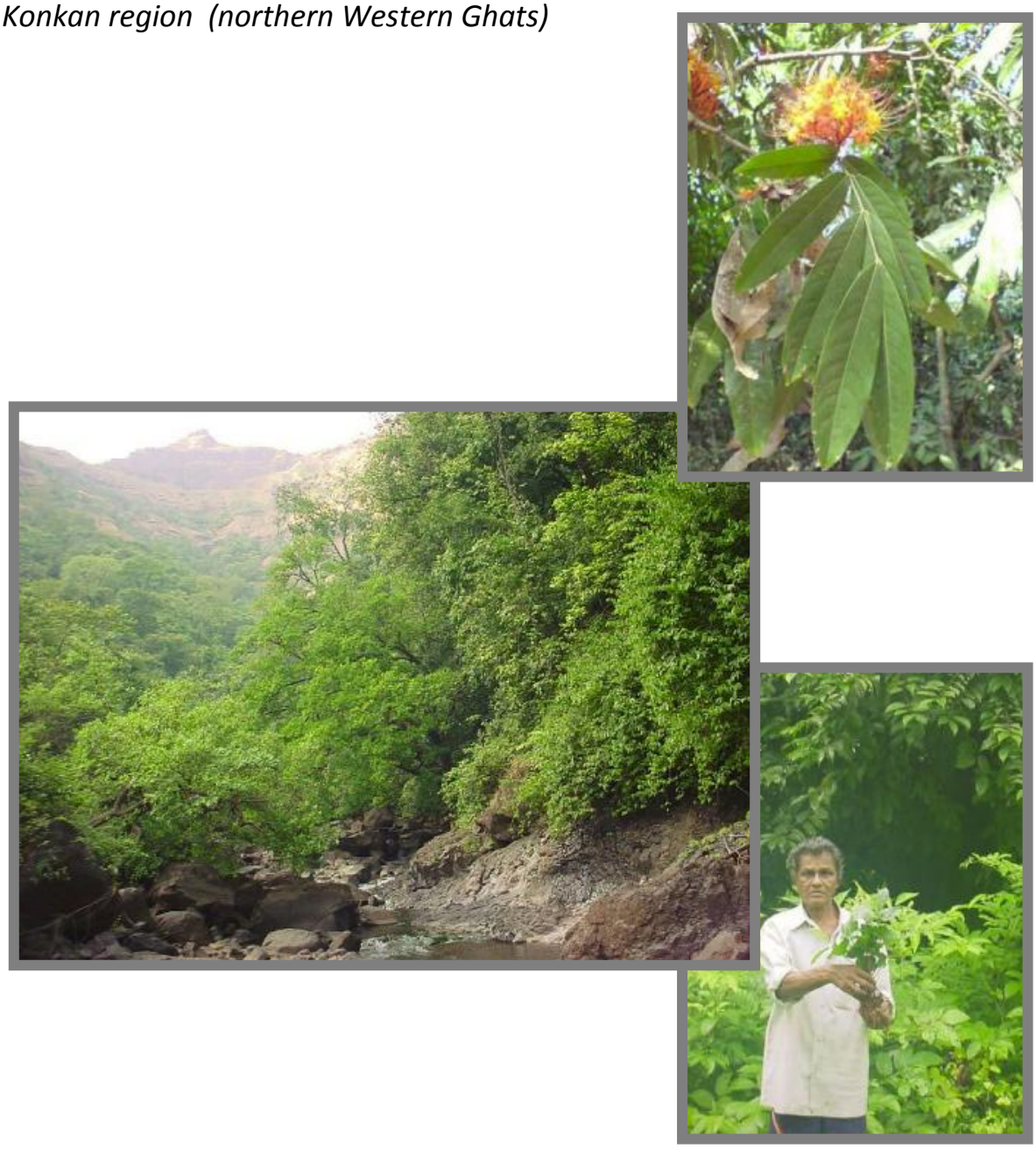
Rare trees in forest fragments– *will they survive*?

A study of four climax forest tree species within sacred groves of the Konkan region (northern Western Ghats)



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Acknowledgement

The best supporters of conservation I know have to be my parents. To share the concern for the loss of forests and biodiversity and support the cause for conservation based only on my words and pictures has to be commended. I could only wish people could show more willingness to support conservationists without questioning their motives too much. I would therefore like to thank my parents for all their support and encouragement. The rest of my acknowledgments go to AERF. I feel pride in being part of this small but committed team of individuals. I thank Dr. Archana Godbole and Jayant Sarnaik for keeping the enthusiasm alive and providing a direction to all our efforts. Lastly, I couldn't have completed this project and the report without Mr. Sanjay Pasthe and his willingness to learn, Atul Joshi for his valuable insights, Jyoti Raskar and Aditi Lele for their cheerful help and support and of course, the team at the Rufford Foundation. Thank you all and I hope you find this interesting reading!

Sameer Punde

Author's note:

The opportunity to work in the Western Ghats on receiving the Rufford Small Grant was an important and unforgettable milestone in the beginning of my career in conservation. Not only has the RSG provided crucial support during the initial stages of my work in the northern Western Ghats but it has also been a great learning opportunity for me as well as for my entire team. It all began at a remote village in the Ratnagiri district right in the middle of the monsoon season of 2005. The rain was mercilessly thrashing down on us and with the day's experience still fresh in our minds, my two enthusiastic bosses – Archana Godbole, Jayant Sarnaik and I had an informal discussion about the lack of ecological studies in the Konkan region and the need to study the ecology of trees within sacred groves. This sparked an idea for a project and a few weeks later and my proposal for the RSG was ready! I am truly indebted to both Dr. Godbole and Mr. Sarnaik for all their support and encouragement. This has been a successful project in terms of increasing our understanding of the ecology of sacred grove habitats. On the basis of the result of this project, I am able to provide inputs to our on-going effort in the restoration of sacred groves and the revival of traditional conservation practices of the region. The success of this project led to more discussions, more projects and hopefully better conservation effort on our part. Through my initial visits to the field and discussions with experts as well as through the review of current research literature on these topics – I came to understand that it is in sacred groves that I will find rare trees and plants, it is the sacred grove that will show me how forests used to be in the this unique landscape and it is certainly the sacred grove that is a living example of conservation areas well before India followed the Western pattern of setting up statutory protected areas. Even though scared groves are championed as true community conservation areas, I wondered how effective these areas were in the face of rampant deforestation in the Konkan region. This project and the report you are now reading is evidence of the investigations I have undertaken during the year 2006-07 with support from the Rufford Foundation.

Sameer Punde

Executive summary

The Western Ghats is a global biodiversity hotspot and the Konkan region lies in the northern section of this area of global significance. Although the Western Ghats has received wide conservation and research interest since its recognition as a biodiversity hotspot, the northern Ghats – especially the Konkan region has not be considered a priority area for conservation or even development. The Konkan region houses a vast cover of dry and moist deciduous forest types with patches of evergreen forests in some sections. Even so, less than 2% of the region is currently being protected and the rest faces rampant deforestation. In such a scenario, forest patches traditionally protected by local communities (sacred groves) play a vital role in conserving regional biodiversity.

The Applied Environmental Research Foundation (AERF) is a non-government organisation (NGO) working in the Konkan region of the northern Western Ghats for over 10 years. The main focus of the organisation's work has been on the revival of the tradition of sacred groves and to ensure protection of such habitats through active community participation. In recent years, the AERF has directed its efforts towards the restoration of degraded sacred groves and rehabilitation of rare and endangered plant species of the Konkan region.

The present study was devised with the objective of understanding the ecology of forest fragments (sacred groves in this case) and the populations of rare trees found within them. Even though many have highlighted the importance of sacred groves as viable conservation areas, the effectiveness of these small forest patches in ensuring the survival of populations of rare tree species needed further investigation. The objective of this project was therefore two fold - 1) To assess the effectiveness of small forest fragments (sacred groves) in ensuring the survival (population recruitment) of rare tree species. This assessment was based on a study of four tree species and 2) To assess conservation status of the four tree species selected for the study in the Konkan region. In order to fulfil these objectives, the AERF team undertook a range of activities including plant population studies, interaction with local communities and experts as well as testing and monitoring the germination and survival of seedlings *in-situ* as well as *ex-situ*.

As a result, the project has been able to provide the following major outputs:

- The study has been able to prove that sacred groves are effective areas for the conservation of rare tree species. Even small fragments below 1ha in size are equally important in ensuring the survival of such species. However, population recruitment and ultimately survival of the species depends on a range of habitat and landscape level factors since many climax forest tree species of the Konkan region rely on birds and mammals for seed dispersal.
- Population recruitment of rare tree species within forest fragments is severed due to fragmentation and isolation and therefore the general management recommendation is to undertake habitat restoration, species rehabilitation and finally to shift the management focus from sacred groves habitats to the management of entire landscapes within which many sacred groves may be placed and connected.
- This project has been a good learning experience for the entire AERF team and has led to the development of a number of follow on projects, which include further research and the development of a strategy to combat mass deforestation in the Konkan region.

1.0 Introduction

"Instead of an essentially continuous forest…. the landscape now presents…. isolated trees, cluster of trees, small groves scattered in a matrix of artificial grassland. Within the remnant forest stands, a number of changes of possible importance may take place."

Curtis (1956)

These were probably one of the first observations of habitat fragmentation, its extent and its effect. Although Curtis was referring to the status of temperate forests in Europe, the situation is now no different in most parts of the world including globally recognised hotspots such as the Western Ghats of India.

Habitat fragmentation is possibly one of the biggest threat that global biodiversity faces. Diamond (1989) perceived it as one of the four major threats to biodiversity and therefore mentioned it as one of the "Evil Quartets" - in his widely cited analogy.

The present document is the final report for the project entitled *"Conservation Assessment of over-exploited medicinal tree species restricted to the traditionally protected forest fragments of the Western Ghats of Maharashtra, India."* The project was led by Sameer Punde with support from the Applied Environmental Research Foundation (AERF) – a non-government organisation based in India. The project received financial assistance from the Rufford Maurice Laing Foundation for a period of one year beginning March 2006. The objectives of the project were two fold – firstly, the team aimed to assess the importance of sacred groves as conservation areas based a study of four rare tree species mostly found within the sacred groves of the Konkan region. Secondly, the project also assessed the conservation status and the ecology of the four species selected for the study. The project therefore addresses issues of forest conservation in the Konkan region based on a species based approach although it also touches upon the aspects of habitat and landscape ecology. To achieve these objectives, the team undertook a range of research and implementation activities including ecological studies,

closely interacting with local people as well as testing the propagation and planning rehabilitation of the rare tree species within degraded sacred groves. Details of each activity conducted as the project progressed along the year have been provided further on in the report. This report is presented in the format of a research document although research was not the only motive behind the project. The document begins with an introduction to the team and a background of the project work. Since research has been one of the major components of the project, a hypothesis was conceptualised and tested. Data was collected to prove the hypothesis and the results have been presented here in an informal, *un-academic* fashion. The core hypothesis was broken down into specific research questions, which are then answered on the basis of the data collected during fieldwork. The project has been able to prove that sacred groves are important areas for the conservation of rare tree species although survival of populations of such rare species depends on a range of factors including habitat quality, habitat structure, habitat size and presence of seed dispersers. Habitat fragmentation and isolation has an effect on population recruitment but contrary to other studies, this report provides evidence towards the importance of even small forest fragments for the survival of species. The general recommendation is however, that restoration of sacred groves is very much required and there is a need to shift the focus from conserving sacred grove habitats towards managing landscapes in which networks of sacred groves and forest fragments may be placed.

