Fig. 2, insets).

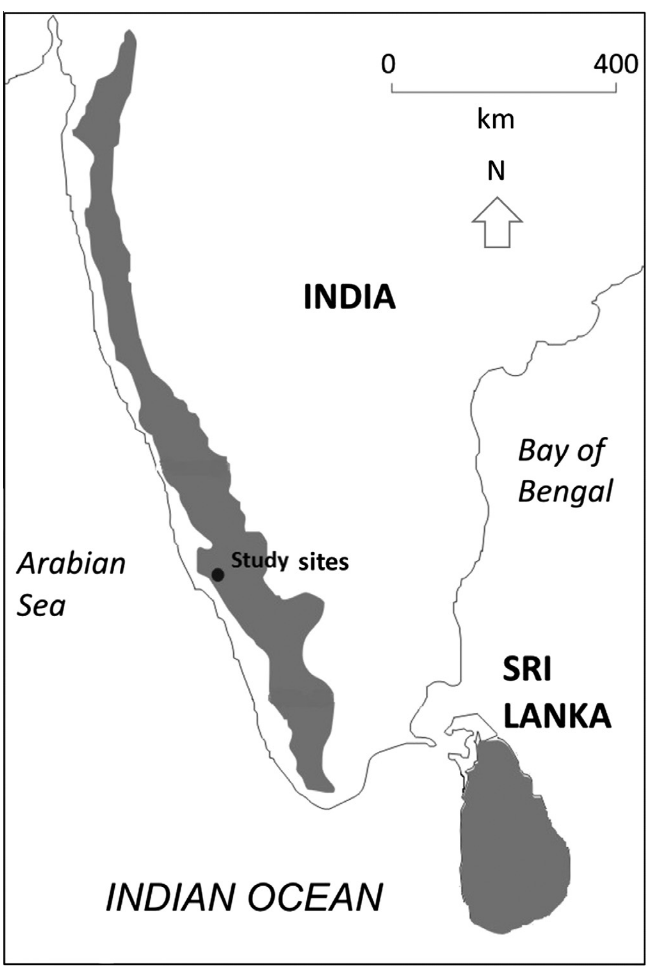

Fig. 1. Map of India and Sri Lanka, showing the location of the Western Ghats-Sri Lanka hot spot (gray) and the study landscapes, where the two sacred forest groves, approximately 40-km apart, were sampled. The extent of the Western Ghats and Sri Lanka is based on Conservation International's Biodiversity Hotspots map for this hotspot (http://www.conservation.org/where/priority_areas/hotspots/asia-pacific/Western-Ghats-and-Sri-Lanka/Pages/default.aspx).

