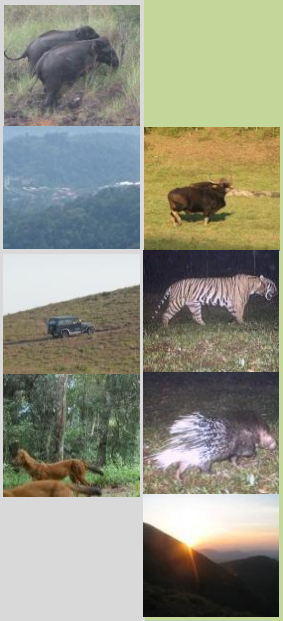
Conservation of the Periyar-Agasthyamalai Corridor in the Southern Western Ghats



Knowledge Generation, Dissemination of Information and Capacity Building for Key Stakeholders.

Summary of Datasets

Asian Nature Conservation Foundation

Conservation of the Periyar–Agasthyamalai Landscape in the Southern Western Ghats:

Knowledge Generation, Dissemination and Capacity Building for Key Stakeholders

Summary of Datasets

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Conservation of the Periyar-Agasthyamalai Landscape in the Southern Western Ghats: Knowledge Generation, Dissemination and Capacity Building for Key Stakeholders

This report provides an overview of the study conducted by the Asian Nature Conservation Foundation (ANCF) (http://www.asiannature.org/) in 2011-12 to create a GIS based conservation database focused primarily on the elephant ranges of thePeriyar-Agasthyamalai landscape in the southern Western Ghats. This database drawn from a landscape level field study spanning 17 forest divisions of the states of Kerala and Tamil Nadu adds to the conservation databases already established by the ANCF of the major elephant landscapes of the Western Ghats.

The study was funded by the Critical Ecosystems Partnership Fund (CEPF) (http://www.cepf.net/), a global leader in enabling civil society to participate in, and benefit from, conserving some of the world's critical ecosystems. The study was carried out with the support of the State Forest Departments of Tamil Nadu and Kerala.

A key component of the study has to do with putting the conservation information generated through the surveys conducted under the study into the public domain besides organizing capacity building programmes among key stakeholders such as natural resource managers, civil society organizations concerned about sustainable development and local communities, without whose support and active participation no conservation would be possible.

ANCF Study Team

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Contents

1 Project Rationale

1.1 The Western Ghats and its importance

The Western Ghats in India is one among the 34 global biodiversity hotspots (Mittermeier et al. 2005) and also the source of all the major rivers of peninsular India (Figure 1 & 2) Thus, its conservation is important both for the biodiversity as well as the ecological functions that are essential to safeguard the livelihoods of the several million people living in peninsular India.

Nevertheless, the biodiversity rich landscapes of the Ghats are under severe pressure from a) ill planned location of development projects like hydro-electric power projects, mining areas, railways and highways besides agriculture and settlements that result in destruction (loss) of biodiversity b) unsustainable commercial exploitation of biodiversity partly as a result of a lack of awareness of the value of biodiversity among natural resource planners and c)increasing demand for natural resources to meet the basic human needs of communities that live in and around the landscapes.

Figure 1: One of the 34 biodiversity hotspots of the world

The Western Ghats of India and the Central Highlands of Sri Lanka combined are one of the 34biodiversity hotspots of the world.

A 'biodiversity hotspot' is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. Biogeography is the study of the distribution of species, organisms and ecosystems in space and through geological time.

The southern Western Ghats of India and the Central Highlands of Sri Lanka were closely linked in the time when Sri Lanka and India were attached to Gondwanaland. The forests of

these mountains are said to be ecological relics dating back to the time of Gondwanaland and share a remarkably high incidence of highly localized endemics. The flora of the Agasthyamalai Hills bears a remarkable similarity to that of Sri Lanka'ssouth-western wet zone. A total of seven species of mammals are endemic to the southern Western Ghats and Sri Lanka considered together as one ecological unit; they are the Mountain Shrew, Slender Loris, Stripe-necked Mongoose, Sri Lankan Giant Squirrel or Grizzled Giant Squirrel, Layard's Striped Squirrel, Dusky Striped Squirrel, and the Travancore Flying Squirrel.

1.2 Traditional conservation approaches, their limitations and consequences

Conservation initiatives in India have been largely confined to the Protected Areas (PAs) such as wildlife sanctuaries and national parks. However, wild species distribution ranges widely in nature and areas of high biodiversity values do not necessarily fall within PA boundaries. Lack of conservation programmes that go beyond PAs into the broader landscape is a major weakness of India's conservation planning. Very often the problem is exacerbated by the lack of easily comprehendible, field level information/data on the existence and status of wild habitats and critical habitat inks across the landscapes. There is little information that is accessible in user-friendly form to planners, conservation activists and grass roots communities. This situation is partly responsible for the uninformed location of projects and developmental activities that result in the fragmentation of habitats and loss of biodiversity. This is one of the weaknesses in development planning that the present project aims to address.

The Western Ghats

Figure 2: Schematic map showing the geographic spread of the rivers originating from the Western Ghats

The Western Ghats starting from the border of Gujarat and Maharashtra, south of the Tapti river, runs approximately 1600 km along the western edge of India through the states of Maharashtra,Goa, Karnataka, Tamil Nadu and Kerala, ending at Kanyakumari, the southernmost tip of the country. The Western Ghats are broadly categorised as the northern and the southern Western Ghats, with Wayanad in Kerala providing the transition zone. The southern Western Ghats are generally wetter, of higher elevation and more diverse. This mountain chain has over 30 percent of all plant, fish, herpeto fauna, bird, and mammal species found in India, with over 5000 species of flowering plants, 139 mammal species, 508 bird species and 179 amphibian species. Endemism is high and new species continue to be discovered in these mountains. At least 325 globally threatened species occur in the Western Ghats. They harbour numerous wild relatives of everyday food and medicinal plants like those of grains (rice, barley), fruits like mango, garcinias, banana, jackfruit, spices like black pepper, cinnamon, cardamom and nutmeg, making them an important source of numerous medicinal plants and vital genetic resources. The riversoriginating in the Western Ghats sustain the lives of entire peninsular India.

1.3 Landscape level planning based on the conservation of the Asian Elephant

The Asian Elephant is an umbrella species in the biologically rich tropical forests of South and Southeast Asia. It is often seen by conservation planners as the flagship species for guiding strategies for the conservation of biological diversity. With an estimated population of approximately 28000individuals in the wild, survival of this wide-ranging species is highly threatened in India due to the continued loss of natural habitats and the sharply rising incidence of elephant-human conflict.

Over the last ten years ANCF has been involved in substantive field biodiversity surveys centred on the habitat of the Asian Elephant. It has established detailed GIS based database on the Elephant Ranges of South India through periodic surveys. The database contains spatial data on areas of elephant distribution, elephant corridors, their legal status, land use and vegetation patterns of all elephant bearing Forest Divisions within the four Elephants Ranges designated by Government of India's Project Elephant. These cover major parts of the Western Ghats from the Mysore-Nilgiri landscape to thePeriyar–Agasthyamalai landscape. The database also has the additional vector layers of rivers, highways, railway lines, agriculture/settlements and other non forestelements e.g. commercial plantations such as tea, coffee, cardamom and rubber. Apart from the above spatial information, the database is also built into textual data on elephant population size, intensity of human–elephant conflict and conservation problems of each Forest Division within various Elephant Ranges. Much of this database has been updated periodically through fresh surveys with the last majo rupdation of habitat information taking place during the period 2003–2005. However there still remained a significant gap in the extent/coverage of the database within the Periyar–Agasthyamalai landscape. This data gap was filled in through a fresh survey for that region carried out as part of the current project.