1.1 The project team

The Applied Environmental Research Foundation (AERF) is a non-government organisation (NGO) actively involved in community-based conservation in India. For over a decade, the Foundation has been working in various parts of India although the organisation's focus has been on the sacred groves of the Konkan region. During initial phases of its work, the AERF concentrated on generating awareness regarding the importance of sacred groves as repositories of biodiversity and the urgent need to conserve them. Through the years the Foundation has touched upon various aspects of traditional forest conservation and land use practices of the Konkan region. In recent years, AERF has felt

the need for restoring degraded groves and to ensure their protection through active community participation.

Recognising AERF's commitment and on-going efforts in community based forest management in the northern Western Ghats, AERF's director – Dr. Archana Godbole recently received the prestigious Whitley Associate Award to support continuation of her work on sacred groves.

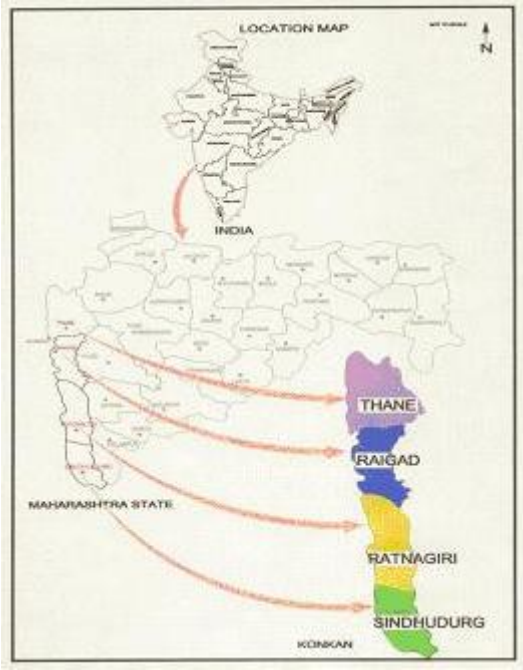
The current study on rare trees of sacred forests has been an important and primary step towards understanding the ecology of sacred groves and the populations of rare trees found within them. Although the project was led by Sameer Punde, a trained conservation biologist, he received support from the entire AERF team for various activities undertaken during the project. The AERF is a multidisciplinary team of researchers and practitioners committed to the cause of biodiversity conservation and sustainable development. The team understands the need to take a participatory approach whilst implementing its projects and therefore local people's inputs, traditional understanding and local needs are considered important aspects of research and implementation. The team brings in wide experience and understanding from the field of ethnobotany, community based conservation, ecological restoration, forestry as well as aspects of environmental management. The largest advantage was however, the team's experience, knowledge and commitment towards the conservation of the biodiversity in the Konkan region: a beautiful region placed within the northern section of the Western Ghats – a global biodiversity hotspot.

1.2 The study site – the northern Western Ghats

The Western Ghats and its adjoining areas have been identified as a global biodiversity hotspot (see www.conservation.org). The region is adorned by a continuous mountain range that runs parallel to the entire western coast of peninsular India. Characterised by monsoon climate, the unique topography of the Western Ghats gives rise to a range of temperature-precipitation regimes along its elevation gradient. This unique topography and local climatic variations supports a diversity of forests and vegetation types. The entire Western Ghats has over four thousand recorded flowering plants, 1500 of which are known to be endemic. Forest range from evergreen to dry deciduous types, which provide crucial habitat for charismatic mega fauna such as the tiger (*Panthera tigris*) and the Asian elephant (*Elephas maximus*). The Western Ghats therefore receives considerable

conservation and research interest, nationally as well as internationally. Tiger reserves, biosphere reserves, national parks, wildlife sanctuaries and forest reserves comprise the range of strategies used by national and international agencies to conserve the biodiversity of this hotspot. But there exists a stark disparity in conservation and research interest between the south and the northern Western Ghats. This may be because the northern Western Ghats and adjoining areas are relatively drier, receive less rainfall and therefore support lesser biological diversity. The dominant vegetation here is of the dry deciduous type with a few patches of moist deciduous and semi- evergreen forests. There is a need to study the biodiversity of this understudied a conservation.

Work related to the current project was confined within the administrative boundaries of 3 districts viz. Raigad, Ratnagiri and Sindhudurg. These three districts, fall within the Konkan region, which is bound by the mountain range of the Western Ghats towards the east and the Arabian Sea towards the west. Due its unique geographic setting, the Konkan region receives the highest rainfall in western Maharashtra. However, protected areas in the northern region are few and sparse, especially within the Konkan region. In the Ratnagiri district alone, less than 2% of land is set aside for conservation (see www.mahaforest.nic.in). In such a scenario, traditionally protected areas such as sacred groves form an important component of the Ghat landscape. For centuries, local communities throughout India have set aside forest patches protected in reverence of a local deity. Today these sacred groves are probably the only remnants of climax forest vegetation of the Western Ghats and are therefore important repositories of local and regional biodiversity.



Map of the Konkan region

2.0 Building a hypothesis – project background and objectives

The current study is based upon the argument behind the effectiveness of forest fragments, particularly sacred groves, as conservation areas. To prove this argument, the team followed a well-defined research design. The team began with a hypothesis, which was later, proved on the basis of the data collected during the course of the project. The following section provides a background to the issues addressed in the project as well as details of how the hypothesis and objectives of the project were formulated.

2.1 Sacred groves as conservation areas

Ever since the conservation movement gained momentum in India, sacred groves received appreciable research interest. First described and studied by Ethnobotanists and recently by ecologists, the study of sacred groves significantly contributed to the understanding of how local communities perceive landscapes. Sacred groves are small patches of native vegetation ranging from less than a hectare to a few square kilometres traditionally protected and managed by local communities (Ramakrishnan 1998). Religious beliefs still forms an integral part of rural society and culture in India and it was evident that sustainable use of land and forests was also part of traditional culture. In recent years, modernisation and the advent of a market driven economy has had a negative effect on rural belief systems and traditional knowledge. As a result, the once forested landscape of the Western Ghats now faces excessive deforestation and degradation. In such a

scenario, sacred groves now form important residual patches of climax vegetation and often harbour populations of rare and endangered plants (Sukumaran et al. 2004). Although the ecological value of sacred groves as important repositories of regional biodiversity has been championed by many including Godbole and Sarnaik (2004), Lee and Schaff (2003) to name a few, sacred groves are essentially small fragments of forest habitat placed within a landscape undergoing mass deforestation. The question therefore arises on the effectiveness of these protected habitats in ensuring the persistence of populations of rare tree species. The purpose of this study was therefore to assess the survival of rare tree species within sacred groves using an estimate of population size and area of habitat and its effect on reproduction and regeneration of some tree species. Before commencing on details of the study objectives and methods, it is essential to briefly discuss the main scientific underpinnings of the study, which has been introduced in the following paragraph.

2.2 Theoretical underpinnings- the Small Population Paradigm (SPP)

Caughely (1994) before he passed away suggested a dichotomy in the field of conservation biology, which he aptly named - the Small Population Paradigm (SPP) and the Declining Population Paradigm (DPP). Fuelling wide spread discussion and at times criticism, Caughley essentially categorised current conservation science and practice into two. The Small Population Paradigm (SPP) essentially referred to growing scientific interest in the “effect of smallness on persistence of populations” whereas the Declining Population Paradigm (DPP) encompassed a scientific body dealing with the “cause of smallness” (Hedrick et al 1996). This could very well be a distinction between cause and effect of small populations. It was essential to introduce this concept here since the current study deals with persistence of small populations of rare tree species within forest fragment and therefore the SPP forms a scientific base for the study. A large body of scientific literature proves that smaller populations are more likely to go extinct than larger ones (Primack 1993). However, Caughley did argue there is lack of understanding with reference to the ecology of small populations and their conservation. The current study touches on the effect of smallness on tree populations in terms of population recruitment and the processes involved with recruitment (seed dispersal, germination etc). The study

therefore is based on the SPP however; practical aspects for the conservation of the studied species have also been addressed. Although Hedrick (1996) argues that Population Viability Analysis should form an important component of small population study, the current study was limited to a time-period of one year and therefore a full-blown PVA was not possible. However, the population studies and the data collected will certainly form a basis for further investigations especially in terms of population viability analyses.

2.3 The Research Hypothesis

Population size, isolation and fragmentation have an effect on seed dispersal, regeneration and therefore survival of populations of slow growing climax tree species within sacred groves of the northern Western Ghats.

2.4 Project Objectives (as outlined in the project proposal)

- To understand the distribution of some rare tree species within the Konkan region and study their confinement to sacred groves of the region
- To understand the conservation status of the species
- To document baseline population and distribution data of the species
- To identify and assess the impact of threats to the species
- To involve local people in the conservation process

2.5 An introduction to the four species selected for the study

To assess the effect of “smallness” within sacred groves, four rare medicinal trees of the Konkan region were selected for the study. No specific criteria were used in selecting the species but through AERF’s on-going work in the area, it was observed that a few species were mostly or in some cases almost exclusively found in sacred groves. A list of such species was complied out of which four species that would be best indicate the ecological processes within these habitats were selected. A brief introduction to the species along with botanical information has been provided here.

2.5.1 Antiaris toxicaria, Lesch

The species – *Antiaris toxicaria* belongs to the family Moraceae. This is a tall evergreen tree species, which is often conspicuous in areas where it is found, mainly due to its sheer size. The tree is usually tall with a straight trunk, often buttressed and its crown jutting

distinctly out of the forest canopy. Flowering in the form of receptacles begins during November and December and soon the tree bears fruits in January. Fruits are a reddish drupe, velvety to touch measuring 2-3 cm in diameter. The *Antiaris toxicaria* is distributed throughout the Western Ghats of India as well as some parts of south-east Asia including Java where its is known as the Upas tree. There have been several references of the lethality of Upas tree in local legends of Southeast Asia. There were beliefs of being affected even by merely sitting under the tree. Although most of these claims are unrealistic, the Upas tree has at times caught people's imagination and been referred to in literary texts and poems, an example of which has been given below.

"The Upas tree had reared its head,
And sent its baneful scions all around,
Blasting, where'er its effluent force was shed.
In air and water and the infected ground,
Allthings wherein the breath and sap of life is found"
-Southey
(extract from "The Flowering Plants of India" Education Society Press, Bombay)

Unlike beliefs in the Indonesian archipelago, local people in the Konkan region are unaware of the poisonous latex of the *Antiaris*. Being naturally restricted to patches of moist deciduous to semi-evergreen forests in Konkan, people here generally unaware of the species. Locally known as *Chand-phal* (*Chand*: moon, *phal*: fruit) or Daswan, there have been reports of the use of seeds to treat diabetes. Although the use of the seeds for medicinal purposes has not been confirmed by any scientific investigation, a minor trade of the seeds is gradually flourishing in certain pockets of the Konkan region.

In Konkan, *Antiaris toxicaria* is almost exclusively found in sacred groves. Even within these protected forests, populations are usually small and regeneration of the species is slow. This is an under-studied species of the region and understanding of its distribution and phenology is absent in published literature. It was therefore an interesting and a challenging experience to study this majestic tree species.

