# How exotic tree plantations aid the restoration of Tropical Montane Forest (Shola) in the Western Ghats: Observations from the Palni Hills

Aalap Dikshit* and Joachim Schmerbeck*

*Department of Natural Resources, TERI University, New Delhi

## 1. Summary

We have studied *Acacia mearnsii* plantations of three different age classes (up to 2, around 15 and above 25 years) in the Upper Palni Hills regarding the number and diversity of Shola trees regenerating under them. We found 45 Shola tree species regenerating under the exotic plantations while the number of species as well as the number of trees increased drastically with increasing plantation age. The number of young *Acacia mearnsii* trees decreased in an ever more drastic manner with plantation age down to zero in the oldest plantations that we studied. In order to restore Shola forest we suggest (1) not to remove existing *Acacia mearnsii* plantations and (2) to consider silvicultural options in the management of this plantations to enhance the nursing effect on Shola tree species.

## 2. Introduction: Degradation, Restoration, Succession

If an item of our daily life is damaged, we cannot use it any more in the way it was thought of to be used. We have to repair this item in order to get it back to work. If something is damaged in nature, we call it “degraded”. Degradation means nothing else but “reduced to a lower rank” (see FAO 1999). In ecology this reduction addresses mainly the structure of the ecosystem and its biodiversity. In the context of land use this can also mean a reduced productivity of one or several goods, a reduced standing biomass or the reduction of any other feature that the land manager has in focus.

A broken item of our daily life will remain useless if it is not fixed. Not so in nature. Nature is able to fix itself, to recover from degradation, if the agent that caused the degradation is removed. Ecological restoration is nothing else but the “process of assisting the recovery of degraded, damaged or destroyed ecosystems” (Primack 2006). Within this process the land manager has the option to establish an ecosystem that is different from the original one. This might be the case if it is not possible to go back to what was there before (e.g. due to the extinction of some species) or if the restored ecosystem needs to fulfil functions that require a modification from the original (e.g. recreation).

Restoration activities are most efficient when they adapt the natural processes of regeneration. Forest is a good example here: the development from an area without forest to a stable forest ecosystem is call “succession”. Succession is basically nothing else but the directed sequence of different species associations on the same site as a reaction to a change in the environmental conditions (see e.g. Ratnam et al. 2011). Important for restoration activities is, that this change in environmental conditions is not something, that happens only from outside the ecosystem. Drastic changes are caused by the organisms that are part in the succession themselves. A good example here is a tree that grows on barren land creating shade where previously there was full sun. This means in turn, that every phase in the process of succession requires a new set of species that suits this new conditions. Accordingly species are separated in early and late successional species, while those appearing very early are called pioneers and those which are the latest, called climax species. Figure 1 indicates the two extremes of environmental conditions at the beginning and the end of succession by comparing grassland with forest at the interface where they meet.

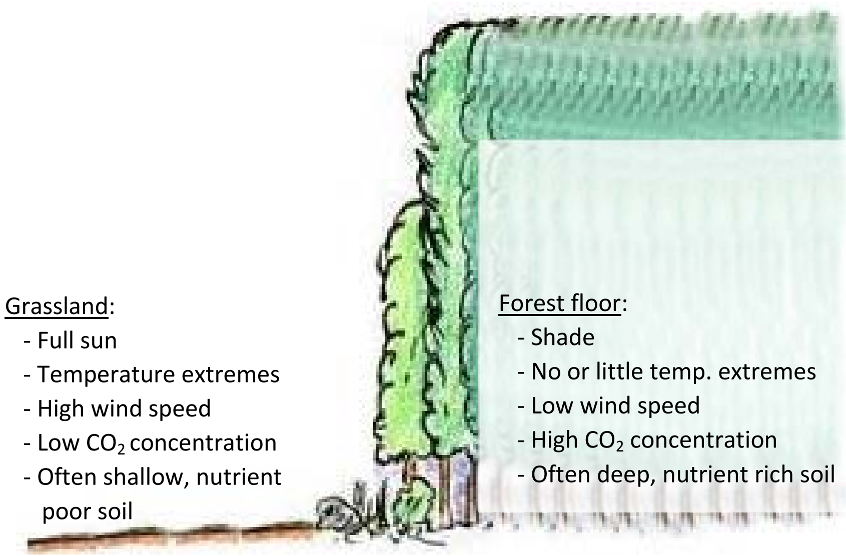


Figure 1: Environmental conditions on grassland and forest floor (image taken partially from http://www.waldwissen.net/wald/naturschutz/arten/wsl_waldrand/index_DE)

Pioneer species are specialized in coping with the extreme conditions on open areas like grassland (see figure 1) which enables them to establish there and to spread. In this process they change the environmental conditions slowly towards the conditions in the forest interior. The time this process needs depends very much on the climatic region it happens in and the species that are available at the side (local or regional species pool). In general it can be stated that the process is slow and can take several hundred years. The first phase, however, can happen within decades if fast growing species are available.