1.4 Use of ANCF's GIS based database

This database has been used by various government and non-government agencies for designating and conserving wildlife corridors. A few examples would include:

(1) Wildlife Trust of India, a conservation NGO used the database for planning the widening of bottleneck corridors located between BRT and Kollegal Forest Divisions (Bekkatur–Arabikare corridor) and Wayanad North and Brahmagiri Wildlife Sanctuary (Brahmagiri–Tirunelli corridor) through acquisition of private land with funding from private donors.
(2) Karnataka Forest Department for widening the Kaniyanpura corridor to strengthen contiguity between Bandipur Tiger Reserve and the Eastern Ghats with funding from Project Elephant,Govt. of India.
(3) Tamil Nadu Forest Department, which is in the process of securing a few vital corridors that exist in the Nilgiri North and Coimbatore Forest Divisions with funding from the TN State Government.

Additionally, the information from ANCF's database has also been used for validating environmental impact assessment exercises of development projects. One instance in which a project was halted due to potential negative consequences on the biodiversity of the region was in the case of the extension of a railway line from Chamrajnagar to Coimbatore via the Moyar valley, a crucial elephant habitat/corridor in Sathyamangalam Forest Division.

1.5 ANCF's GIS based database for the Periyar-Agasthyamalai landscape in public domain

ANCF's GIS based biodiversity database is still underutilized as a planning tool for natural resource management of the region. If this is to happen ANCF must

a) Systematically complete the coverage of existing gaps,

b) The information must be placed in key parts of the conservation planning structures of the Government and

c) Efforts must be made to conduct programmes to publicize the value and practical use of the database.

For those familiar with science based biodiversity management it is not difficult to see the value of promoting (for instance) the list of critical elephant/wildlife corridors within each landscape. Other applications include, identifying locations for development projects after taking into account conservation value, derived from these databases.It can also be effectively used in various conservation activities such as:

(i) Preparing Management Plans for the conservation of elephant populations in the three major landscapes (Nilgiri–Mysore, Anamalai and Periyar-Agasthyamalai),

(ii) Identification of priority sites for conservation by incorporating available data on lesser known species,

(iii) Strengthening the existing PA network within each landscape by incorporating the location of critical habitat links that need special focus. The factual situation on the ground is that many of the vital corridors have been cut-off in the past due partly to the lack of knowledge about the existence or importance of such crucial links. Hence, creation of awareness about such areas at local level such as with field based forest managers, NGOs, local people and the media will enhance the chances of conservation of these corridors, the landscapes in which they are embedded and the constituent biodiversity.

1.6 Project approach

1. Update ANCF's GIS database on critical links in the Periyar–Agasthyamalai landscapes of the Western Ghats with fresh surveys. Additionally, gather baseline information on the status and distribution of threatened species of mammals listed in Appendix 2 of CEPF Western Ghats manual. The proposed field surveys would gather data across 17 Forest Divisions spread across the landscape (Figure 4).

2. Consolidate and make available the information on habitats including vegetation and land use patterns, critical links and other data available on the lesser-known species (mammals listed in CEPF Appendix 2). Incorporate the information into readable, accessible packages in websites (ANCF, India Biodiversity portal, Western Ghats Biodiversity Portal, others) CD-Roms, popular magazines and other media vehicles.

3. Use the information packages to create awareness among stakeholders of the Periyar–Agasthyamalai landscape about the importance of the Western Ghats and its biodiversity, and the ecosystem services that it provides. Innovative model programmes for the local people, school and college students and teachers, and media to be conducted with the assistance of NGOs including religious and cultural organizations.

4. Target specific biodiversity awareness programmes at forest resource managers aimed at improving the capacity of state forest department staff for science based conservation planning at the landscape level including establishing scientific monitoring programmes for the relevant globally threatened species, critical links and key sites in the Periyar-Agasthyamalai landscape.

2 Profile of the Periyar–Agasthyamalai Landscape

2.1 Geo-physical information of the Periyar-Agasthyamalai landscape

The Periyar-Agasthyamalai landscape, lies between 8o2’ N and 10o, 15’ N and 76o, 4’ E and 77o, 46’ E. It is the southernmost of the four major landscapes of the Western Ghats in southern India (Figure3). The landscape stretches over 7000 km^2 in Tamil Nadu and Kerala states and is presently managed under 17 different Forest Divisions (Table 1 & Figure 5). The landscape comprises the southern part of the Periyar plateau, and its eastern spur (the Varushanad and Meghamalai Hill ranges), the Achankovil Valley, the Agasthyamalai and Mahendragiri hill ranges on the southern side.