Male receptacles of *Antiaris toxicaria*

2.5.2 Hydnocarpus pentandra (Buch. -Ham.)

This species finds a place in the botanical family – Flacourtiaceae. Hydnocarpus pentandra is endemic to the Western Ghats although the species has also been observed in some parts of the Eastern Ghats as well (Ghaneshan pers. comm). This evergreen tree species is often seen as a medium size tree with a smooth bark, oblong leaves and a hard spherical fruit. The fruits of this species are quite distinct – often the size of a cricket ball, dark brown in colour and exceptionally hard even when ripe. Seeds have known to be used for extracting oil traditionally used in oil lamps and for treating leprosy (Yadav and Sardesai 2002). The Hydnocarpus is rare in the northern Ghats more frequent further south mostly found in damp areas along stream and riverbanks (Kirtikar 1994). Pascal and Ramesh (2002) in their Atlas of Endemics of Western Ghats have plotted the distribution of the Hydnocarpus although focusing more on the southern Western Ghats. The current project has probably been the first attempt to understand the distribution of Hydnocarpus pentandra in the northern Western Ghats. Combining the distribution map of the north and south, the distribution of the species is generally restricted to certain patches of evergreen to semi-evergreen patches within the Western Ghats. Additional data will certainly reveal that the Hydnocarpus pentandra is a species of conservation concern and efforts to include the species in the IUCN red data book must be considered.

2.5.3 Saraca asoca (Roxb.) de Wilde

The Saraca asoca is listed as vulnerable in the IUCN red-list. Locally known as the Sita-ashok, the species is considered sacred by Hindus and Buddhists and is mentioned in the Hindu epic – Ramayana. The epic describes the queen Sita being imprisoned by the demon Ravana in a garden of Ashoka trees and therefore the species was named Sita-ashoka. The Sita ashoka is a beautiful evergreen tree species, relatively short and with a spreading crown. The species belongs to the family Fabaceae and bears short, stout legumes in the month of April. The flowers are fragrant, bright yellow to begin with and then turning red by May. Due to its flowers and foliage, the species is popularly planted near houses and temples and is considered sacred. The Sita ashoka is medicinal; its bark has been known to have a stimulating effect on ovarian tissue and to curb internal bleeding (www.himalayanhealthcare.com). The species is found throughout India and it is often found planted near temples. However, this species is now considered to be under threat and has been included in the IUCN red list. It has been categorised as a vulnerable (VU) species and it was therefore essential to understand the status of the species in the Konkan region where it is claimed to have more presence.

2.5.4 Strychnos nux-vomica L.

"*Among the Malabar immigrants to Ceylon there is a belief that the seed (of Strychnos), if habitually taken, will act as a prophylactic against the venom of the cobra: and I have been assured that the Indian coolies accustom themselves to eat a single seed a day with that obje*ct"

-Tennent ("Flowering Plants of India")

The *Strychnos nux-vomica* was another poisonous tree species of the Western Ghats that was included in this study. This species is member of the Loganiaceae family. It is a medium sized evergreen tree species, flowering between January to March and fruiting soon afterwards. Fruits are yellow, spherical with 2-3 coin like seeds embedded in a think pulp. The pulp as well as the seeds has been known to be poisonous although the seeds are used in minute quantities in local medicine. The seeds are also a source of Strychnine, which finds a use in Homeopathic medicine. The *Strychnos nux-vomica* is found throughout south Asia and is found in open habitats. This is probably the more commonly found species amongst the four selected for this study. However, it was observed that populations of this species were mostly found within sacred groves. Another interesting aspect related to this species is its unique association with hornbills found in the Konkan region. This was therefore an appropriate species to study and compare dispersal and regeneration within, between and outside sacred groves, details of which have been furnished further on in this report.

***Strychnos nux-vomica* fruits**

Strychnos nux-vomica

Malabar Pied Hornbill (*Anthracoceros coronatus*)

3.0 A detailed account of project methods and activities

The overall aim of this project was two-fold. Firstly, the project was aimed at understanding the ecology of rare tree species within sacred groves. Since sacred groves are essentially fragments of once extant forests of the Western Ghats. The intention was to understand how fragmentation affects populations of climax forest species. Secondly, the project attempted to assess the conservation status of the four tree species identified for the study. The criteria for the selection of these species have already been discussed earlier (see 2.3). Since all the four tree species have been known to be rare in the northern Ghats, the project also provided an opportunity to assess current conservation status of these species in the study area. With these objectives in mind, the principal investigator and his team undertook a range of activities, details of which have been provided in this section.

3.1 Project work and time-line

Work on the project began early in 2006. A preliminary visit to the study site was arranged in February although majority of the data collection didn't begin until May 2006. Based on the project objectives (see section 2.4), the team undertook a range of activities including data collection, awareness generation as well as germination tests. Since the monsoon (rainy) season that spans between June to October makes fieldwork difficult in the Western Ghats, the team began the project with a well-defined pre-monsoon and post-monsoon fieldwork plan. The focus during the pre-monsoon period was on collecting distribution data whereas after the monsoon, regeneration could be clearly observed and therefore more time was spent on assessing seed dispersal, regeneration and germination in different areas within the study site. Activities such as awareness generation, documenting traditional knowledge as well as interviewing local people were undertaken throughout the year as and when the opportunity arose. Details of each activity undertaken during the course of the project have been provided here.

3.1.1 Deciding a fieldwork strategy (Jan & March 06)

As soon as the Rufford Small Grant was received early in January 2006, preliminary visits to the study sites were arrange, one in January followed by another short visit in March. During these visits, the team visited a number of sacred groves within the Sangameshwar area where AERF had previously undertaken work. During these first visits to the field, a trial of various sampling methods was undertaken which eventually helped in deciding a methodology for data collection for the coming months. The team tried out cluster

sampling plots as well as parallel transects and randomly laid quadrats to estimate population density within a few scared groves. The opportunity during the first two visits was also used to gather information from local people, initiate discussion with local experts as well to familiarise the team with the study area and the species to be studied. As a result of these first visits to the field, the team could develop a well-defined work plan as well as a sampling and data collection strategy for the project.

3.1.2 Generating awareness (April – Dec 06)

Raising people's awareness regarding the need to conserve sacred groves as well as the species found within them has been an important component of AERF's on-going work. Generating awareness, creating an interest in the issue and amassing public support is usually the first step towards implementing a conservation project (Brown & Wyckoff-Baird 1994). AERF has already undertaken extensive work to raise awareness regarding the need to conserve sacred groves. However, the importance of sacred groves as areas where rare as well as medicinal plants are found was a concept new to both local communities and ecologists alike. It was through this project that an initiative to link rare medicinal plants and sacred groves was taken. Since medicinal plants are still extensively collected and used in the Western Ghats, local communities value areas where medicinal plants are found. In such a case, it was conceptualised that a useful but rare plant would therefore be an appropriate 'flagship' species in order to promote and gain community support for the conservation of sacred groves.

At every village visited during the project, a printed brochure depicting information regarding sacred groves, rare plants and the four species selected for this study was given. Often the issue of the importance of sacred groves for rare plants was discussed at

a few village meetings and during informal discussions with villagers, local medicine men and experts. A scanned copy of the brochure and an English translation of the same have been provided in the appendix of this report. Often, local names of plants differ even between villages separated by a few kilometres. The colour brochure depicting photographs of the species was vital in documenting local people's knowledge of its distribution and use in traditional medicine.

3.1.3 Interviewing local people and experts – understanding distribution and documenting ethnobotany (June - August 06)

Often local people provide crucial information about how a species is distributed or used locally (Wong 1999). Throughout the duration of the project local people were regularly consulted. The project team met with a number of local experts – botanists, local medicine men, ayurved (herbal) doctors, forest officers and knowledgeable locals based in various sections of the Konkan region. On the basis of information and locations mentioned by these informants, the team visited areas to plot the distribution of the four species as well as estimate the density of the species within these locations. At every site visited, informants were asked for other locations known to the informant where the species could be found. The team therefore undertook explorations based on information about provided local informants. This form of sampling is referred to as the *'snowball sampling technique'* popularly used in social science research. Although this form of sampling is opportunistic, it was a cost-effective method to prepare a distribution map for each species selected for this study. Furthermore, information provided by local people was useful and it made explorations easier which otherwise would have been quite a cumbersome exercise. In addition to documenting distribution, the team were also able to document traditional knowledge linked to each species. A study of local knowledge is therefore important in understanding how local communities value wild medicinal trees as well as perceptions towards forests and sacred groves in a rapidly changing landscape.

3.1.4 Assessing geographical range of each species, habitat size and locations (June - August 06)

The current project is based upon the understanding that the four tree species selected for this study are *'restricted range'* species. It was therefore important to understand the distribution of the selected species within the Konkan region, identify locations where large populations of these species are found and finally assess the conservation status of these species. To prepare distribution maps, the project relied mostly on information provided by

local people and site exploration undertaken by the team. In addition to the primary data collected through such explorations, secondary data was also used which was collected from published and unpublished sources such as herbarium sheets, flora, academic literature as well as information provided by expert botanists.

Distribution was plotted on a base map using a GPS. Point locations where the species were found were taken along with demarcation of habitats. Where possible, locations of each individual within the populations were plotted which could further help in a spatial analysis (Gibson 2002). Although a spatial analysis is beyond the scope of the present study, the data could certainly be used for such an analysis if the need arises. Boundaries of sacred groves where species were found were also plotted which was used to calculate habitat size, edge area as well as distance of marked individuals from habitat edge.

Geographic Information System (GIS) is now considered as an important tool in conservation biology. Due to certain limitations, the data could not be incorporated into a GIS. In due course the data will also be incorporated in such a system, which will allow better representation and understanding of species distribution.

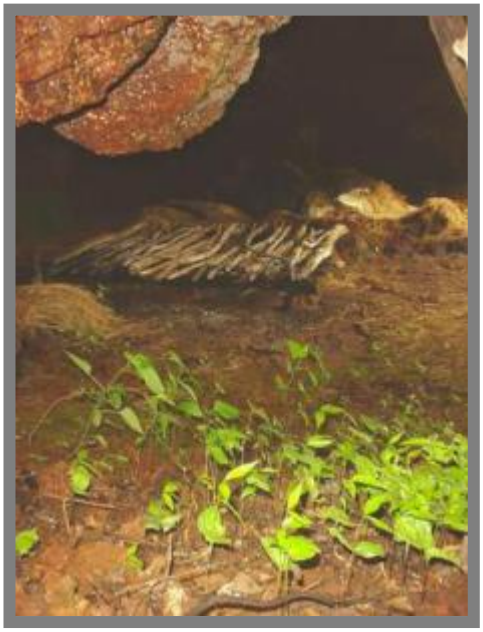
Apart from such analyses, one of the main objectives of this study was to assess the conservation status of the species using IUCN criteria and categories (2001) Regional guidelines developed by Red List Authority (RLA) were also referred to since this was primarily a regional assessment. Data relevant to the extent of occurrence, area of occupancy for the selected species were used against IUCN criteria, details of which have been provided further on in this report.

3.1.5 Regeneration and seed dispersal studies (September 06 – Jan 07)

Understanding population dynamics and life history characteristics in general are fundamental to the conservation of rare plant species. (Fiedler et al 1998). As a part of this project, four aspects of population biology were focused upon viz. population size, population structure, seed dispersal and regeneration. Based on these aspects, one of the project objectives was to assess the effect of population and habitat size on seed dispersal and regeneration. It was also initially conceptualised that on the basis of the data collected during the one-year time period of the project, an attempt to construct a static life table could be made. However, this has not been included in this report. The exercise of constructing a life table was meant more to be leaning experience for the principal

investigator rather than a thorough analysis, although this project will clearly provide a basis for further investigations in this direction.