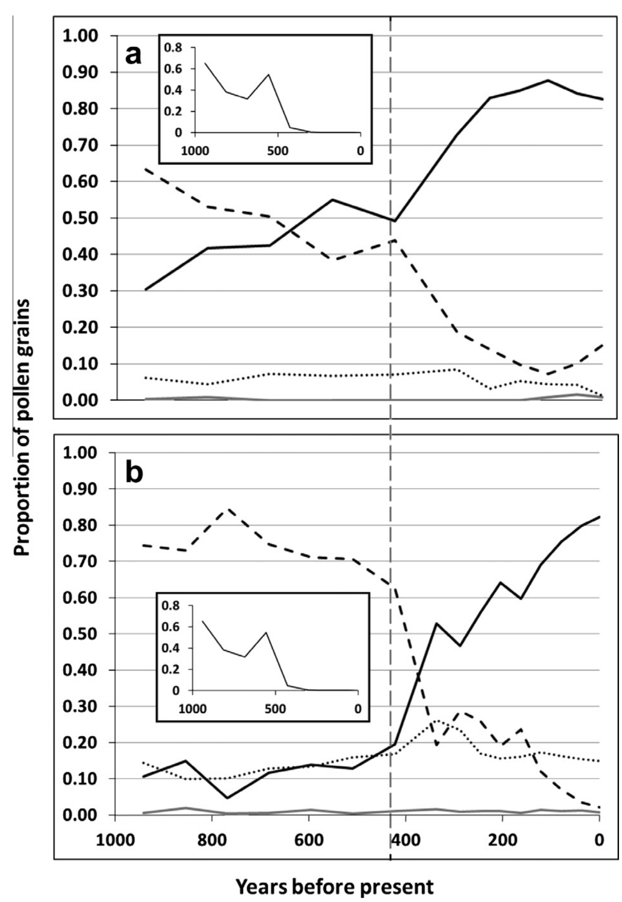

Fig. 2. Changes in the proportion of pollen grains, in sediment sequences, representing different components of the vegetation, viz., forests (trees and shrubs: continuous line), non-forest (grasses, sedges and herbs: dashed line), domesticated crops (dotted line) and miscellaneous types such as understory ferns (gray line) over 1000 years BP. 2a and 2b represent the vegetation dynamics in the two sacred grove sites. In both sediment sequences, the vertical dashed gray line represents the transition point leading to a steep increase in the proportion of forest pollen and a simultaneous decrease in the proportion of grass pollen. Insets indicate abundance of charcoal particles (number of charcoal particles per cm^3) in sediment sequences.

4. Discussion

The results of vegetation change in the two sacred forest groves studied provide an insight into the dynamic nature of this social–ecological system. These two groves underwent sharp vegetation change around 400 BP, although the gradual increase in forest and decrease in non-forest vegetation appears to have preceded these changes. This 1000-year change contrasts vegetation change in non-sacred parts of the landscape, where in fact a gradual decline in forest cover took place over the last 1000 years (Bhagwat et al., 2012). This raises the possibility that cultural drivers may have played an important role in forest recovery at the two sacred grove sites. In contrast to much of the literature on sacred forest groves, which assumes these to be 'remnant' forests (Ramanujam and Kadamban, 2001; Ramanujam and Praveen Kumar Cyril, 2003; Mani and Parthasarathy, 2005), the results indicate that these two sacred forest groves are not fragments of once-continuous forest, but instead they are a result of forest recovery possibly supported by certain cultural practices. Although local ecological history of each forest fragment is different, and sacred groves in general may well have continuous vegetation cover throughout their history, our results suggest that some sacred forest groves might be regenerated patches of forest. It is noteworthy that recovery of forest vegetation in two sacred groves is in sharp contrast to the decline in forest cover elsewhere in the same landscape. While this decline in forest cover was driven by a combination of landscape burning, soil erosion and changes in monsoon intensity (Bhagwat et al., 2012), forest within sacred groves has recovered against all these factors, indicating the important role that cultural divers might have played in reforestation.

We suggest that the transformation from grass-dominated to tree-covered landscape over a period of 1000 years, and a sharp increase in forest over the last 400 years is likely to have been driven by the following changes in the social–ecological system: (1) The land use change and a subsequent change in the ecological space created conditions for increase in forest and decrease in non-forest vegetation; (2) The enforcement of land use led to further increase in forest in proportion to non-forest vegetation; (3) A further recovery of forest vegetation occurred as the new land use became a norm and was widely accepted within the community; (4) The continued increase in forest cover encouraged 'buy in' from local community, reinforcing and strengthening a new paradigm, i.e. conservation of sacred forest groves (Fig. 3). The regime shift around 400 years may have been related to 'cultural revitalization', a process of society-wide changes, defined by Wallace (1956), a 20th century American Anthropologist, as "a deliberate, organized, conscious effort by members of a society to construct a more satisfying culture".

Forest recovery can be attributed either to 'passive' forces, such as land abandonment followed by forest regeneration (e.g. Rivera et al., 2000; Rosenmeier et al., 2002) or it could be 'active', as a result of conscious decision by a community to restore forest (e.g. Tolentino, 2008; Brancalion et al., 2012). In the present context, Wallace's idea provides insights into possible cultural drivers of reforestation in sacred groves of the Western Ghats of India, where the evidence points to a combination of passive and active forms of recovery. Considering that tree cover in sacred forest groves has increased in contrast with decreasing forest cover in the wider landscape over the past 1000 years (Bhagwat et al., 2012), active forms of reforestation might have gone hand-in-hand with land use change at these sites. It is also likely that vegetation recovery was aided by the presence of continuous forest at a distance of 10-km, acting as seed source for many heavy-seeded, animal- or bird-dispersed tree species (Bhagwat et al., 2012). A variety of possibilities could therefore be put forward to explain this forest recovery:

1. *Positive influence of 'cultural taboos' on forest recovery:* In many parts of the world cultural taboos on cutting down trees from certain parts of the landscape have led to forest conservation (Fournier, 2011; Gao et al., 2013). Examples from across the tropics have shown that traditions of animistic beliefs or nature worship are often associated with sacred forest groves (e.g. Murugan et al., 2008; Massey et al., 2012). It is possible that in the Western Ghats of India such cultural taboos came into force or were strengthened around 400 BP, as a result of which the forest recovered sharply.
2. *Formalization of land use:* A transition from shifting cultivation to settled agriculture often leads to the formalization of land boundaries and enforcement of land use (e.g. Chi et al., 2013; Mertz et al., 2013). As a result, vegetation in land parcels – depending on the nature of their use – can change its character. This could be a possible explanation for the change in vegetation within sacred forest groves in the study area. It is likely that formalization of land use was brought about by change or transition in the prevalent social–political context. A significant change in the political regime is known to have happened in South India around 400 BP: After the fall of the Vijayanagara Empire, local chieftains (Haleri Kings) in Kodagu are known to have gained control over the region from 1600 until 1834 AD (Belliappa, 2008). These local chieftains are also known to have formalized land use and demarcated boundaries of land parcels

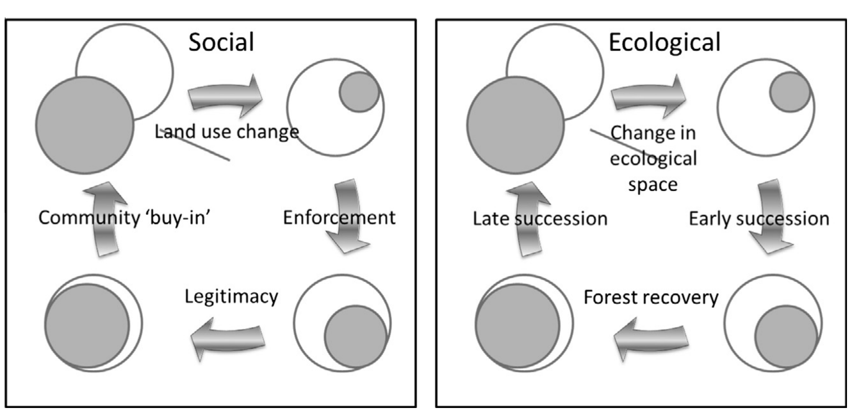

Fig. 3. Visual representation of Wallace's (1956) 'cultural revitalization' overlaid with changes in the 'social' and the 'ecological' realms. Wallace's framework suggests progressive change in society leading to a paradigm shift. This can be applied to social–ecological systems of sacred forest groves, where social and ecological changes might have accompanied each other leading to the 'regime shift' from grass-dominated to forest-dominated landscape at the sacred grove sites studied in the Western Ghats of India.

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by digging deep trenches (known locally as *kadangas*) and other means. Such demarcation might have helped forest recovery within sacred grove land parcels.

3. *Societal awareness of forest loss:* Contemporary examples have suggested that large-scale changes in land use are a result of paradigm shifts in local communities (e.g. Luoga et al., 2005; Dalle et al., 2006). A paradigm shift is characterized by a shift in attitude towards a natural resource. In the case of sacred forest groves, it is possible that such recovery of forest was initiated due to the recognition of the effects of forest loss on human activities. There might also have been simultaneous recognition of the value of forest in maintaining certain 'ecosystem services': water storage, provision of useful plants or cultural services. Water storage might have been particularly relevant at that time because of the climatic influence of the 'Little Ice Age' (*c.* 1550–1850 AD). During this period, many tropical regions including South Asia are known to have faced severe water shortages leading to droughts and famines (Uberoi, 2012). Therefore, preservation of forest to maintain groundwater, recharge aquifers and provide water for arable crops, might have been important for communities dependent on farming at that time.