This process happens naturally, which means, without the assistance of humans. Without this process the establishment of any terrestrial ecosystem, after it was subject to natural disturbances like storms and landslides, cannot happen. The succession from barren land to forest applies to almost all landscapes which can potentially carry forest. These are almost all locations below the altitudinal and latitudinal tree line. There might be some exceptions of areas that are too cold, too dry, too moist or too saline for forest. A good indicator, if a landscape can support forest, are forests that grow close by or right in the neighborhood like in figure 1. If succession cannot be observed where forest can potentially occur, frequent disturbances keep the process from taking place. In most cases, these agents are human land management systems like burning and grazing.

The Western Ghats are potentially forest land. However, the pioneer species of the local tropical montane forest (Shola forest), are very slow growing and their effort in colonizing open areas is relatively easily outbalanced by low frequency fires and grazing of domestic and wild herbivores. Exotic tree species, like *Acacia mearnsii,* are pioneering trees that are growing much faster. They fulfil exactly the same function as the local pioneers (creating shade, easy the micro climate, adding organic material and nutrients to the soil) as the local pioneers do, but in a much smaller time frame. This process has be verified many times in the scientific literature (see e.g. George *et al*., 1993; Lugo, 1992, Parrotta, 1992; Lugo *et al*., 1997; Guariguata *et al*. 1995; Parrotta, 1995; Fimbel and Fimbel, 1996). From a Shola-Restoration point of view, they are of great help in successfully restore these forest in a relatively short time.

We wanted to know how this process works and selected *Acacia mearnsii* plantations of different ages in the Palni Hills to mimic the process of succession. In three clearly distinguished development phases we looked into the type and number of Shola regeneration in this plantations.

## 3. Methodology

Study area

The Western Ghats are one of the major mountain range of the world, running for 1,600 km N-S at the western coast of India. The Western Ghats are much older than the Himalayas (Pai, 2008).

They are a global biodiversity hotspot: they have an exceptional concentrations of endemic species and experiencing exceptional loss of habitats (Myers et al., 2003). There are around 4050 species of plants found in the Western Ghats, out of which, 1600 were endemic. (Myer, 1990).

The tropical montane forests of the Western Ghats are situated at an elevation between 1400 to 2400m and are commonly referred to as “Sholas” (Meher-Homji, 1967). The Shola forests are of high ecological significance in protecting the headwaters of rivers (Swarupanandan et al; 1998). They help in retaining soil moisture and regulate the release of rain water (Swarupanandan et al. 1998).

This study was carried out in the Palni Hills an eastward spur of the Western Ghats in Tamil Nadu. It has maximum length of 65 km and a maximum width of 40 km covering an area of 2068 $km^2$ (Mathew, 1999).

Data collection

To study the successional development of *Acacia mearnsii* plantations we established an unreal time series of three different age classes. In each of this classes we investigated the extent of Shola tree regeneration. The young plantations were the ones which had been cut before 1 -2 years, the mid-aged plantations were the ones that were cut 15 years previously, and the mature plantations were the ones that were never cut since they were established. We had here only one plantation which was approximately 30 years old. As we wanted the plantation age to be the only factor that varied between the different plantations, all selected plantations had the similar exposition (East and West). Each age class was represented with four stands, while for mid aged plantations we could find only three stand. In each stand we installed four temporary plots. We therefore studied all together 46 plots. In each plots we assessed Shola tree regeneration of five development stages defined by their size and the diameter at breast height (dbh) which is measure at 1.3 meter from the base of the tree. The development stages where: seedling 1: >0 =<0.3 cm, seedling 2: >0.3=<130 cm, sapling 1: >130 cm, dbh >0 =< 3cm, Sapling 2: >130 cm, dbh >3 =< 7 cm, matured trees: dbh >7 cm). For the assessment of each development stage we installed circular plots with an increasing size starting from $7m^2$ for seedling 1 up to $700m^2$ for matured trees. In each plot we identified the species, and counted the number of trees. Based on our assessment we calculated the abundance of Shola tree species by counted the Shola tree species we found under each plantation class, calculated their number per hectare (ha) and estimated their biomass by calculating the basal area, which is the sum of the cross section of all trees at dbh in $m^2$ per ha.