Seeds and their dispersal has been an area of interest for most population ecologists mainly because seeds are founders of populations and may therefore augment or cause the degeneration of local populations (Silvertown 1987). Plants have evolved a range of strategies for the dispersal of seeds, which still fascinates most ecologists. Seed dispersal strategies may include agents such as wind, water, birds, mammals, ants and even fish (Fenner and Thompson 2005). Interestingly, Peters (1994) notes that animals, mostly birds and mammals, primarily determine the distribution and abundance of seedlings in tropical forests. It was therefore appropriate to consider seed dispersal and seedling establishment as an indictor for assessing persistence or *health* of the tree populations studied here. Fenner and Thompson (2005) further explain that seed dispersal by birds is complex and is often affected by a range of factors including habitat structure, canopy gaps, perching sites as well as behaviour and abundance of dispersers. Fragmentation and habitat size also has an effect on dispersal distances as demonstrated by Cordeiro and Howe (2003). Based on their study, the authors state that as forest patches become increasingly fragmented, seedling recruitment in bird dispersed seeds of a tropical tree species decline drastically. Replicating some of the methods used to prove this phenomenon, the present study used a systematic sampling method whereby number of seeds and seedlings were counted at 5-meter intervals from a parent tree or trees. Using this data, Population recruitment curves (PRC) and seed shadows were plotted for species selected for the study. Seed shadows and PRCs are essentially representations of seedling density and dispersal distances at specific distances from a parent tree (Gibson 2002) (see graphs).



Regeneration of *Strychnos nux vomica* caused by bats

For the purpose of this study, PRC and Seed shadows from different sacred groves varying in size were compared in order to understand whether population density and habitat size has an effect on dispersion and recruitment. Results of this analysis can be refereed to in the results sections.

3.1.6 Germination trails, raising seedlings and rehabilitation (Feb 07 onwards)

Data collected for plotting the PRC and Seed shadow primarily involved counts of seeds and seedlings per unit area within an identified population. Although this data was important in understanding dispersal and recruitment in different habitats and populations, the PRC is primarily based on a one-time count of population recruitment within an identified population. This does represents a snapshot of spatial variation within a population, however, a temporal dimension is also required in understanding dynamics within populations. An attempt was therefore made to document seedling survival for *Strychnos nux-vomica* and *Saraca asoca* at two locations. A total of six 2m x 2m permanent plots were laid in two populations. Numbers of seedlings were enumerated every two months from September 06 to April 07. Although the number of samples was small and data collection was small to undertake statistical analysis, this procedure was a good beginning for a more rigorous and systematic collection of data. Based on the experience gained from this project, a larger number of permanent plots will now be laid in the various sacred groves identified for restoration by the AERF. It is therefore fair to say that this exercise was more a learning experience and a basis for further study rather than a scientific investigation. A representation of the data on seedling survival for the two species has been given in the results section.

In addition to this, a number of germination tests were undertaken and seedlings were raised at AERF's existing nursery set up for the purpose of restoration of degraded sacred groves. The project field assistant based at the study site, Mr. Sanjay Pashte is well

versed with nursery techniques and propagation and was enthusiastic enough to undertake various trails of crude seed treatments and document successful germination and growth. As results of his efforts over 250 seedlings of *Antiaris toxicaria*, *Hydnocarpus pentandra*, *Strychnos nux-vomica* and some saplings of *Saraca asoca* have grown and are now ready for plantation. During this year's restoration programme, the raised seedlings will be planted in select locations. Results of the various germination tests and seed treatments have been provided in the results section.

AERF's nursery

First batch of *Antiaris toxicaria* saplings at the nursery

4.0 Project outputs

In sync with the format of a typical research document, the methodology and project activities were described in the previous section. The results of the project have been presented and discussed in the following section. There were three main outputs of the project viz. 1) the team were able to assess the distribution and status of the species in the Konkan region 2) the research hypothesis was proved and 3) activities to provide input to the restoration of sacred groves and rehabilitation of the species under study were undertaken. Details of these achievements have been furnished here.

4.1 Distribution maps and conservation assessment using IUCN regional guidelines

One of the major challenges of this project was to understand and plot the distribution of the four species within the Konkan region. As mentioned in section 3, plotting of the distribution maps was done with the help of information provided by local medicine men, experts, as well as through referencing secondary literature. Although a majority of the maps were prepared based on site explorations. Each location was plotted on a base map using a GPS unit. The resulting distribution maps for each of the four species have been provided here. Along with each distribution, a general note on habitat suitability and regional distribution has also been given.

In addition to this, one of the primary objectives of this study was also to assess the conservation status of the four tree species within the Konkan region. It was assumed that all four species were '*restricted range*' species and in the face of rapidly deteriorating forests in the region, the species would be further restricted to small remnant patches such as sacred groves. It was therefore necessary to assess the status of the species using the widely accepted IUCN red list criteria and categories 2001 (see www.redlist.org). Criteria B of the IUCN categories relates to the geographical range of the species as one of the three criteria used to include priority species into global or regional red lists. Area of occupancy and extent of occurrence of a species as well as severely fragmented populations are the main data inputs required to include a species in the IUCN red list based on criteria B. The distribution studies and density estimates undertaken during the study were set against these three inputs. IUCN defines them as:

- **Extent of occurrence (Criteria A and B)** Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary that can be

drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy.

- **Area of occupancy (Criteria A, B and D)** Area of occupancy is defined as the area within its 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats.
- **Severely fragmented (Criterion B)** The phrase 'severely fragmented' refers to the situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonization.

Guidelines for applying the IUCN criteria and categories on a regional scale have been provided in IUCN (2003) *Guidelines for applying red list criteria at regional levels: Version 3.0.* Based on these guidelines, the criteria were used for the assessment of the four species selected for this study. Details provided below.

4.1.1 Distribution and status of *Antiaris toxicaria* in the Konkan region

Antiaris toxicaria is essentially an evergreen tree species mostly found in the climax moist-deciduous to evergreen patches of forests in the Konkan region. Through this study it was found that the distribution of this species was restricted mostly to the lower reaches of the western slopes of the Western Ghats although presence of this species have been reported further east (Punekar, Joshi, *pers. comm*). It was found that the species was entirely restricted to the sacred groves of the region. Population density within these patches was generally low (between 0.8-1/ha). The species were found in altitudes ranging between 100-300m above sea level.

The assessment of the conservation status of the species based on IUCN criteria reveals that although the species is distributed throughout the Western Ghats as well as in some parts of South East Asia, the population in the northern Western Ghats, especially in the Konkan region is geographically distinct. There have been reports of the presence of the species in the district of Pune and Kolhapur however population density has been estimated to be low and severely fragmented. Surveys in the district of Sindhudurg proved unfruitful. An estimate of the global population of the species is unavailable although the

populations within the Ratnagiri district are a major proportion within the state of Maharashtra. Populations are fragmented and known to be found only in small forest patches such as in sacred groves. Area of occupancy has been estimated to be less 2000km^2 and surveys in the region have revealed the presence of the species in less than 10 locations. Therefore, based on regional estimates undertaken here, the following category could be assigned to the species.

IUCN category: VU B2ab(iii,iv) (Vulnerable)

4.1.2 Distribution and status of *Hydnocarpus pentandra* in the Konkan region

This species of Flacourtiaceae is an evergreen tree species endemic to the Western Ghats but Ghaneshan (*pers comm*.) notes the presence of this species in the southern section of the Eastern Ghats as well. *Hydnocarpus pentandra* is rare in the northern Ghats and has been claimed to be more frequent towards the south as the number of rainy days increase along the north-south gradient. However, whilst comparing the distribution map of the species in southern Ghats by Pascal with the map made here, the species appears equally rare in both regions. The extent of occurrence of the species generally appears sparse and patchy. Based on the fieldwork undertaken in the northern Ghats, it was observed that the *Hydnocarpus pentandra* is primarily a riparian species, mostly found along stream banks in the lower reaches of the Western Ghats not beyond 300m above sea level.

Most of the Western Ghats, especially the northern Ghats, is threatened by mass deforestation. Land ownership in the Konkan region is mostly on private hands and therefore deforestation is not regulated. This has resulted in the confinement of this species in sacred groves and therefore populations are fragmented and density has been estimated to be low. Moreover, population recruitment has also been observed to be very

low in all the populations observed in the northern Ghats. In the face of rampant deforestation resulting in the loss of mature individuals and inherently low population recruitment in fragmented habitats, the conservation of this species should be a regional if not a national concern. Based on IUCN criteria, the area of occupancy is estimated to be below 2000km^2 however; the number of locations where the species was found was above 10. In addition to this, status of the species in the southern Ghats is unknown but it is estimated to be at a higher density. On the basis of these assumptions the status of the species is downgraded one step (as per IUCN regional guidelines) to Near Threatened (NT).

IUCN category: Near Threatened (NT)

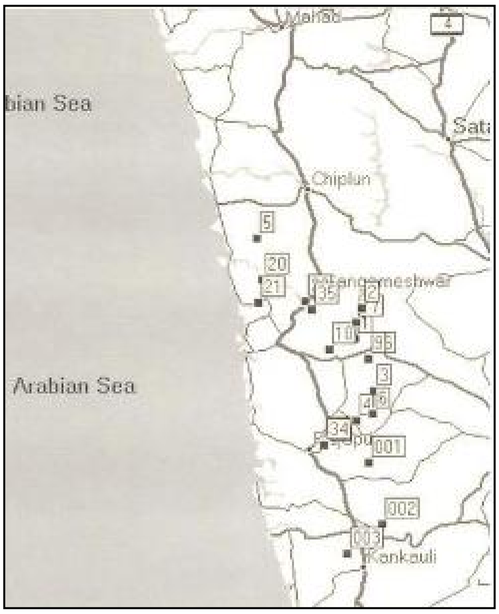
4.1.3 Distribution and status of Saraca asoca in the Konkan region

The S*araca asoca* is a species of religious importance in India. It is found to be popularly planted in gardens and near temples but the status of the species in the wild is believed to be under threat. This species of the family Fabaceae is a short, spreading evergreen tree species distributed throughout India. As a result of the studies undertaken here, it was found that the *Saraca asoca* is also primarily a riparian species found in low elevation ranges. Wild populations of the species have been observed to be clumped. Dense stands of the species on the banks of mountain streams have been seen in the Konkan region however locations of such stands are few and sparse. Even though presence of the species was observed throughout the Konkan region, dense, regenerating populations were found in less than 10 locations within the area surveyed. Moreover, a significant presence of the species is found on private lands, where farming and fuel wood extraction is a primary land use activity. In such cases, the trees are lopped and regenerating saplings uprooted. However, under such conditions, small populations of the species still thrive in some areas of the Raigad district. A previous assessment of the species has assigned it a threat status – Vulnerable (VU) based on an assessment of its extent of occurrence and area of occupancy. The survey undertaken as a part of this study confirms this status and it is therefore fair to claim that the status of this species has not improved since it was last assessed and that its status in the Konkan region is equally threatened

due to deforestation. The plantation of the species such as in temples or gardens has not resulted in the establishment of new populations therefore measures to conserve the species should focus upon protecting and managing existing populations.

IUCN category: VU• B1+2c (Vulnerable)

4.1.4 Distribution and status of Strychnos nux-vomica in the Konkan region



This member of the Loganiaceae family is a medium sized evergreen tree species. The species is distributed throughout the Western Ghats and other parts of India. In the Konkan region it is widely distributed – from the coastal strip right till the base of the Western Ghats upto 300m above sea level. It is often found in open forest habitat such as forest openings, scrub and sometimes even in degraded forests. It is also seen bordering farms and agricultural land. Interestingly its distribution matches with that of the Great Pied Hornbill *(Buceros bicornis)* and the Malabar Pied Hornbill *(Anthracoceros coronatus)* since its dispersal depends on these two bird species. Both bird species are endangered and included in the IUCN red list. Whether this has affected the distribution of the *Strychnos nux vomica* in the region needed further investigation. The survey undertaken as a part of the current study has provided the required answers.