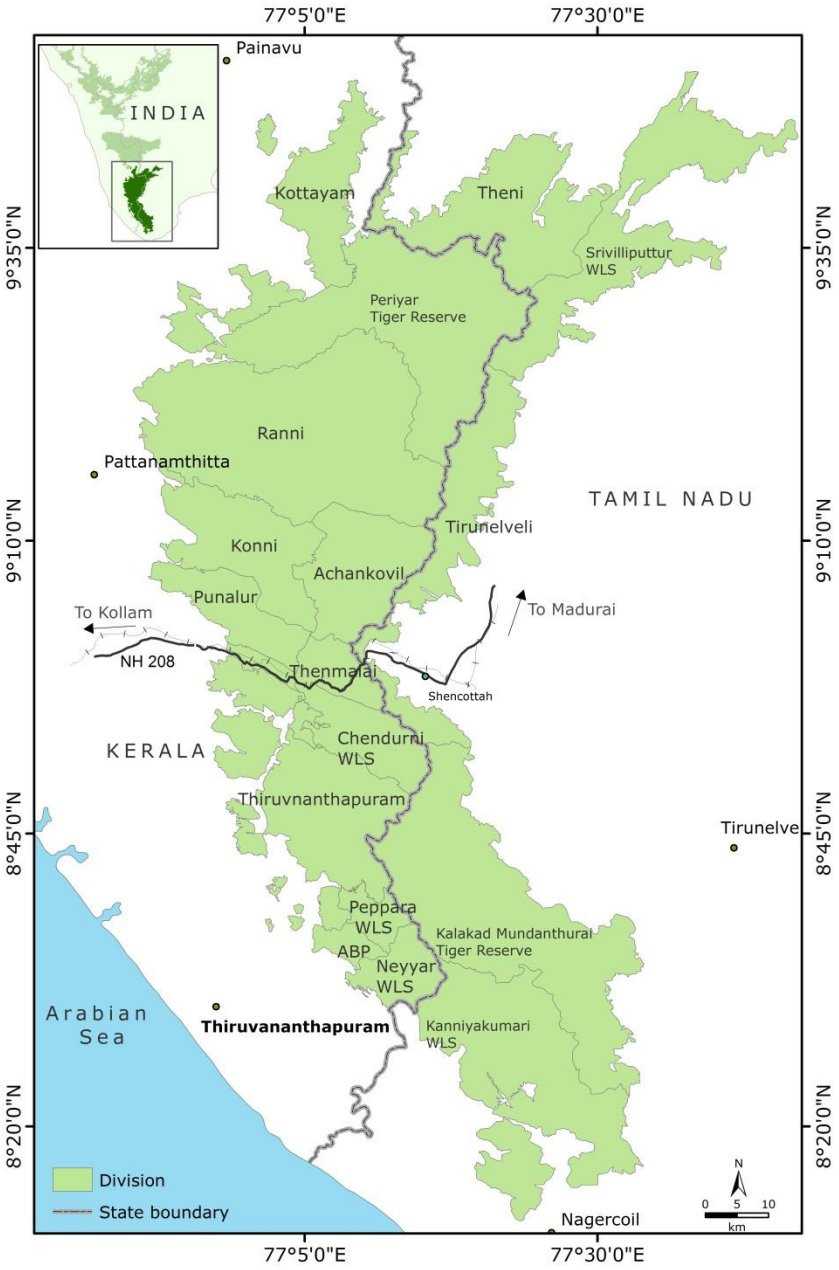


Figure3: Forest divisions in the Periyar-Agasthyamalai landscape

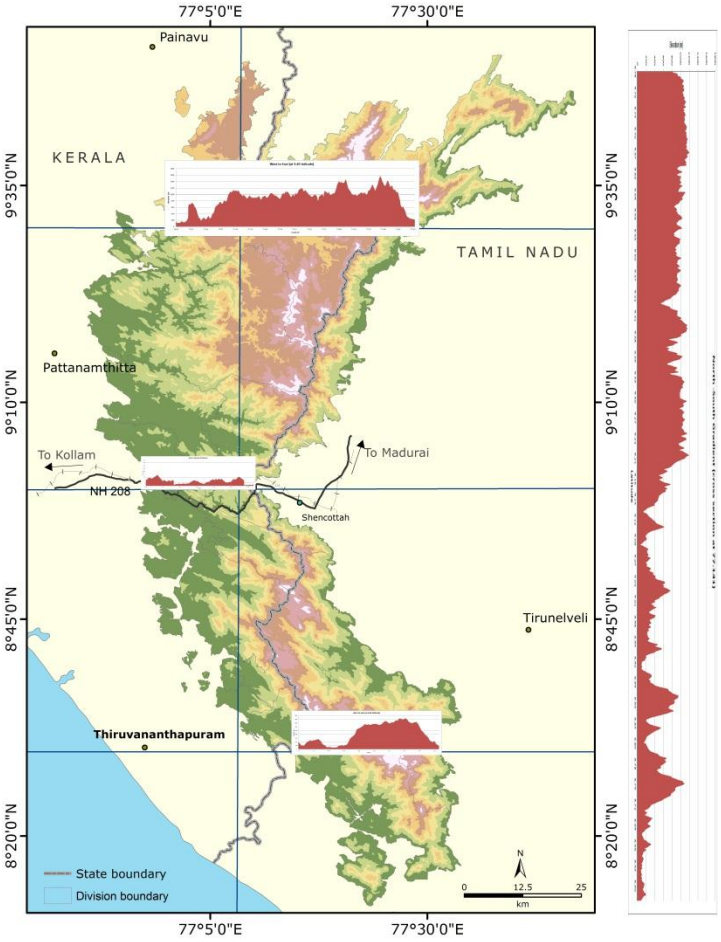


Figure 4: Landscape map along with cross sections giving an idea of the elevations

Climate

The Periyar-Agasthyamalai landscape with varying topographical features (Figure4), experiences a range of climate conditions. On the basis of climatic conditions the year could broadly be divided into three seasons viz.

(1) Dry season that stretches across four months from January to April,

(2) Southwest monsoon or first wet season, lasting for four months between May and August

(3) Northeast monsoon or second wet season, lasting for four months from September to October.

Temperature varies from 17.2to 28.3 °C with a mean of 24.2 °C. The ambient temperature in the first half of the dry spell is relatively lower than the second half. The southwest monsoon, which starts in the month of May is much more intense in the western parts (forest divisions in the Kerala part (Figure 7A) of the landscape, while its intensity is low in the eastern parts of the landscape (the forest divisions of Tamil Nadu (Figure 7B) due to topographical features, which shadows the southwest monsoon strength (Figure 6). The northeast monsoon that starts in September reaches its peak in October and declines gradually from November. The eastern part of the landscape receives the maximum rainfall from this monsoon. The latter half of the northeast monsoon is cooler due to the onset of winter.

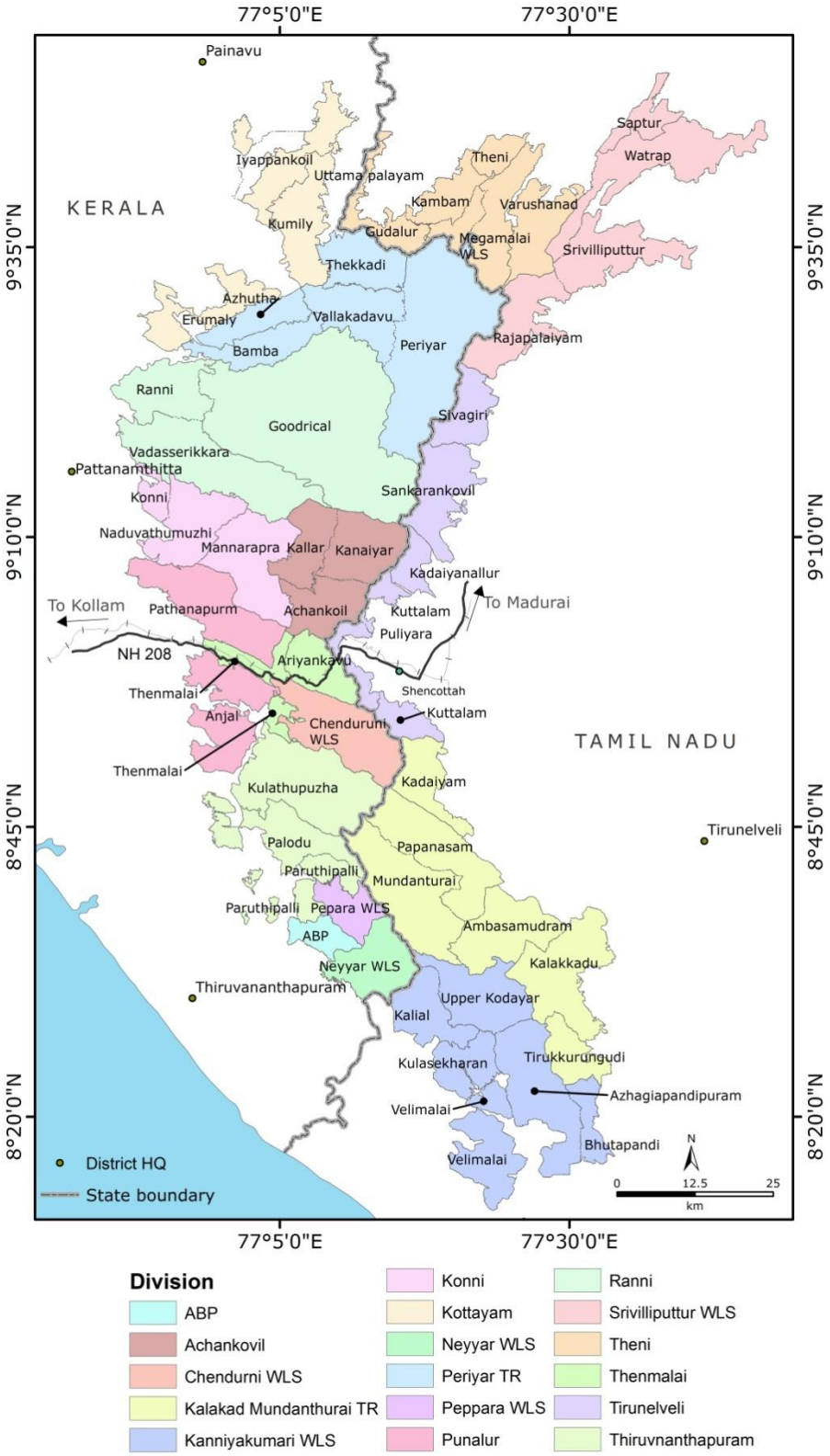


Figure 5: Ranges in the Periyar-Agasthyamalai landscape

Table 1. Forest Divisions in the Periyar-Agasthyamalai Landscape their extent, status and number of corridors