## 5. Results

We found a total of 45 shola tree species regenerating in our plots. Their number increased with increasing plantation age (3 in young, 19 in mid-aged and 36 in matured plantations). All the species we found in young plantations were present in the matured ones. Whereas, out of 19 species found in mid-aged plantations, only 10 were found in matured ones. This means that in the process some species appear and disappear at a later stage.

The young plantations did not only harbor a low number of species, the number of individual trees was also the lowest amongst the age classes. However, the number of trees increased with increasing plantation age. We counted 281 and 714 trees per ha regenerating in mid aged and matured plantations respectively. Within each plantation type small seedlings were most abundant. The highest amount of taller regeneration (Sapling 1 and 2) are harbored by the oldest plantations that we studied (figure 2).

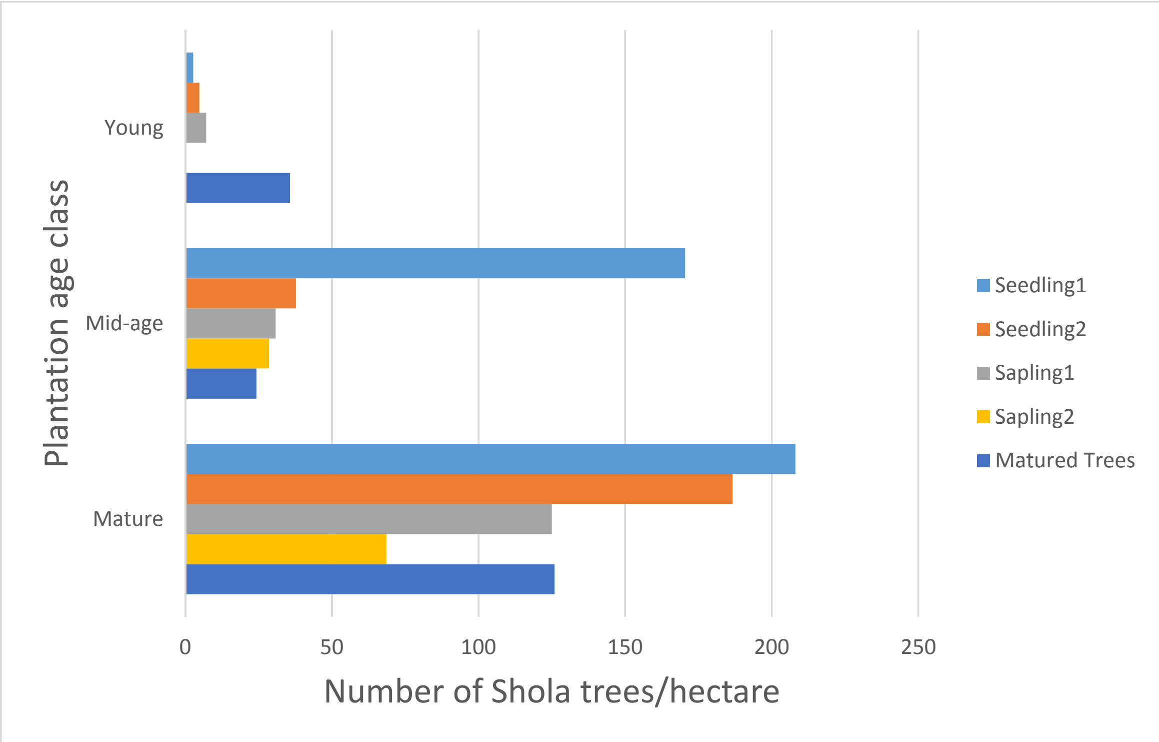


Figure 2: Density (plants/hectare) of Shola trees of the different development stages among the studied age classes

At the same time does the regeneration of *Acacia mearnsii* decline drastically as plantations grow older (figure 3). *Acacia mearnsii* is a pioneering tree species. It needs full light to grow and to produce seeds. Once in the shade, it vanishes.