The *Strychnos nux vomica* is claimed to be a relatively common tree species in the Konkan region but during the survey undertaken here, many sparse individuals were seen at a number of locations (see map) but there was a stark absence of continuous populations in the region. On interviewing local people, the response was that the species used to be common however now it is only seen at specific locations. The seeds of the species are known to be a potent poison but was used in small quantities in local medicine more than a decade ago, however in recent years modern drugs have replaced traditional medicine. As a result, local people have lost the value for the species and often cut it down for the fear of cattle being poisoned by feeding on its foliage. An estimate of about 30% of population decline in the Konkan region can therefore be estimated over a period of ten years which meets IUCN criteria A. The IUCN category – (VU) A4cd could be assigned to this species but due to the absence of national population estimates, absence of an

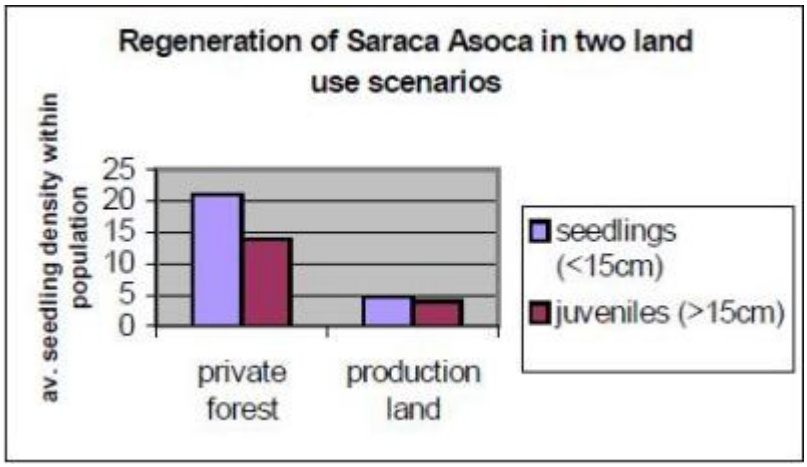
estimate of proportion of global population within the region and the potential of re-colonisation from the south and east due to the large ranging area of its disperser (hornbills), the above said threat category is downgraded by two steps (see IUCN regional guidelines) and the species is therefore assigned the LC status.

IUCN category: Least Concern (LC)

4.2 Traditional knowledge, land use and conservation implications

The study of traditional knowledge linked to a species, in other words, the Ethnobotany of a species is crucial towards understanding how local people value a species. Traditional knowledge can, however, be a double-edged sword when it comes to the conservation of a species! In the case of the Konkan region, local people are more likely to protect or preserve a plant species if it known to be useful. However, if a species is considered to be poisonous even though cases of poisoning have been rare – local people tend to cut these plants. An example of the four tree species considered for this study will further explain the above statement. *Antiaris toxicaria* and *Strychnos nux-vomica* are both poisonous tree species. Interestingly, local people in the Konkan region know of the poisonous seeds of the *Strychnos* species but are unaware of the lethality of the *Antiaris*. This lack of understanding may probably be because *Antiaris* is rare as compared to the *Strychnos* and therefore less likely to be known to people. However, even in villages where *Antiaris* populations are considerable and local people regularly collect its seeds, collectors are unaware of its toxic latex. This directly relates to the threat the species may face in its habitat. Since, *Strychnos* is known to be a poisonous species, its seedlings are usually uprooted so that cattle do not feed on them. Lower branches are often lopped so that grazing animals cannot reach the foliage. This largely affects how the population of the species is distributed and its regeneration within a landscape of a village. In comparison, since knowledge linked to the toxicity of the *Antiaris* is absent and that its seeds are useful, local people tend not to disturb or disrupt population recruitment. However, the effect on population recruitment due to the collection of seeds is a subject that may require further investigation. But, in general, if a species is known to be useful even though it is not currently being used, local people are more likely to protect a particular tree. In one such case, *Saraca asoca* populations were found along the borders of farmlands in the Alibaug block of the Raigad district and in Chiplun block of Ratnagiri district. Here, the absence of any local knowledge regarding the medicinal value or religious importance of the species has led many landowners to indiscriminately lop or even clear fell entire populations of the species to make way for plantations of commercial tree crops. On further enquiry it was

found that older respondents were aware of the medicinal value of the species however the next generation of farmers were unaware of the presence of *Saraca asoca* in their own lands. The shift from subsistence agriculture to a more intensive, commercially driven form of land-use also has its effect on the species. The following graph depicts how regeneration (and ultimately survival) of the species occurs in two types of major land use regimes in the Konkan region.



As stated earlier in this report, a majority of lands in the Konkan region are under private holding. Flat lands and lands in the lower reaches of the Ghats are brought under cultivation whereas the rest of the lands contain secondary growth forests. These privately owned forests have regenerated since shifting cultivation ceased in the region more than a decade ago. In terms of biodiversity and native vegetation these lands seem promising, supported by the fact that *Saraca asoca* populations are *healthier* in private forests than on production lands (see graph). However, these private forests are now being increasingly put to unsustainable use, often clear felled for timber or to make way for commercial plantations. There is a need for a strategy that balances production and land use requirements of local people and conservation of native vegetation on private lands. This should be the direction of the project in its next segment, details of which have been discussed in the section entitled “Future Work” towards the end of this report.

4.3 Use of the flagship species strategy for the conservation of sacred groves

Flora and Fauna International (FFI) define flagship species as:

"Flagship species are high profile and charismatic species, often with important cultural associations, whose protection will act to conserve species using the same habitats. They can act as conservation symbols for the broader environment in which they occur."

The flagship species is essentially a strategy used for the conservation of a larger habitat using a single species as the focus. Following on from the discussion in the section 4.2, traditional knowledge and the local use of a species in the Konkan region is an important factor that determines how a community manages a species and the habitat within which it is placed. A useful species such as a wild medicinal plant is more likely to be protected even though the species may not currently be used. Based on the project experience, it is fair to claim that the knowledge of the usefulness of a species is enough an incentive for people to protect a species. Such species would further be useful in highlighting the conservation value of a site. Useful and traditionally valued species are therefore good flagship species as well. As this project progressed, it was conceptualised that the four medicinal trees selected for this study are appropriate flagship species for the conservation of sacred groves. Therefore, the core message projected to local communities was that rare medicinal trees are now only found in sacred groves and it is therefore necessary to conserve these places. The message was conveyed to target groups through the distribution of printed material and also through village meetings and informal group discussions with local people.

4.4 Proving the research hypothesis

"The great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact"

-T.H. Huxley

To recap, the core research hypothesis of the project was:

Population size, isolation and fragmentation have an effect on seed dispersal, regeneration and therefore survival of populations of slow growing climax tree species within sacred groves of the northern Western Ghats.

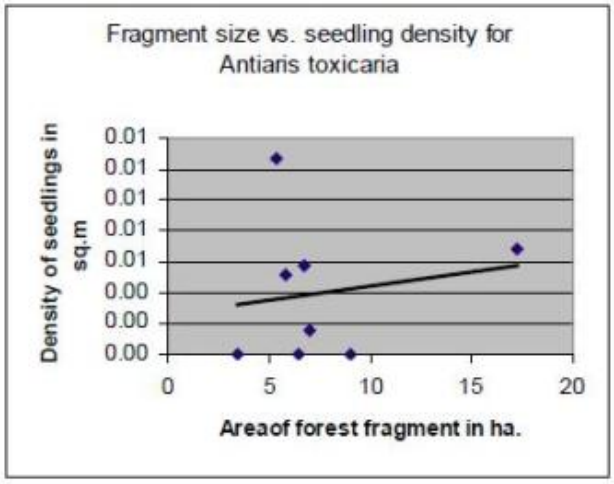
To prove (or disprove) this, the hypothesis was broken down into specific research questions. As the study progressed through the year, data collected helped to provide some answers at times more questions arose. In this section, each research question that arose and the corresponding data to answer these questions has been discussed here. At the end of the section, all corresponding answers have been linked to prove the core hypothesis of the project.

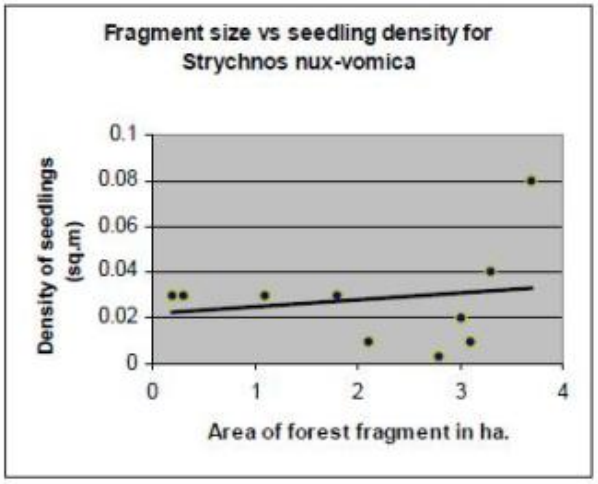
One of the primary outputs of this study has probably been the assessment of the effect of habitat fragmentation on plant populations. In doing so, the project aimed to assess the survival of the tree species within different sacred groves. This has been the beginning of an in-depth study of the phenomenon and the results presented here are by no means complete. Although the data collection was rigorous during this one-year period, the amount of data that the team was able to collect was small and probably not adequate enough for a full-fledged analysis. However what has been presented here is how the process of enquiry took place and the results achieved at each stage. In the following paragraph, research questions that adhere to the core hypothesis (see 2.3) have been answered. Data collected has been presented to support the team's explanations for the observed phenomenon in the field.

Research Question 1: Do large fragments have better regeneration than smaller ones?

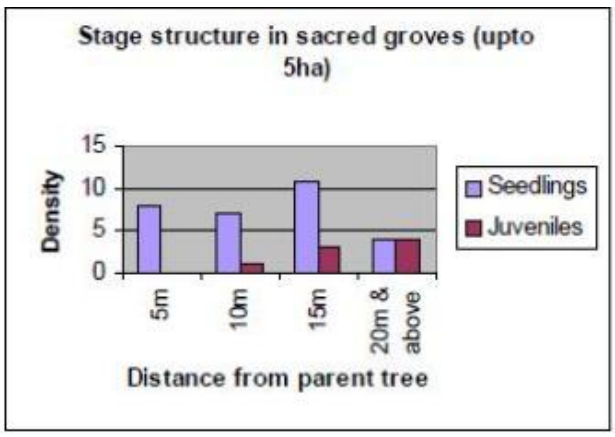
Yes, but not necessarily. The data collected through this project shows a general trend but certain disparity does occur. In general, a larger habitat is likely to have better regeneration (measured as seedling density per unit area). The correlation coefficient (r) is positive (r=0.88) but certain data points within the graph do not follow this trend and therefore the corresponding *p-value* (*p*~0.02) shows an in-significant relation. The small sample size may have also resulted in not significantly proving this relation. At a few locations within the study area, high regeneration was observed even in small fragments ranging between 5-10 ha in size. Other factors such as habitat quality, diversity, connectivity and population of dispersers do come into play when it comes to population recruitment. Although at this stage it would be fair to claim that larger habitats show better recruitment but in some cases smaller fragments may also house healthy populations of rare tree species.