Division Name	Area (km^2)	Status	Corridors
ABP Special FD	44.5	Biological park	-
Achankovil	268.3	Territorial	-
Chendurni WLS	171.8	WLS	-
Kanniyakumari WLS	502.7	WLS	-
KMTR	892.8	Tiger Reserve	-
Konni	330.7	Territorial	-
Kottayam	387.9	Territorial	-
Neyyar WLS	113	WLS	-
Pepara WLS	64.4	WLS	-
Periyar TR	777	Tiger Reserve	-
Punalur	280	Territorial	-
Ranni	923	Territorial	-
Srivilliputtur WLS	410	WLS	-
Theni	543	Territorial & WLS	-
Thenmalai	210.3	Territorial	2
Tirunelveli	352.2	Territorial	1
Thiruvananthapuram	433.5	Territorial	-

Vegetation

The landscape consists of forest and non-forest elements (Figure 8). The forest elements represent a diverse vegetation type from Tropical Dry Thorn Forests at the low altitudes with the lowest rainfall to Dry, and Moist Deciduous Forests, Semi-evergreen and Evergreen, high altitude Mountain Grasslands along with the existence of Myristica swamps (Ramesh et al. 1997).

Mean monthly rainfall data from various forest divisions of the Periyar-Agasthyamalai landscape (data from 2007 to 2011)