The available evidence points to a number of changes in the social–ecological context within which sacred groves might have 'emerged' in the Indian Western Ghats. These changes appear to have gone hand-in-hand with cultural revitalization leading to transformation in the social–ecological system. Without a detailed temporal understanding of the stakeholder community in question, going back to 400 BP, it is difficult to identify which of the three drivers suggested above might have been important in the forest recovery in sacred groves; it is very likely that a combination of these drivers led the forest to recover. Even though our results are based on two study sites, the social, cultural and political changes have taken place at the regional scale. This suggests the possibility that the emergence of sacred groves around 400 BP may have been a region-wide phenomenon.

Management implications: This case study provides important lessons for contemporary forest restoration. The first lesson is the need to recognize social–ecological system and to understand synergies between the 'social' and the 'ecological' realms. A consideration to both these realms can help forest recovery in the face of unfavorable environmental conditions. A restoration program that pays attention to social, ecological and cultural factors is therefore likely to be more effective. Second, even though an individual sacred forest grove might be small and insignificant for forest conservation, recovery can take place simultaneously in patches across the landscape. Such network of restored patches can maintain 'ecological memory' (*sensu* Bengtsson et al., 2003), and provide corridors and connectivity even in seemingly fragmented landscape (Bhagwat et al., 2005a,b). Third, conservation policies should encompass forest fragments outside of protected reserves because the presence of restored forest fragments in the wider landscape can enhance the function of already protected areas. Such patches further support biodiversity and a wide variety of 'ecosystem services' beneficial to the local communities. The overarching management implication is that a successful forest recovery program needs to operate at the scale of a landscape in conjunction with transformation of the social–ecological system within which such forest restoration takes place.

5. Conclusions

This study of long-term ecology of two sacred forest groves in the Western Ghats of India shows that these groves are not remnants of once-continuous forest, but they are regenerated forest patches. The social, cultural and political context within which forest regeneration took place indicates that the emergence of sacred groves might be a region-wide phenomenon. This finding challenges the popular assumption that sacred forest groves are fragments of forest that was once continuous. The recovery of forest within these groves is likely to have been driven by a variety of changes in the social–ecological system of sacred forest groves. These might include positive influence of 'cultural taboos' on forest recovery, simultaneous formalization of land use as a result of political regime change, and societal awareness of forest loss in the face of harsh environmental conditions. This case study points to the possibility of 'cultural revitalization' and indicates that such revitalization takes place in response to wider environmental changes. This has implications for adaptation of natural-resource dependent communities to future environmental changes. It also provides an important insight into contemporary management of forest restoration and recovery programs by suggesting that an intervention that is mindful of the social, ecological and cultural factors is likely to work more effectively.

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Appendix A. Pollen morphotypes

Sacred grove 1	Sacred grove 2	Associated vegetation type
Acacia	Acacia	Forest
Aglaia	–	Forest
–	Acanthaceae	Non-forest
Amaranthaceae	Amaranthaceae	Non-forest
Apiaceae	Apiaceae	Non-forest
Apodytes	–	Forest
Artocarpus	Artocarpus	Forest
Asteraceae	Asteraceae	Non-forest
–	Baccaurea	Forest
Caryota	Caryota	Domesticated
–	Cassia	Domesticated
Coffea	–	Domesticated
Cyperaceae	Cyperaceae	Non-forest
Dimocarpus	–	Forest
Dimorphocalyx	–	Forest
Diospyros	Diospyros	Forest
Drypetes	Drypetes	Forest
Elaeocarpus	Elaeocarpus	Forest
Eurya	–	Forest
–	Fern (rough)	Miscellaneous
Fern (smooth)	Fern (smooth)	Miscellaneous
Flacourtia	Flcaourtia	Forest

(*continued on next page*)

Pollen morphotypes (*continued*)