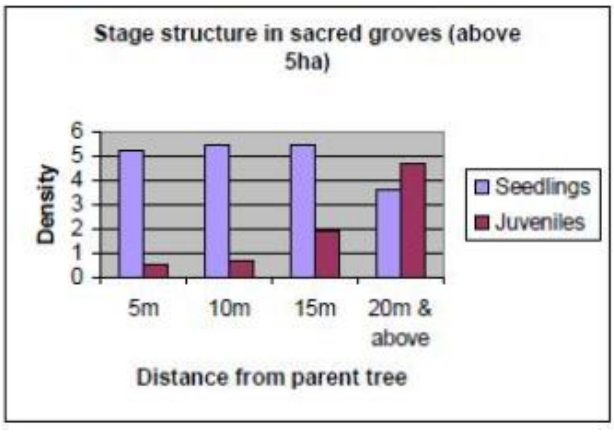
The following two graphs depict outputs of a correlation analysis of habitat size and seedling density for *Antiaris toxicaria* and *Strychnos nux vomica* within sacred groves of the Konkan region.





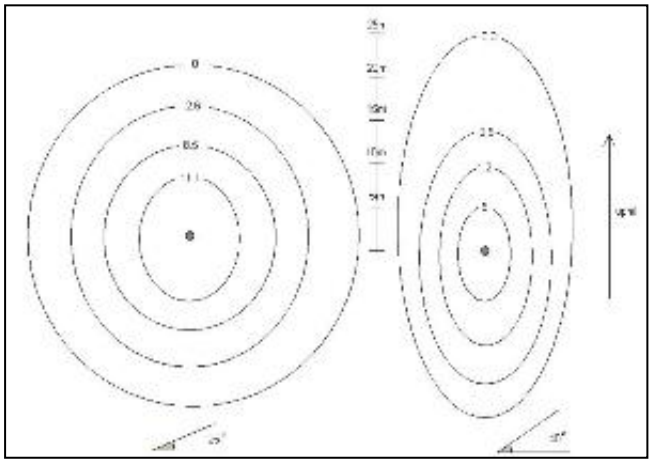
It is understood that sample size has been inadequate to undertake any rigorous statistical analysis and therefore, alternative representations of the data have been provided here to allow the reader to come to specific conclusions. In conjunction to the correlation analysis undertake above, the following graphs help to understand and prove that larger fragments not only tend to have higher seedling density but seedling survival is also relatively higher. Seedling density estimates were categorised into two: 1) juveniles – seedlings above 15cm height which are probably at least a year old, and 2) seedlings – less than 15cm height which are indicate the number of recently germinated seedlings. This is a simple method to determine the age of the seedlings based on their height and therefore referred to as *stage-structure distribution*. Based on this categorisation, it is further useful to infer the survival of the seedlings within the habitat.

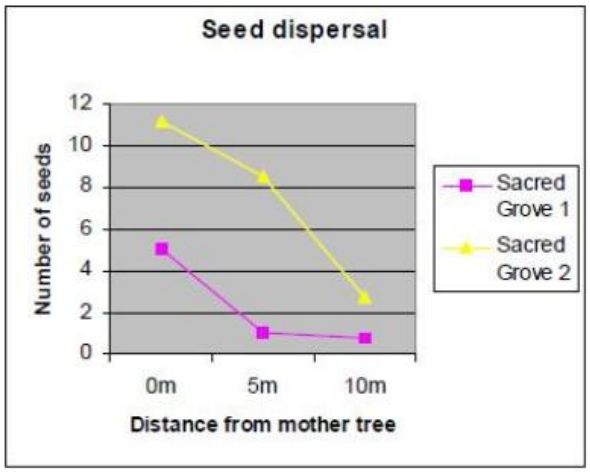




The above two graphs do explain how dispersion and recruitment differ in large and small sacred groves although there a may be a number of factors apart from habitat size that may affect this phenomenon. It is however interesting to note from the two graphs that although more dispersal occurs in larger fragments and there are more juveniles which is a result of seedling survival, there is a higher seedling density within 15m from the parent tree in smaller fragments. Based on field observations, quality of habitat and behaviour of disperser are also important factors.

To further explain the phenomenon, a different example has been depicted in diagram 1. The diagram depicts seed shadows for *Antiaris toxicaria* in two different habitats. Isoclines of average seed density per tree were roughly plotted for the two habitats and the corresponding PRC has also been shown



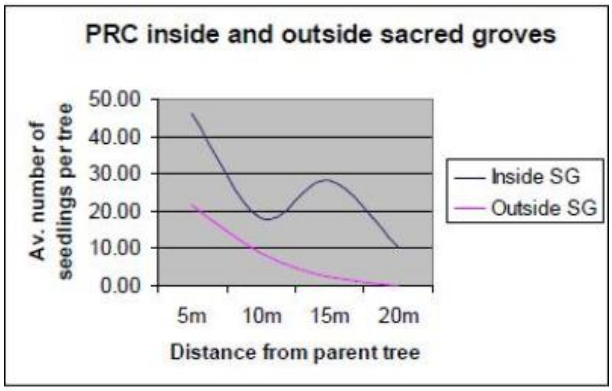


Based on this representation of seed dispersal in different habitats, it is evident that a range of factors intrinsic to the habitat such as quality, structure and even slope (as shown in the diagram) may effect seed dispersal, population recruitment and ultimately survival of the species within a habitat. The current study focused on a few such factors such as habitat size, habitat quality (in terms of tree density and average vegetation height) as well as population density and structure. Relation of habitat size with respect to population recruitment has already been discussed earlier. However, one of the major effects of fragmentation is on the movement of fauna and plant propagules within and between habitats. It has been proved that small habitats result in smaller populations of dispersers or ultimately the loss of dispersers altogether. This has a knock-on effect on seedling recruitment. Fenner and Thompson (2005) also note that habitat structure and behaviour of disperser (often birds and mammals) is also a major driving factor. It is therefore fair to

claim at this point that it is not essential that larger fragments are better habitats than smaller ones. A range of factors affects population dynamics and the effect of fragmentation on a habitat or a population are different even within similar populations or habitats.

Research Question 2: Does regeneration differ inside and outside sacred groves?

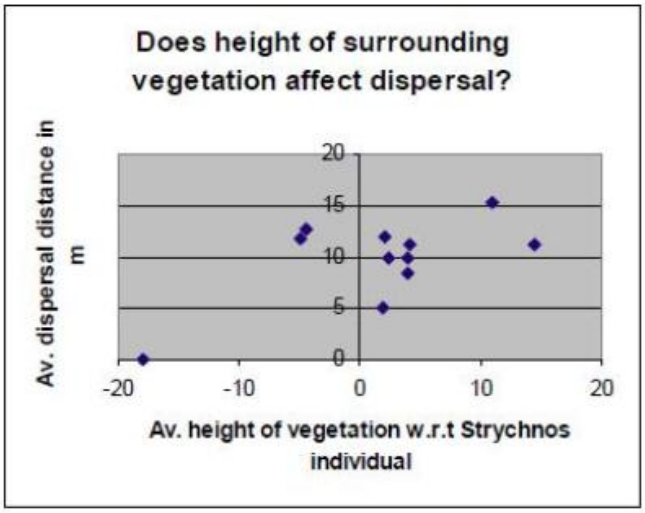
It does differ. This study focuses on seed dispersal and seedling recruitment as two of the many processes within tree populations. The assumption is that the two processes possibly best indicate the health and dynamics within a population. An attempt has therefore been made to examine and compare dispersal rates and seedling distribution in different sacred groves. To begin with, a comparison of trees inside as well as outside sacred groves was undertaken. *Strcyhnos nux-vomica* and *Saraca asoca* were probably the only two species out of the four which could be observed outside sacred groves. Seedling density at specific distances from parent trees was recorded for a total of 36 individual trees at 15 different locations in the Konkan region. A population recruitment curve (PRC) was plotted for observations made inside as well as outside sacred groves and the data has been represented in the graph shown here. Although a two-sample *t-test* (one- tail) conducted to compare means of dispersal distances and seedling density per tree within and outside sacred groves revealed an insignificant difference between the two groups [dispersal (p~0.04) and density (p~0.13)]. The graph shown above does depict a different pattern in seedling distribution and density inside and outside sacred groves.



Research Question 3: In bird-dispersed seeds, does quality of surrounding habitat affect dispersal distances?

Yes although height of surrounding vegetation is a factor. Seeds of the *Strychnos nux vomica* are primarily dispersed by birds although there have been observations of bats playing a role as well. The fruits of the species are a favourite food for the Great Pied Hornbill (*Buceros bicornis*) and Malabar Pied Hornbill (*Anthracoceros coronatus*) (Pande 2003). Since these species were observed throughout the study area, it was an interesting relationship, which needed further study. Fenner and Thompson (2005) again point out that habitat structure and behaviour of the disperser determines how dispersal occurs.

During the course of this project, it was observed that hornbills feed on the fruits of the *Strychnos* tree and then perch on a nearby tree that is often tall enough to perch after which seeds are defecated. In the absence of tall trees in the vicinity of a parent tree, seedlings were either entirely absent or clumped right under the canopy of the parent tree. The height of surrounding vegetation as adequate perching sites was assumed to be an important factor in the dispersal and germination of seeds. When observations of seedling density and dispersal distances were made, difference in heights of the parent tree and surrounding vegetation was recorded. Based on this data, the following representation was made.

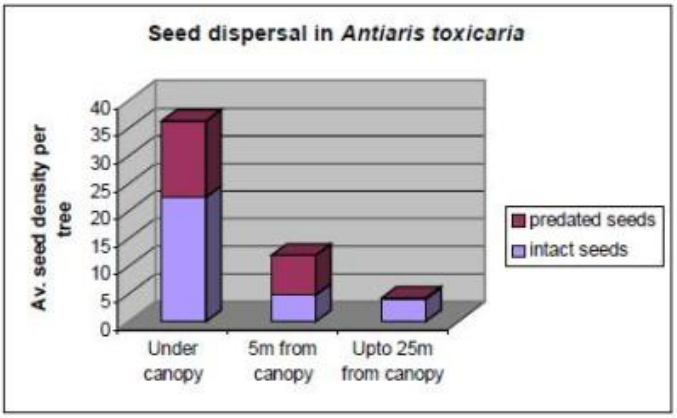


Average dispersal distances for recently germinating seedlings were plotted against height differences. The data points show clumping towards the centre of the graph indicating that highest dispersal is seen when surrounding vegetation is between 5-10m taller or shorter than the parent tree. Taller vegetation is better than shorter as can be seen by the data points towards the right hand corner of the graph. An interesting addition to this observation is that Cipollini & Levey (1997) hypothesize that plants bear poisonous fruits as a strategy to possibly force dispersers not to spend too long at a single plant, thus reducing the likelihood of seeds dispersal beneath the parent plant. *Strcyhnos nux-vomica* bears poisonous fruits. If this hypothesis is true in this case then it explains short feeding periods of hornbills on *Strychnos* fruits although further data collection and a systematic study in this direction is required.

Although this represents just one factor of the ecology of a tree species and its disperser, it is a beginning towards understanding how seed dispersal and mutualism between tree and disperser is affected by habitat fragmentation.