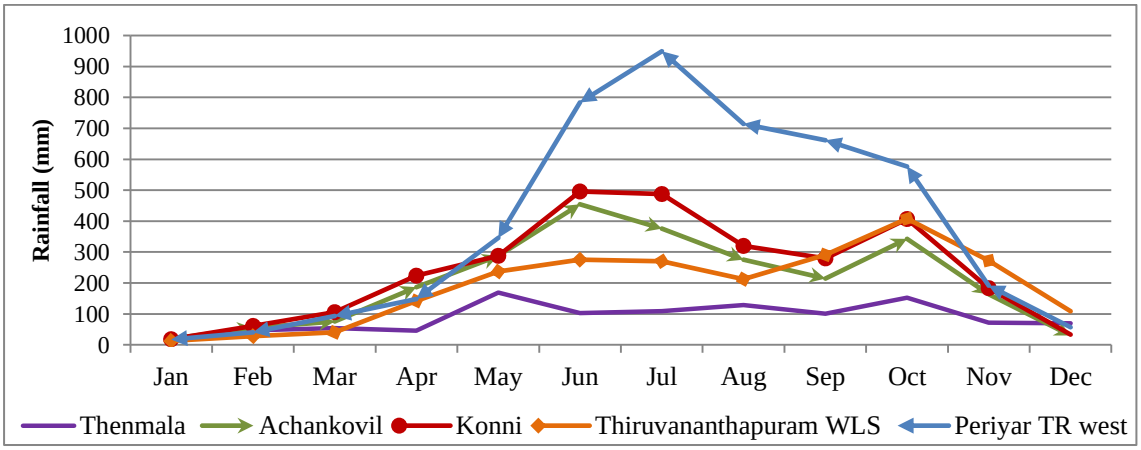


Figure 7A:Kerala part in the landscape

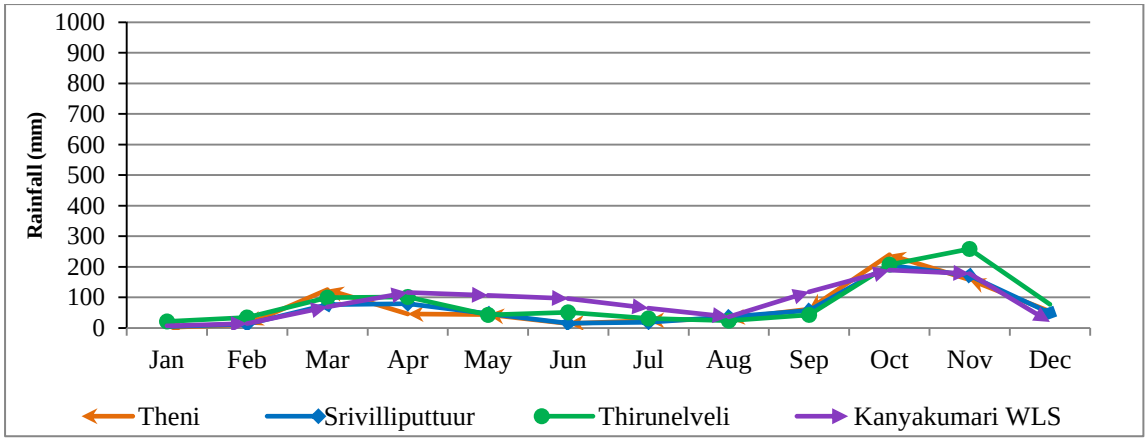


Figure 7B:Tamil Nadu part of the landscape

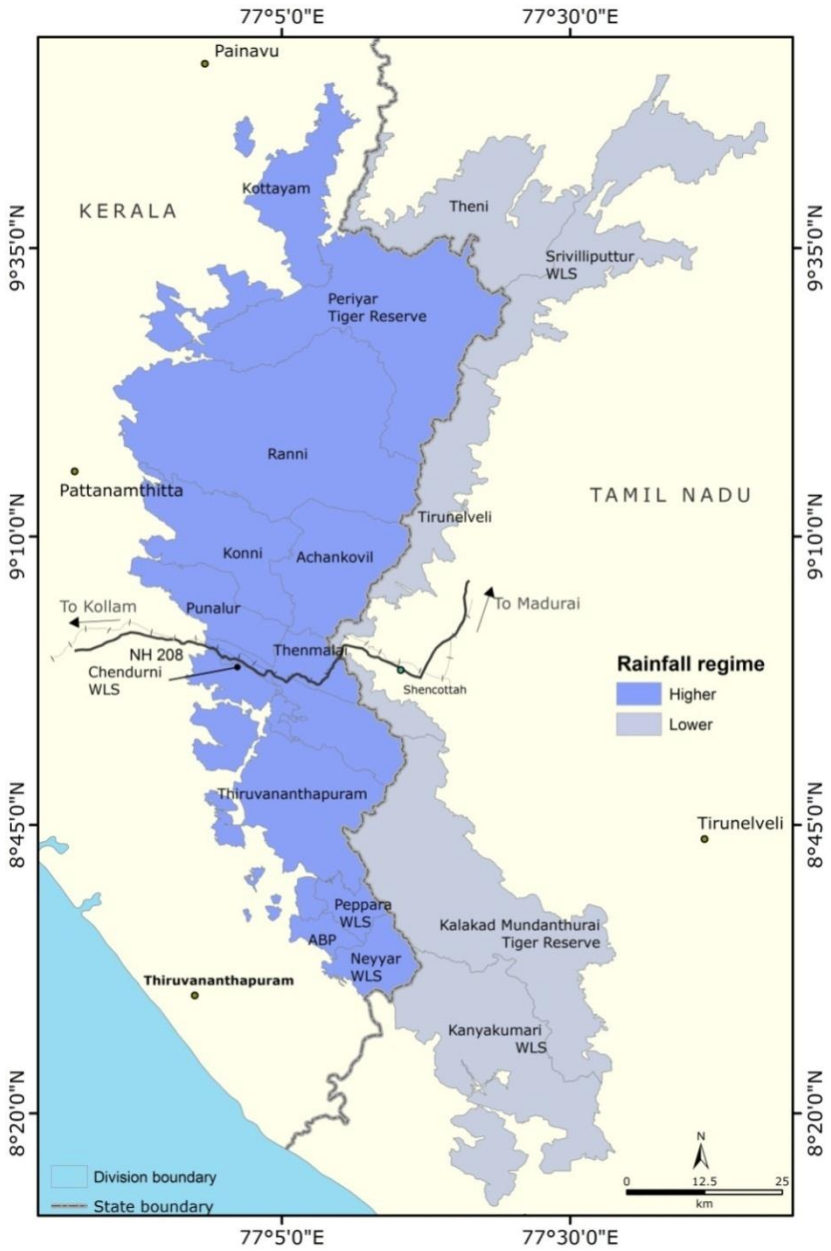


Figure 6: Schematic map of the P-A landscape showing the western and eastern sides of the landscape. The western side is wetter and receives rain mainly from the Southwest Monsoon, whereas the eastern side is drier and receives rain mainly from the North East Monsoon

2.2 Large mammal populations

The landscape on the northern side probably maintains the most intact elephant range in southern India. However, developmental activities such as human settlements and cultivation including commercial plantations and vehicular movements along the Madurai–Kollam National Highway 208and the railway line running parallel to the NH, have largely cut-off the habitat contiguity between the Agasthyamalai–Mahendragiri hill ranges and the Periyar plateau (Figure. 8). Therefore, larger mammals such as the elephant, gaur, sambar deer etc. ranging in the Agasthyamalai–Mahendragiri hill ranges are isolated from the larger population found on the northern side.

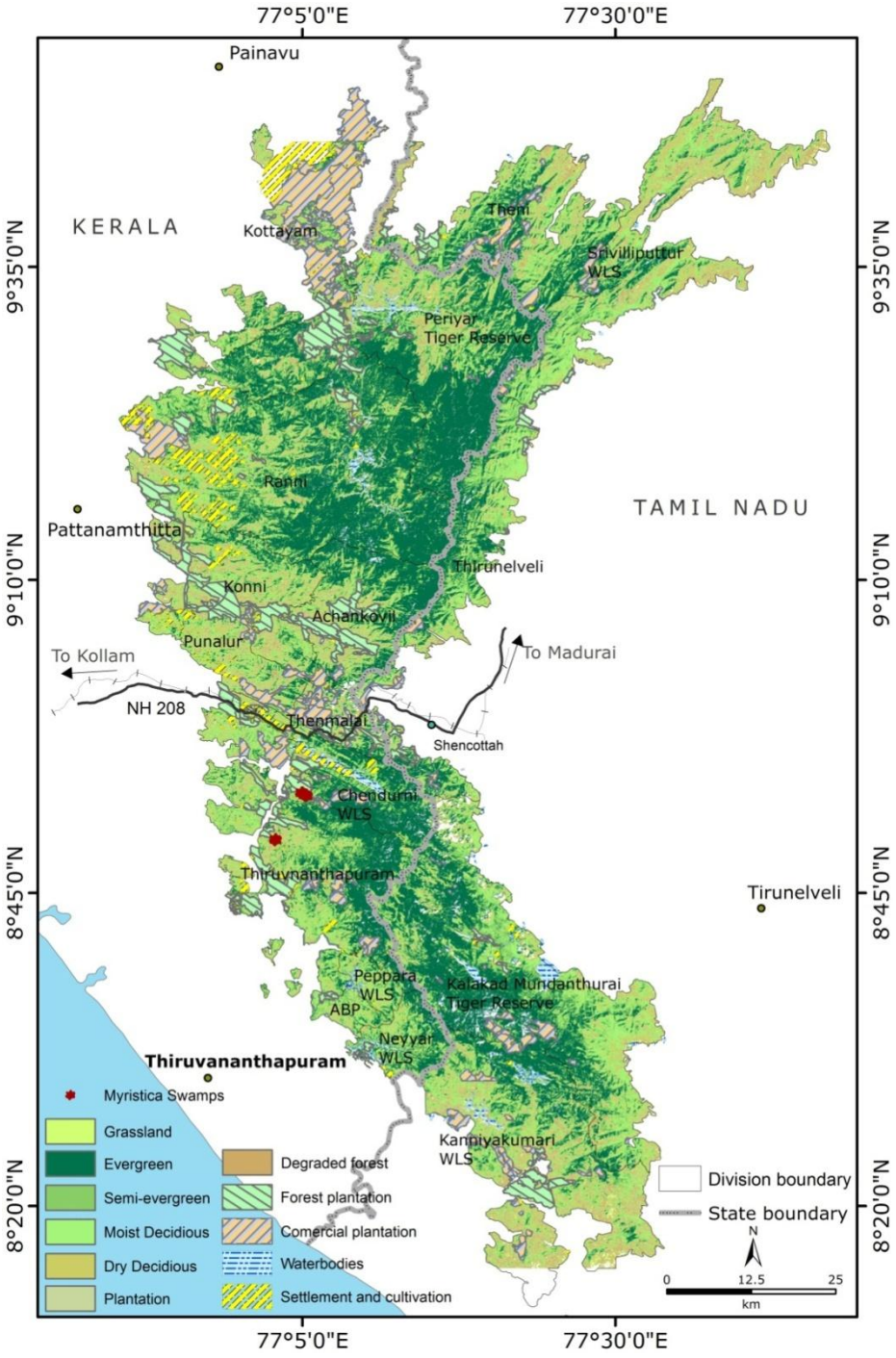


Figure 8: Vegetation types of the landscape

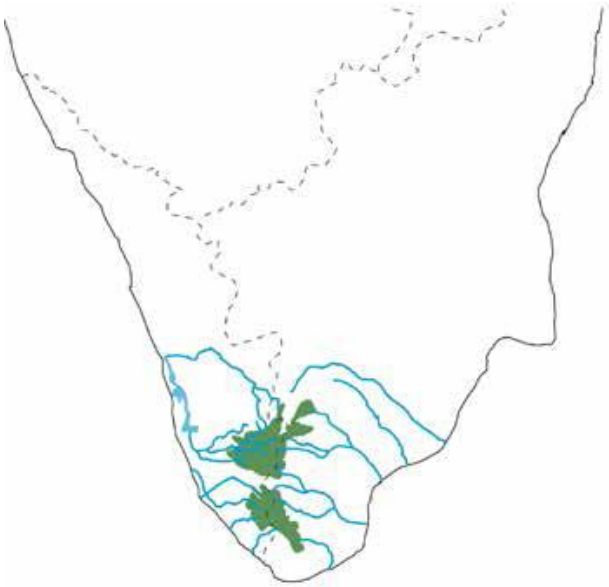


Figure 9: The water security that the Periyar-Agasthyamalai landscape provides to south & central Kerala and the southern rain shadow districts of Tamil Nadu makes it vital to the survival of this entire region.