Sacred grove 1	Sacred grove 2	Associated vegetation type
Glochidion	–	Forest
–	Gomphandra	Forest
Grass	Grass	Non-forest
–	Holoptelia	Forest
Hopea	–	Forest
Knema	–	Forest
Labiatae	–	Non-forest
Litsea	–	Forest
Lophopetalum	–	Forest
Lythraceae	Lythraceae	Forest
–	Macaranga	Forest
Malvaceae	Malvaceae	Non-forest
Mangifera	–	Forest
–	Melastomataceae	Forest
–	Meliaceae	Forest
Memecylon	Memecylon	Forest
Michelia	–	Forest
–	Moraceae	Forest
–	Neonauclea	Forest
–	Other	Non-forest
–	Pandanaceae	Non-forest
–	Randia	Forest
–	Rubiaceae	Forest
–	Sapotaceae	Forest
–	Semecarpus	Forest
Murraya	–	Forest
Phyllanthus	–	Forest
Strombosia	–	Forest
Syzygium	Syzygium	Forest
Toona	–	Forest
Tri-lobed fern	–	Miscellaneous
Unidentified	–	Miscellaneous
–	Vernonia	Forest

Appendix B

List of possible plant taxa corresponding with pollen types in sacred forest groves (adapted from species checklist in Bhagwat et al., 2005a).

Forest canopy taxa
Acacia
  Acacia spp.
Aglaia
  Aglaia anamallayana
  Aglaia jainii
  Aglaia simplicifolia
Apodytes
  Apodytes beddomei
Artocarpus
  Artocarpus heterophyllus
  Artocarpus hirsuta
Baccaurea
  Baccaurea courtallensis
Dimocarpus
  Dimocarpus longan
Dimorphocalyx
  Dimorphocalyx beddomei
Diospyros
  Diospyros candolleana
  Diospyros montana
  Diospyros sp.
  Diospyros sylvatica
Drypetes
  Drypetes elata
Elaeocarpus
  Elaeocarpus serratus
  Elaeocarpus tuberculatus
Eurya
  Eurya japonica
Flacourtia
  Flacourtia montana
Glochidion
  Glochidion bourdillonii
  Glochidion malabaricum
Gomphandra
  Gomphandra tetrandra
Holoptelia
  Holoptelia integrifolia
Hopea
  Hopea parviflora
  Hopea ponga
Knema
  Knema attenuata
Litsea
  Litsea floribunda
  Litsea mysorensis
  Litsea oleoides
  Litsea stocksii
Lophopetalum
  Lophopetalum wightianum
Lythraceae
  Lagerstroemia microcarpa
Macaranga
  Macaranga peltata
Mangifera
  Mangifera indica
Melastomataceae
  Memecylon malabaricum
  Memecylon talbotianum
  Memecylon umbellatum
  Memecylon spp.
Meliaceae
  Dysoxylum malabaricum
Michelia
  Michelia champaka
Moraceae
  Ficus amplissima
  Ficus asperima
  Ficus beddomei
  Ficus callosa
  Ficus hispida
  Ficus microcarpa
  Ficus mysorensis
  Ficus nervosa
  Ficus racemosa
  Ficus sp.
  Ficus tsjahela
  Ficus virens
Neonauclea
  Neonauclea purpurea

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Randia
Randia rugulosa
Rubiaceae
Ixora nigricans
Sapotaceae
Madhuca longifolia
Semecarpus
Semecarpus anacardium
Murraya
Murraya paniculata
Phyllanthus
Phyllanthus emblica
Strombosia
Strombosia zeylanica
Syzygium
Syzygium cumini
Syzygium gardnerii
Syzygium hemisphericum
Syzygium heyneanum
Syzygium mundagam
Syzygium munronii
Syzygium phyllareoides
Syzygium zeylanicum
Toona
Toona ciliata
Vernonia
Vernonia monosis

Open-canopy taxa
Apiaceae
Pimpinella spp.
Pandanaceae
Pandanus spp.
Malvaceae
Labiatae
Cyperaceae
Asteraceae
Amaranthaceae
Acanthaceae

Domesticated taxa
Caryota urens
Cassia fistula
Coffea arabica

Understory ferns and miscellaneous taxa
Fern (rough)
Fern (smooth)
Tri-lobed fern
Unidentified fern

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