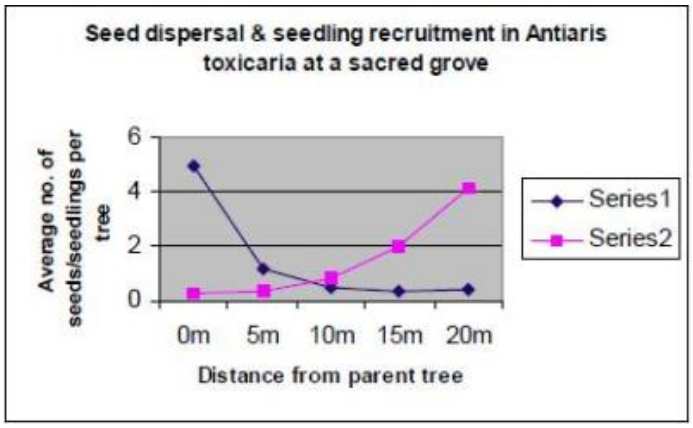
Research Question 4: Does better dispersal ensure successful regeneration amongst populations?

Yes. Dispersal of seeds is allegedly advantageous to plants such that seeds or seedlings may escape from predators or pathogens near the parent, prevent competition between parent and offsprings and finally locate and inhabit suitable new locations (Venable & Brown 1988). However, the key ecological question is whether dispersal of seeds is crucial to ensure the survival of a species within a habitat. As a part of this study seeds were collected at regular intervals from the parent canopy of the *Antiaris toxicaria* in three separate scared groves. Collected seeds were then sorted in two groups – 1) seeds that appeared intact and viable and 2) eaten and infected seeds. A representation of this data can be seen here.



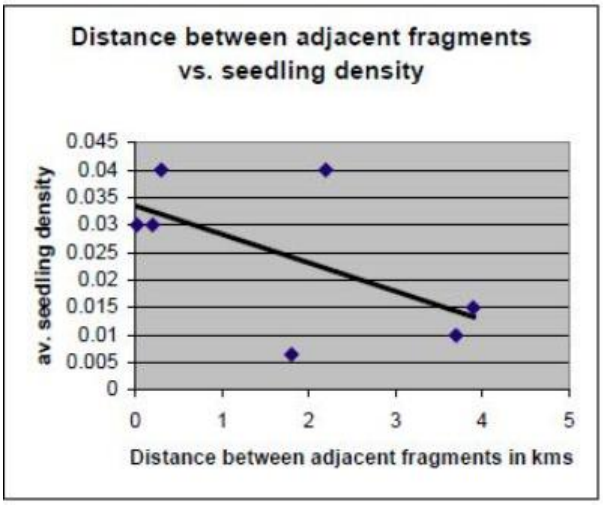
The graph clearly shows higher seed predation near the tree canopy as compared to seeds falling farther away from the parent tree. The data reveals that between 40-60% of seeds sampled from upto 5m from the parent tree were predated whereas a significant drop in seed predation (only upto 5% of total sample) was observed beyond 20m from the tree canopy.

So, the farther the seed gets from the parent tree the more likely it will germinate. To prove this statement, seed density and seedling density curves were plotted (see following graph). This further supports the statement that although a higher proportion of seeds fall under the canopy and are eventually affected by predators and pathogens, a smaller proportion of seeds do get adequately dispersed and a more likely to survive and contribute to the survival of the species.



Research Question5: Does isolation of habitat affect population recruitment?

Yes, but not always. Often habitat fragmentation and isolation are interdependent. It is evident that continuous forest is turned into small patches of trees; distance between patches may play a role in the movement of dispersers between fragments. Zuidema et al (1996) supports the fact that the more isolated a patch, the less likely it will be visited by a disperser and lesser regeneration it will have. *Strychnos nux vomica* is dispersed primarily by hornbills and was therefore an appropriate test for this hypothesis. In the Konkan region, almost each village has a sacred grove. In a few cases, a village may have more than one sacred grove separated by a few hundred meters. Neighbouring villages may have sacred groves separated by a few kilometres. Such cases were considered for this aspect of the study and distances between sacred groves as well as the density of *Strychnos* seedlings within each patch was calculated. As a result the following representation was made:

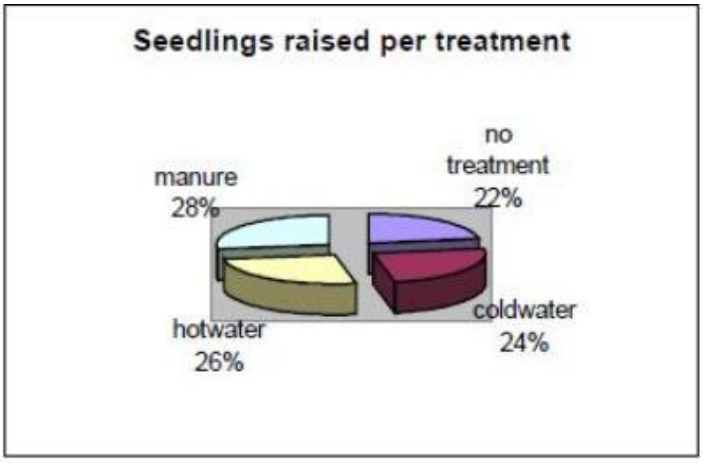


Although, there lacks a clear trend in this data set due to limited data, it can be inferred that fragments closer to each other have a higher average seedling density but this trend

is unaffected in distances between a few hundred meters to upto 2kms. At distances larger than 2kms, average seedling density within adjacent fragments is distinctly low. This again depends on the travelling range of the dispersal agent (birds in this case), which may be unaffected by distances within 2kms. This could be a possible explanation to this trend however; further investigation currently undertaken by the team will provide further clarifications.

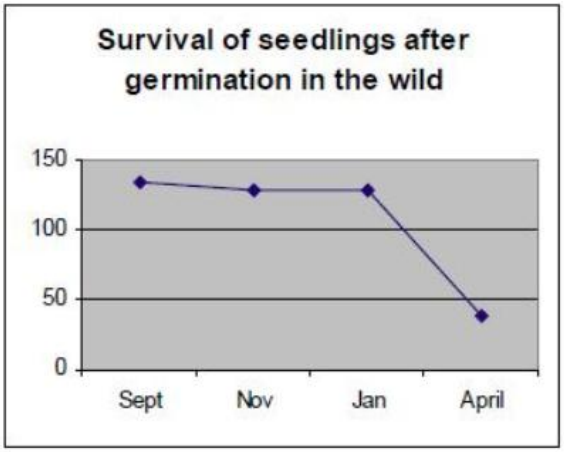
4.5 Seedling nurseries, permanent plots and seedling survival

This project was originally conceptualised not only to be a research project but to also include a component of implementation. AERF's work in the Konkan region has mostly been directed towards conservation action, the objective behind which has been to revive the tradition of sacred groves and to induce community participation towards the protection and restoration of sacred grove habitats. In the last two years, AERF has focused its efforts towards the restoration of sacred groves in 8 villages of the Ratnagiri district. As a part of this activity, local people were provided an opportunity to raise seedlings in their own nurseries. These seedlings were then planted into degraded sections of sacred groves. Many rare tree species were re-introduced into sacred groves as a part of this activity. Following on from this experience, seeds of the four species selected for this study were collected from the wild and propagated in an existing nursery. Upto 5 different seed treatment procedures were used to test the germination of the seeds. Results of the treatments have been given in the following graph.



Over 300 saplings of *Antiaris toxicaria*, *Hydnocarpus pentandra*, *Saraca asoca* and *Strychnos nux-vomica* were raised as a part of this initiative. These seedlings will now be re-introduced into areas within the geographical range of the species. In addition to this, survival of seedlings naturally germinating in sacred groves was regularly monitored for a

period 8 months – from the end of the monsoon till the beginning of monsoon in the following year. It was found that only about 30% of the total seedlings germinated survive in the following year given that anthropogenic disturbance is minimal. The highest mortality occurs in the summer season (from March-May) when soil moisture is the lowest and average day temperatures are the highest. In deciduous forests, incidence of direct sunlight on the forest floor is also highest during this season, which also may be a factor behind seedling mortality in forests.



5.0 Discussion & Conclusion

On the basis of the results shown in the previous section, an attempt has been made to resolve the argument over the effectiveness of sacred groves as conservation areas. Moreover, this section of the report discusses the significance of this study and its application with relevance to the conservation and management of sacred grove habitats. In addition to this, major drawbacks and challenges incurred during the project have been mentioned and finally future directions of this work have also been outlined.

5.1 Effectiveness of sacred groves as conservation areas

As stated by Curtis (1956), small groves and forest stands are bound to undergo change when compared to continuous forests. It is evident that the ecology of a grove or a network of groves is distinctly different to the dynamics that occur in a continuous forest. However, a major concern amongst conservation biologists is whether forest patches are likely to ensure the survival of species found within them. Based on the data collected and represented in this report, it is clear that a range of factors potentially affect the survival of species within a habitat but in the case of small populations of rare tree species found within sacred groves, the following conclusions of the study could be made:

- In the absence of continuous forest, groves however small in size are important for the survival of rare tree species
- Rare tree species continue to survive in sacred groves fragments in low densities however population recruitment in some cases is severely affected by low dispersal and high seedling mortality
- Seed dispersal, seedling distribution, regeneration (population recruitment) and survival are good indicators to assess the health of a population of plants.
- The more dispersed seeds are within a population, the more likely it is for seedlings to survive.
- Habitat quality and structure are important factors to ensure the survival of bird dispersed tree species.
- Landscape level effects such isolation; edge effect and connectivity are important and should be considered whist undertaking the conservation of sacred groves and the species found within them. It is therefore recommended that AERF undertake efforts beyond scared groves and plants in isolation towards landscapes within which sacred groves are placed.

5.2 Drawbacks and challenges faced during the study

The current study was undertaken for a period of one year. During this year, data collection was undertaken such as to best incorporate seasonal variations into the study of plant populations. However, due to a range of factors the data has been limited, patchy and in some cases inadequate for the team to undertake a full-scale statistical analysis. This has affected the quality of analysis presented in this report although the team has made an effort in addressing the problem and providing an adequate picture of events that happen on the field. Other major challenges incurred during the project were the challenging work conditions on field especially during the monsoon (rainy) season. In the past two years, the Konkan region has experienced the heaviest rainfall in more than a decade due to which flooding and landslides were common. However, the team were regularly in touch with correspondents in the study area, safety of the team was always a priority and therefore fieldwork schedules were appropriately planned.

5.3 Significance of the study and future direction of work:

To recap, habitat fragmentation affects regeneration of rare tree species as a result of low dispersal. This ultimately indicates that fragmentation not only affects species and populations but also severs ecological processes such as mutualism between fruit bearing trees and dispersers. On the long run this has a knock on effect on trees and birds as well as mammals, which then results in the loss of diversity within forest fragments. Therefore, the challenge is to maintain diversity and ensure the conservation of rare species within forest fragments.

The results of this study suggest that mere protection of sacred groves will not be enough to ensure the survival of rare tree species and efforts should be directed towards augmenting population recruitment and allowing dispersal agents to take effect. This may be undertaken through habitat restoration, species rehabilitation, re-introduction, and creation of habitat that benefits dispersers. Finally, sacred groves and forest patches need to be considered as an integral part of landscape management and use.

AERF is committed towards the conservation of forests in the Western Ghats. This project has been a starting point for young researchers at the AERF. On the basis of the experience and understanding gained from this project, the team were able to conceptualise as well as develop a number of follow on projects, details of which have been given here.