2.3 Ecological status

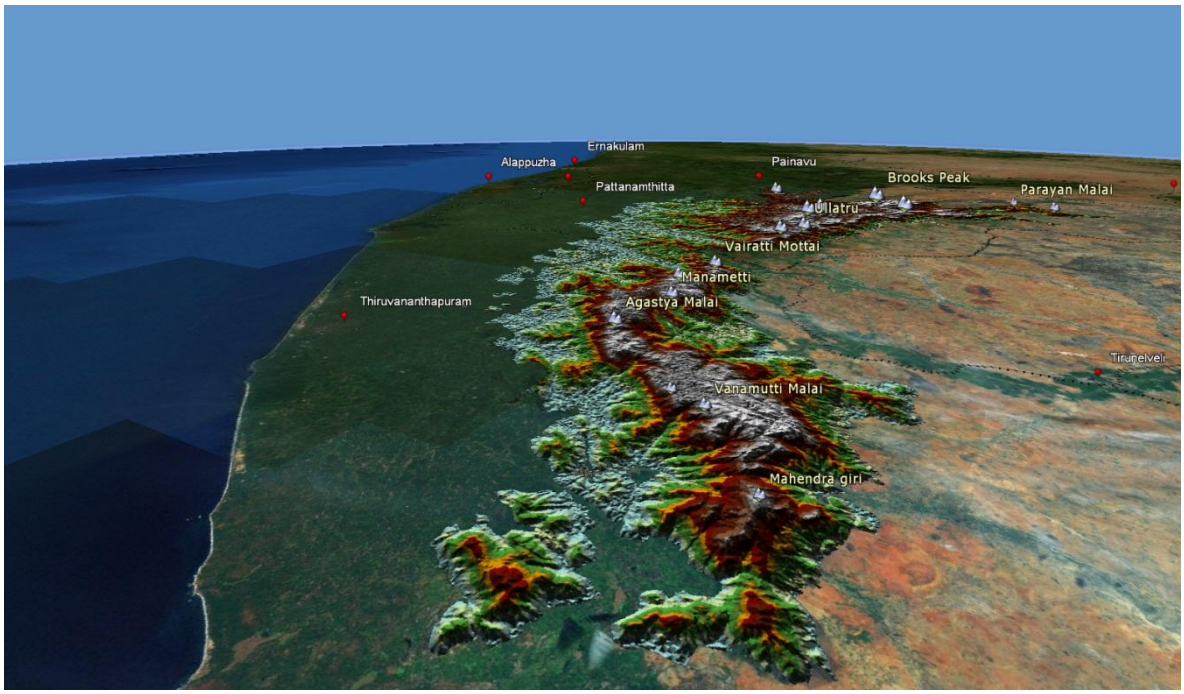
The Periyar–Agasthyamalai landscape is ecologically important within the Western Ghats due to its watershed and biodiversity significance (Figure. 9).The landscape acts as the major source of water for the southern parts of Tamil Nadu and Kerala. Its unique precipitation from both the monsoons (southwest and northeast) with the western side (mostly the state of Kerala) receiving the highest annual rainfall in the landscape, and its major share from southwest monsoon, while the eastern side with relatively lower annual rainfall from the western side but larger share of the northeast monsoon (View 1). Its varied altitudinal gradient results in the richest biodiversity area within the Ghats.

Photo 1: Nilgiri Tahr *Nilgiritragus hylocrius* seen in the high altitude shola grasslands

The landscape has diverse vegetation types starting from high altitude shola grasslands along the crestline to the tropical evergreen forests, thin stretches of semi evergreen and moist deciduous ultimately ending up into tropical dry deciduous and dry thorn or scrub forests at lower elevations. The diverse topography, climate and vegetation types, results in a landscape with a rich faunal assemblage.

Besides, the landscape is also home to a range of endangered and endemic mammalian fauna such as the Asian Elephant, Tiger, Nilgiri Tahr, Lion-tailed Macaque, Grizzled Giant Squirrel and also for a large number of herpeto and avifauna.

More than 50% of the area of the landscape is under Protected Reserves with two of them declared as Project Tiger Reserves. The landscape through its long wet season extending over two third of the year and dense vegetation cover, not only maintains the ecology of the Ghats, but also the plains that surrounds it, by providing clean air and drinking water to several thousand people living in the surrounding area beside fertile soil and adequate water for cultivation in the plains.



View 1: A schematic view of the landscape as seen from the south using Google Earth. The eastern side as can be seen in this image is generally drier. The rain shadow effect in the eastern side along with higher anthropogenic pressure in the form of cattle grazing and firewood collection, results in higher degradation of natural habitats.

2.4 Socio-economic status

The landscape supports people with diverse socioeconomic status. The people of this region could broadly be categorized into three different types based on income levels viz. (i) Families or house-holds below the poverty line, (ii) Middle class families and (iii) Upper class families. The families living below the poverty line have small land holdings for their housing and garden purposes and earn their livelihood mostly by working as daily wage labourers in commercial plantations owned by the middle and upper class families and/or from the seasonal work available with the forest departments. While the middle class families with moderate land holding (<5 acres), mostly earn their livelihood through cultivation, a small segment of this society is employed in the private/ government sectors. The upper class families with large land-holding (>5 acres) have their income coming from large scale commercial plantations like Rubber *Hevea brasiliensis*, Coffee *Coffea arabica*, Cardamom *Elettaria cardamomum* as well as business or professional employment (Table 2). The economic standard of the majority of people living on the eastern side of the landscape is relatively low and therefore dependency on forest is higher than on the western side. The rain shadow effect in the eastern side (Photo 6) along with higher anthropogenic pressure in the form of cattle grazing and fire wood collection, results in higher degradation of natural habitats.

2.5 Indigenous communities in the Periyar–Agasthyamalai landscape

The P-A Landscape is home not only to diverse endemic and endangered flora and fauna, but also to diverse human communities indigenous to the Western Ghats (Table 3). There are about 10communities*viz*. *Kani*, *Malavedar*, *Malampandaram*, *Vettuvar*, *Ulladar*, *Urali*, *Adiyan*, *Malayarayar*, *Mannan* and *Paliyan* living both inside and on the fringes of the forests on the Kerala side of the landscape. *Kani* is the dominant community in terms of number and distribution as well. The *Kani* tribe are primarily cultivators of mono-crops such as Rubber *Hevea brasiliensis* and Silk cotton *Bombax ceiba*. Those on the Kerala side cultivate Tapioca *Manihot esculenta* instead of silk cotton. Many of them supplement their income through wage labourtoo. The *Malampandaram* tribe found in the Achankoviland Ranni Divisions still leads a nomadic life in the forests, hunting and gathering, despite a permanent establishment provided at Achankovil. Among the other traditional communities, the *Malayarayar* is economically and socially better off. Communities like the *Ulladar*, the Malavedar and the *Adiyar* of the Ranni and Konni divisions are dependent largely on agriculture and daily-wage labour for their livelihood. A few households are engaged in bamboo and reed based craft works. Considerable numbers of *Mannans*are still dependent on the forests of the Periyar Tiger Reserve for their sustenance (fishing, NTFP collection and serving as forest watchers). Overall, the livelihoods of tribal people in the settlements of Kerala involve mainly agriculture, wage labour, NTFP collection and firewood collection.