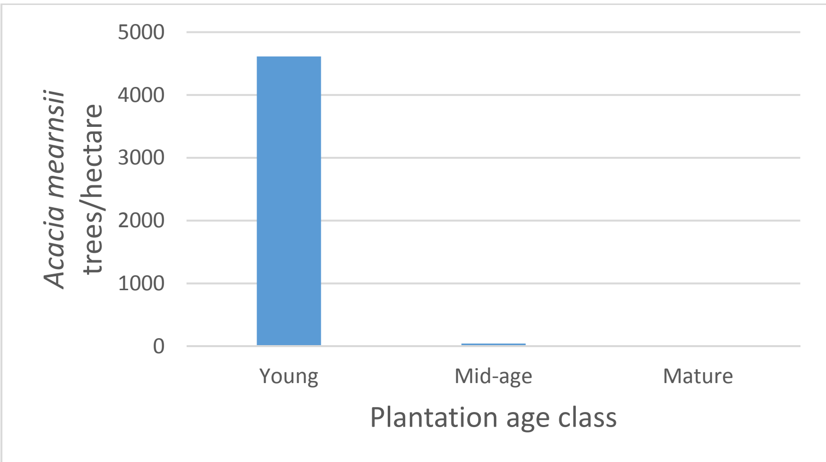


Figure 3: Number of *Acacia mearnsii* trees per hectare regenerating per ha across the different plantation age classes

The basal area of Shola trees was clearly the highest in the oldest plantations. A few trees have already grown into the matured development stage in the mid aged plantations while in the young plantations some old shola trees where present; they are left from the time prior the clear felling of this plantations (Figure 4).

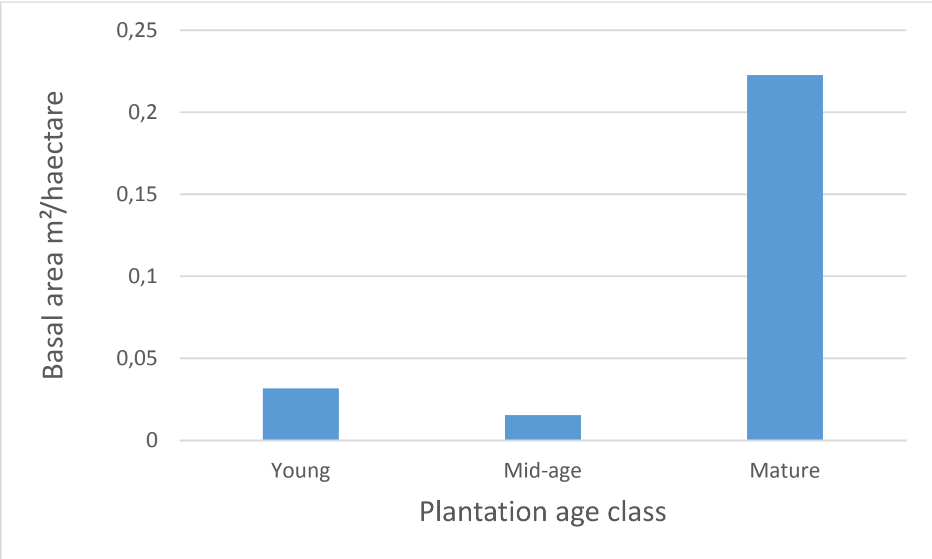


Figure 4: Basal area ($m^2$/hectare) of Shola tree species across the different plantation age classes

More detailed methodology and results can be taken from Dikshit (2015).

## 6. Application

That Shola forest appear right beside grasslands in the Western Ghats which is a clear indicator that this landscape can support forest. This is the base for Shola restoration. However, we do seldom see that Shola trees regenerate on grassland. In the Palni Hills we can observe pioneering tree species like *Rhododendron arboretum* and *Vaccinium leschenaulti* growing in a zone close to the forest edge (see Juyal, 2013). But this pioneer tree species need a lot of time to provide a shelter for other Shola trees to follow as they are growing very slow and are often set back in their growth by fires and grazing pressure. *Acacia mearnsii* grows much faster and, planted or spreading by itself, is much more efficient in facilitating the regeneration of Shola trees. With the time passing, the *Acacia* trees become less in number as they cannot regenerate in the shade. But the Shola trees can and slowly take over the site so that in the end only Shola trees are left.

We found 45 tree species with 15 and 37 trees regenerating in mid age to matured *Acacia* plantations respectively. This number is sufficient to establish a full flashed forest. Therefore, plantations of *Acacia mearnsii* are not hindering, but supporting the restoration of Shola trees. Similar findings resulted from studies on young Eucalyptus and Pine plantations  in the Palni Hills too. Srimathi (2012) found 19 Shola species regenerating under Eucalyptus plantations. Einhellinger (2012) did a similar work for Pine plantations (with a much higher number of stands as we or Srimathi 2012 did) and found 25 Shola tree species regenerating under them. Removing this plantations will create conditions like we found them in the very young plantations that we studied: Dense regeneration of the plantation tee species and hardly any Shola trees. The Shola trees that existed in the plantation that was cut, are destroyed and it will take another 1-2 decades to reestablish them. This means that *Acacia* plantations are not a threat to Shola forest but just the opposite: a shortcut to their establishment.