5.3.1 Follow-on project 1: Up scaling and enhancing AERF's work on sacred groves (received Whitley Associate Award 2007)

The team at AERF has long been discussing the need to up-scale its work related to the restoration and management of sacred groves in the Western Ghats. In the past, the team has worked on a community based, site specific approach however, the need to consider the entire range of ecological scales – from species to landscapes was felt. A project to continue and enhance the organisation's work on the restoration of sacred groves was developed, for which a Whitey Associate Award was recently received. The current project and its results have provided crucial inputs in developing the "up-scaling project." The species based study undertaken here has provided inputs on the ecology of sacred groves and how population recruitment occurs in different habitats. These are useful inputs whilst considering the restoration of sacred groves and the rehabilitation of rare tree species

within them. Apart from this, the study of dispersal and the effect of habitat quality, fragmentation and isolation highlights the need to consider landscape scale effects. The Whitley Award supported project is based on the understanding that sacred groves are an integral of the landscape of the Western Ghats and therefore any intervention activities through the project will consider adjoining land use within the landscape matrix, patch connectivity and edge effect in habitats.

5.3.2 Follow-on project 2: Further study of dispersers, forest regeneration and the need to conserve dispersers (recently received a small grant from Flora and Fauna International)
Dispersal studies of *Strychnos nux vomica* and *Antiaris toxicaria* have probably been the first of its kind in the Western Ghats. Although, the study was focused on a tree species, its seed dispersal and population recruitment, the data collected could have been complemented by a study on hornbills and the extent of their role. Since hornbills play a keystone role in the regeneration of forest species in the Western Ghats, a follow-on project was developed with the objective of understanding the association of hornbills and climax tree species. The project will also touch upon aspects of hornbill habitat preference, nesting behaviour as well as food trees.

The results of the current study on the four tree species portray the importance of conserving dispersal agents to ensure survival of rare tree species. The follow-on project on hornbills with support from Flora and Fauna International (FFI) will also undertake the protection of hornbill nest sites through community participation. Through past experience of the team, sacred groves are important habitats for hornbills since hornbills require old growth trees for nesting and feeding. In the Konkan region, such trees are now only seen in sacred groves. Hornbills will therefore form important flagship species for the conservation of forests in the region.

5.3.3 Follow-on project 3: The study and assessment of private forests in the Konkan region (supported by Ashoka Trust for Research on Ecology and the Environment – ATREE, India)
The Konkan region of the Western Ghats is a global biodiversity hotspot, however, less than 2% of land in the area is being protected as a part of the statutory network of protected areas and forest reserves in India. Sacred groves form important reserves of regional biodiversity but a majority of the biodiversity of the Konkan region is found on privately owned lands which often show the presence of forests in various stages of

regeneration. Red listed species such as the *Saraca asoca*, *Tetrameles nudiflora* and *Sagerea laurifolia* are often found on privately owned lands. A comparative study of *Saraca asoca* populations on private lands has already been undertaken as a part of this study (see section 4.3). The need to study the status of biodiversity on privately owned lands in the Konkan region was felt with a view to provide solutions to landowners for the conservation of rare tree species within production oriented land use systems. Therefore a study was designed for which financial support was received from ATREE for a period of six months. Based on a team discussion and a review of case studies of private land conservation around the world, it was conceptualised that the AERF launch a regional, participatory forest conservation and restoration programme within private forests of the Konkan region. The initiative will go beyond short-term project based work and therefore will assume a long-term programme based approach officially run and managed by the AERF. This programme will involve forming co-management agreements with landowners, building capacity of farmers, generating support and involvement from the urban community and corporate sector as well as to ensure sustainable economic gain for landowners. With this objective in mind, the programme will be initially launched on a pilot scale for which a proposal is being developed and will be shortly submitted for a **Second RSG**. A brief introduction to the concept has been given below.

5.3.4 Follow on project 4: "The AERF Forest Care Programme: protecting, enhancing and restoring the private forests of Konkan through co-management agreements and community partnership." – phase I (proposal to be submitted for a **Second RSG**)

Given that a majority of forests in the Konkan region are on private lands, there is a need to undertake an initiative towards the conservation and the sustainable management of these forests. On the basis of the results of the current study, complemented by the independent study on the status of private forest in the region (see above), AERF has felt the need to develop a long-term initiative to address the problem of mass deforestation in the Konkan region as well as demonstrate sustainable management of private forestlands. The Forest Care programme has therefore been devised and will be initiated on a pilot scale in a few villages for which support will be sought from a **Second RSG**. The main objectives of the Forest Care programme are given here. Proposal for the second RSG will be developed for the pilot phase of the programme during which the first two objectives will be focused upon.

1. To establish management agreements with landowners whereby forests on the agreed land will not be clear felled, a management plan will be mutually decided

upon with the landowners as well as with the village community. The management plan will be developed by the AERF team will be based on a study of the forest patch. Sustainable management of the forest will be the goal of the management plans with a special emphasis on demonstrating the balance between conservation (protection of rare trees) and production (income generation for the landowner).

2. To establish partnership with corporate bodies and the wider urban community, which will further help in financial support to run the programme beyond the pilot phase. Such groups are now showing increased awareness and willingness to contribute and participate towards conservation through volunteer programmes and Corporate Social Responsibility. The Forest Care programme will target such groups for continual support for the programme as well as provide opportunities for urban and rural communities to interact and address a common conservation goal.
3. To form landowner groups whereby a forest based enterprise based on the sustainable management of forestlands can be developed. Access to markets, building capacity of landowners and providing a revolving fund will be some of the activities undertaken to meet this objective.
4. To develop an integrated landscape management plan at the village level. This will involve novel mechanisms for the management of landscapes through a participatory, sustainable approach whereby benefits of ecosystem services such as watershed forests are equally shared and managed by the community.

The Forest Care programme will be primarily developed to address the problem of mass deforestation in the Konkan region, in the absence of statutory protected areas. The programme will be based on the four objectives outlined in the previous paragraph however, for the pilot phase of the project the first two objectives will be focused upon. Support for the pilot phase will be sought from a second RSG.

A recently clear felled private forest which had a population of *Saraca asoca*

Logs of *Hydnocarpus pentandra* being piled for transport

5.4 Conclusion

In conclusion, this RSG supported project has been a good first step towards understanding the ecology of sacred groves and the rare tree species found within them. Even though the study undertaken here has short comings in terms of small sample size and inadequate data for statistical analysis, the results have been able to prove the conservation value of sacred groves and problems faced by tree populations whilst surviving in sacred groves. The study has also been able to provide the conservation status of four rare tree species within the Konkan region. Result and experiences of the study have been useful in providing inputs to AERF's on-going work on the restoration of sacred groves, understanding the ecology of some tree species as well as helped in developing new proposals and projects. Finally, it has been an enriching and useful learning experience for the principal investigator and the entire AERF team.

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Appendix I

Scanned copy of the Marathi brochure:

English translation of the Brochure:

The Konkan region is known for its natural beauty and diversity. Various types of trees & plants are found here, many of which are useful to us, especially those that have medicinal properties.

As population grew and development of the Konkan region took place, people have forgotten about importance of natural wealth, which has led to cutting of forests and many useful and medicinal trees have become rare.

Traditionally, the people of this region have used as well as valued the natural wealth and protected it such as through sacred groves. Even now, we have to take efforts to conserve our natural wealth and rare medicinal trees.

AERF is an NGO working in the Konkan region for over 10 years; we are now conducting a study of four rare medicinal trees of the region. Brief information of these species has been given here:

Antiaris toxicaria Locally known as Daswan, Chand-phal

This rare tree is found only in the Western Ghat region of India but is also found in some parts of Southeast Asia. In Konkan it is now found only in thick forests and some sacred groves. The Daswan is a very tall tree. It produces small red fruits during February / March which are eaten by birds and monkeys. The sap of this tree is said to be poisonous but the seeds are known to treat diabetes and stomach disorders.

Hydnocarpus pentandra Locally known as Kadu-kawat

This tree is also found only in the Western Ghats. This is an evergreen tree, which produces round, hard fruits of chickoo colour. These fruits are the size of a cricket ball and are very hard. There are many seeds inside and the seed oil is known for the treatment of leprosy.

Strychnos nux-vomica Locally known as Kajra

Kajra is an important medicinal tree found throughout Konkan. It is found in sacred groves and also in open areas such as on farm bunds. The seeds of Kajra are medicinal and are useful for a number of ailments. The fruits are like lemons and are commonly eaten by birds such as Hornbills.

Saraca asoca Locally known as Sita ashok

The garden in which Sita was kept was of these trees. This is a short, spreading tree which produces bright red flowers in bunches and short legumes. The leaves are long and are pink when young. This is a rare, medicinal tree used for treating stomach disorders and problems related to pregnancy.

AERF is a NGO working in Konkan since 1994 for nature conservation through people's participation.

Konkan is rich with natural wealth. Nature provides needs for all life. We should together strive to protect the nature that takes care of us all.

For more information contact our Pune office:

Sameer Punde, AERF-Pune

Appendix II

List of surveyed sacred grove with presence/absence of the species

Name of sacred grove (villages) surveyed	***Antiaris toxicaria***	***Hydnocarpus pentandra***	***Saraca asoca***	***Strychnos nux-vomica***
Ujgaon, Sangameshwar	**X**	√	**X**	√
Washi, Sangameshwar	**X**	**X**	√	**X**
Phansavle, Sangameshwar	√	**X**	**X**	**X**
Devde, Sangameshwar	√	**X**	**X**	√
Bellari, Sangameshwar	√	**X**	**X**	√
Kurdunda, Sangameshwar	**X**	√	**X**	√
Tamhane, Sangameshwar	**X**	**X**	**X**	**X**
Bhowde, Sangameshwar	**X**	**X**	**X**	√
Rawache Gothane, Rajapur	**X**	**X**	√	√
Deud, Ratnagiri	**X**	√	√	√
Ketaki, Chiplun	**X**	√	√	**X**
Marleshwar, Sangameshwar	√	**X**	**X**	**X**
Regni, Lanja	**X**	**X**	**X**	√
Zharye, Lanja	√	**X**	**X**	√
Kundi, Sangameshwar	√	√	**X**	**X**
Pawas, Ratnagiri	**X**	**X**	**X**	√
Kille Nivte, Vengurla	**X**	√	**X**	**X**
Sangeli, Sawantwadi	**X**	**X**	**X**	√
Dhamapur, Malvan	**X**	**X**	**X**	√
Shir, Chiplun	**X**	**X**	**X**	√
Dadar, Chiplun	**X**	**X**	**X**	**X**
Chickli, Chiplun	**X**	**X**	**X**	**X**
Kosumbh, Sangameshwar	**X**	**X**	**X**	**X**
Wanzhole, Sangameshwar	**X**	**X**	**X**	√
Ghodauli, Sangameshwar	√	**X**	**X**	**X**
Kulye, Sangameshwar	√	**X**	√	**X**
Nive, Sangameshwar	**X**	√	**X**	**X**
Ambavne, Sangameshwar	**X**	**X**	**X**	**X**
Saile, Sangameshwar	**X**	**X**	**X**	**X**
Nyayri, Sangameshwar	**X**	**X**	**X**	√
Shivne, Sangameshwar	**X**	**X**	**X**	**X**
Bhowde-Kaj rahati, Sangameshwar	**X**	**X**	**X**	√

Chandreshwar, Sangameshwar	X	X	X	√
Shimbavne, Sangameshwar	X	X	X	X
Deole, Sangameshwar	X	X	X	√
Chafoli, Sangameshwar	X	X	X	√
Meghe, Sangameshwar	X	X	X	√
Janayle, Guhaghar	X	√	√	X
Kataule, Sangameshwar	√	X	X	√
Parchuri, Sangameshwar	X	X	X	X
Ukshi, Ratnagiri	X	X	X	X
Tivne, Ratnagiri	X	X	X	X
Shirgaon, Ratnagiri	X	X	X	X
Khorninko, Lanja	X	X	X	X
Nagaon, Alibaug	X	X	√	X