Photo 2: Kani settlement

Photo 3: Malampandaram settlement

Photo 4: NTFP collection from the forest

Photo 5: NTFP preparation

Photo 6: NTFP being sold in the market

On the Tamil Nadu side, the *Kani* community is found largely in the Kanyakumari and Kalakkad–Mundanthurai Tiger Reserve. Further north the *Paliyar* community is distributed up to the Theni Division. Old records of the Theni Forest Division mention the existence of the *Muthuvar* and the *Mannatiyar* communities in a few settlements. On the Tamil Nadu side, the main livelihoods of the tribal people are livestock rearing, agriculture, and daily-wage labour. Dependence on NTFP is relatively low, while the collection of firewood and woodcutting as a source of income is extensive.

Table 2: Overview of Livelihoods of Tribal People in the Landscape

S. No.	Tribe	# of House hold	Population (apprx.)	Main Livelihoods	Nature of Forest Dependence
1	Malampandaram	21	1051	NTFP	Low
2	Kani	5345	18996	Monoculture of rubber, mixed agriculture, NTFP	High (Heavy land use)
3	Malavedar	202	898	NTFP, wage labour	Medium
4	Vettuvan	133	535	NTFP, wage labour	Medium
5	Ulladan	375	1423	Agriculture, NTFP	Low
6	Urali	-	-	NTFP, Agriculture, wage labour	Medium
7	Adiyan	89	189	Agriculture	Low
8	Malayarayar	24	91	Agriculture (rubber), Other mainstream jobs	Low
9	Mannan	-	-	Agriculture (spices), Fishing, NTFP	Medium
10	Paliyan	214	651	Agriculture, Wage labour, NTFP, Livestock	Medium

Table 3: Indigenous communities of the Periyar-Agasthyamalai Landscape

Division name	Malampandaram	Kani	Malavedar	Vettuvan	Uladan	Urali	Adiyan	Malayarayar	Mannan	Paliyan	Community
ABP Special Fd	-	yes	-	-	-	-	-	-	-	-	1
Achankovil	yes	-	-	-	-	-	-	-	-	-	1
Kanyakumari WLS	-	yes	-	-	-	-	-	-	-	-	1
KMTR	-	yes	-	-	-	-	-	-	-	-	1
Konni	yes	-	-	-	-	-	-	-	-	-	1
Kottayam	-	-	-	-	-	-	-	-	-	-	0
Neyyar WLS	-	yes	-	-	-	-	-	-	-	-	1
Peppara WLS	-	yes	-	-	-	-	-	-	-	-	1
Periyar TR	yes	-	-	-	yes	yes	-	yes	yes	yes	6
Punalur	yes	yes	-	-	-	-	-	-	-	-	2
Ranni	yes	yes	yes	yes	yes	-	yes	yes	-	-	7
Chendurni WLS	-	-	-	-	-	-	-	-	-	-	0
Srivilliputtur WLS	-	-	-	-	-	-	-	-	-	yes	1
Theni	-	-	-	-	-	-	-	-	-	yes	1
Thenmalai	yes	yes	yes	-	-	-	-	-	-	-	3
Tirunelveli	-	-	-	-	-	-	-	-	-	yes	1
Thiruvananthapuram	-	yes	-	-	-	-	-	-	-	-	1
Overall	6	9	2	1	2	1	1	2	1	4	29

2.6 Threats to the landscape

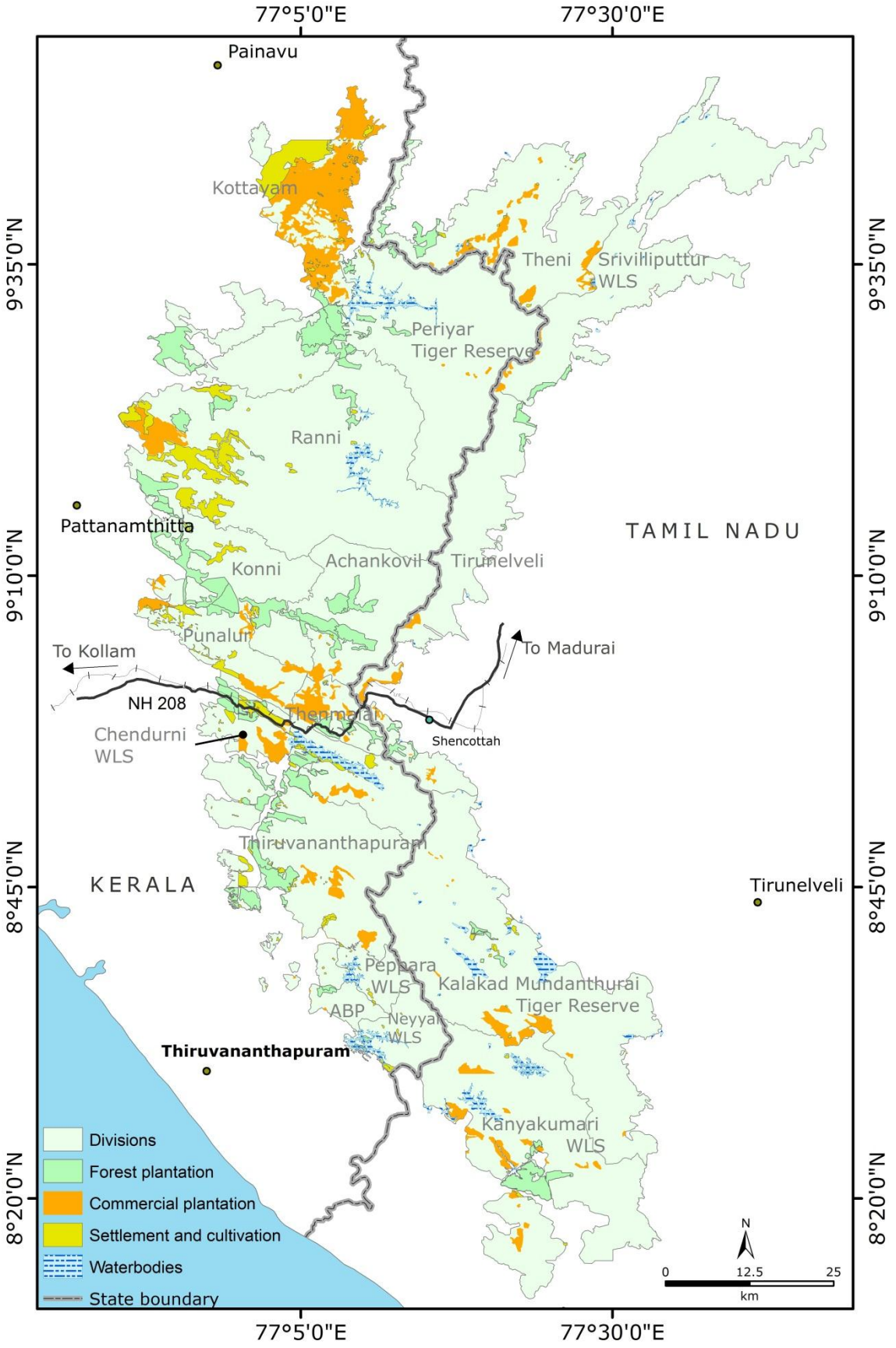


Figure 10: Conservation threats to the landscape

Hydroelectric power projects:

Photo 7 & Photo 8: Upper Kodaiyar Hydroelectric Project in KMTR & Penstock pipes of a Hydroelectric Project in Periyar TR

The natural habitat in the landscape is fragmented by a number of large hydroelectric power projects; Periyar, Kothayar, Sittar, and their associated infrastructure like dams, open canals, penstock pipelines and powerhouses.