We still cannot explain the change in the composition of species as plantations grow old. Abundance and composition of tree regeneration is influenced for example by the amount of light that reaches the ground, impact of wild and domestic herbivores and other disturbances like cyclones. Such knowledge would help to develop forest management practices that allow to optimize the nursing effect of *Acacia mearnsii* plantations for Shola trees. However, based on the knowledge that we have already today (see Bauhus and Schmerbeck 2010) we can state that silvicultural option like protection, thinning and even planting, exist to enhance the process of Shola restoration. Such options should be explored and applied instead of clearing this plantations.

## Literature

Dikshit (2015): The potential of *Acacia* mearnsii plantations to aid in regeneration of native Shola Forest in the Upper Palni Hills, South India. Master thesis, TERI University, New Delhi

Einhellinger (2012): Regeneration of indigenous Shola species under exotic Pine plantations in the Palni Hills, South India. Master thesis (English translation), University of Applied Science Weihenstephan – Triesdorf, department of forestry, Freising, Germany

FAO (1999): Poverty Alleviation and Food Security in Asia - Land Resources, FAO RAP Publications 1999/2, ftp://ftp.fao.org/docrep/fao/003/x6625e/x6625e00.pdf, and http://www.fao.org/docrep/003/x6625e/x6625e02b.htm

Fimbel, A. and Fimbel, C. (1996). The role of exotic conifer plantations in rehabilitating degraded tropical forest lands: A case study from Kibale forest in Uganda. *Forest Ecology and Management*, 81, pp.215-226.

George, S., Kumar, B. And Rajiv, G. (1993). Nature of secondary succession in the abandoned Eucalyptus plantations of Neyyar (Kerala) in peninsular India. *J. Trop. For. Sci.*, 5, pp.372-386.

Guariguata, M., Rheingans, R. and Montagnini, F. (1995). Early Woody Invasion Under Tree Plantations in Costa Rica: Implications for Forest Restoration. *Restoration Ecology*, 3(4), pp.252-260.

Juyal S. (2013): Characterization of forest-grassland mosaic in Upper Palni Hills; Analyzing the vegetation and soil characteristics along the ecotone from grassland to shola, Major Project Thesis, TERI University, New Delhi.

Lugo, A. (1992). Tree plantations for rehabilitating damaged lands in the tropics. *Environmental Rehabilitation*, 2, pp.247-255.

Lugo, A. (1997). The apparent paradox of reestablishing species richness on degraded lands with tree monocultures. *Forest Ecology and Management*, 99(1-2), pp.9-19.

Matthew, K. (1999). *The flora of the Palni Hills, South India*. Tiruchirapalli: Rapinat Herbarium, St. Joseph's College.

Meher-Homji, V. (1967). Phytogeography of South Indian hill stations. Botanical Torrey society, pp.230-242.

Myers, N. (2003). Biodiversity Hotspots Revisited. *BioScience*, 53(10), p.916.

Pai M. (2008): The Western Ghats. [Online] Available at: http://westernghats-paimohan.blogspot.in. [Accessed 1 July 2015].

Parrotta, J. (1992). The role of plantation forests in rehabilitating degraded tropical ecosystems. *Agriculture, Ecosystems & Environment*, 41(2), pp.115-133.

Parrotta, J. (1995). Influence of overstory composition on understory colonization by native species in plantations on a degraded tropical site. *Journal of Vegetation Science*, 6(5), pp.627-636.

Primack R.B. (2006): Essentials of Conservation Biology (4th ed.), Sinauer Associates, Sunderland

Ratnam J, Bond W J, Fensham R J, Hoffmann W A, Archibald S, Lehmann C E R, Anderson M T, Higgins S I and Sankaran M. (2011) When is a 'forest' a savanna, and why does it matter? *Global Ecology and Biogeography*, DOI: 10.1111/j.1466-8238.2010.00634.x, p. 1-8.

Srimathi (2012): Role of Eucalyptus sp. plantations on regeneration of native tree species in the

Swarupanandan, K., Sasidharan, N., Chacko, K. and Chand Basha, S. (1998). Studies on shola forests of Kerala. *KFRI Research Report No. 158*. Peechi: Kerala Forest Research Institute, p.143.

Upper Palani Hills, Tamil Nadu, India. Master thesis, TERI University, New Delhi