Photo 9& Photo 10: Tea and Rubber Plantations respectively

Monoculture Commercial Plantations:

Large scale conversion of natural forests into commercial plantations (Figure. 10) of Tea, Coffee and Cardamom(*Elettaria cardamomum*), other cultivation and settlements have fragmented the habitat contiguity apart from degrading the habitat (Menon and Bawa 1997).

Madurai–Kollam National Highway (NH 208):


Photo 11 and Photo 12: Shenkottah Punalur railway and the Madurai-Kollam NH 208 and the line respectively. These along with the settlements, commercial plantations combined with topographical issues have effectively divided the landscape into two parts

The vehicular traffic on the Madurai–Kollam National Highway (NH 208) and the development of human settlements and cultivation including commercial plantations along the NH 208 (Figure 10) have cut off the southern part of landscape (Agasthyamalai–Mahendragiri hill ranges) from its northern part (Periyar Plateau). Though, in a few places forest contiguity does exist between the two parts of the landscape, no large mammal movement takes place between the two parts, as existing contiguities are not accessible to large mammals due to topographical constraints. Conversion of the Madurai–Kollam meter-gauge railway line, running parallel to the NH 208 into broad-gauge (Figure 11) would further aggravate the fragmentation level.

Pilgrimage Sites


Photo 13& Photo 14: Pilgrimage sites of Azhagar koil in Srivilliputtur WLS and Sabarimala in PTR

Visits by several thousands of pilgrims to popular temples like Sabarimala and Mangala Devi Temples in Periyar Tiger Reserve, Agasthyamalai in KMTR, Azhagarkoil, and Sundaramahalingam koil in Srivilliputhur WLS are not only physically disturbing the wildlife but also pollutes the natural habitats with enormous amounts of plastic garbage that is detrimental to the well being of wild animals.

Railways: Shenkottah Punalur section metre gauge conversion to broad gauge.

The Kollam-Shenkottah railway line - a brief history

The Kollam-Shenkottah railway line, the first one in erstwhile Travancore, is more than a century old. It was built jointly by South Indian Railway Company, Travancore State and Madras Presidency. After the survey in 1888, work started in 1900 and it was completed by 1903. The railway line was constructed by the British to transport forest products, spices and cashew from Kollam to Chennai, their southern headquarters. Their tea estates and coffee plantations thrived on the labour of tribals living in the Thenmalai forests and workers from Tamil Nadu. The railway line has contributed much to the development of the plantation economy in this area. Ambanadu tea estate and Rose malai plantations stand testimony to this. Forest products such as honey from these areas reach towns like Tenkasi and Tirunelveli through this route.

Shenkottah Punalur section

Fig 11: The Shenkottah Punalur section is part of a larger Virudhunagar – Tenkasi – Tirunelveli/ Tiruchendur – Kollam. An alternative route will open up that passes through the Shenkottah Gap. It is 70 km shorter than the other route

The Shenkottah-Punalur section (Figure 11) is 45 km in length that is part of the larger Virudhunagar –Tenkasi – Tirunelveli/ Tiruchendur – Kollam 357 km gauge conversion project sanctioned in 1998.

The first segment was completed when the 52-kmVirudhunagar-Rajapalayam line was opened to traffic in June 2003. Following the commissioning of the onward Rajapalayam-Tenkasi link in September 2004, the entire 121-km Virudhunagar-Tenkasiline became operational. A 61 km stretch between Tirunelveli and Tiruchendur has been completed, so has the 8 km Shenkottah-Tenkasi section in 2008.The 45 km stretch of the Kollam-Punalur metre gauge, closed for conversion works since 2007 has been recently completed.

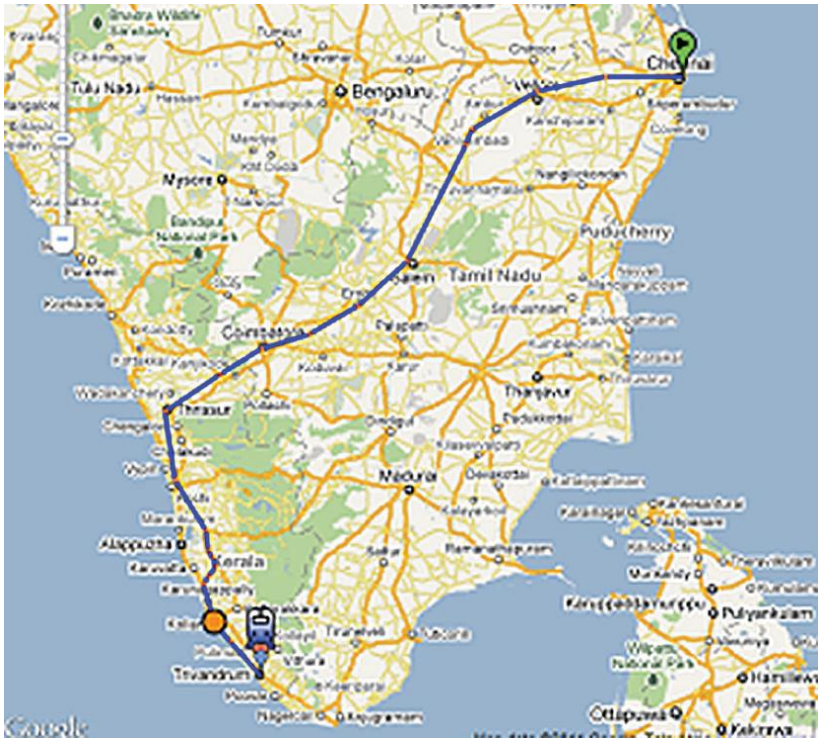


Figure 12: The current Thiruvananthapuram Chennai Line passes through the Palghat Gap

The last section which is the Shenkottah Punalur section has been closed since September 2010 and work should be completed in 3 to 5 years. Following this the entire section will be thrown open to broad gauge traffic. The overall project falls under the Madurai division, one of the five divisions of the Chennai headquartered Southern Railways.

Threats

The main rail connection between Kerala and the rest of the country has been through the Palghat Gap
(Figure12). Broad gauging of the Shenkottah Punalur section will provide the shortest route connectivity between Trivandrum and Chennai, reducing the distance between Thiruvananthapuram and Chennai by roughly 70 km. Though the line is going to be laid on the existing track, with no doubling, expansion or major civil works are involved. With the conversion to broad gauge one can expect heavy and fast train traffic through this corridor. It will not only greatly enhance the access of the Punalur Shenkottah section to the entire south, it will also serve as an important passage across the Western Ghats connecting a wide range of large towns.

The train line passes through the Chendurni WLS. Picturesque stations such as Thenmalai, Ottakkallu and Bhagavathipuram, the Palaruviand Kazhuthurutti waterfalls, the Thenmalai eco-tourism zone and the majestic Courtallam waterfalls. The route is likely to lead to further tourism infrastructure development and bring in a larger volume of tourist traffic.

References

http://beta.thehindu.com/life-and-style/metroplus/article253659.ece?cs...
http://www.thehindu.com/2008/01/25/stories/2008012555080600.htm
http://www.thehindu.com/2010/09/13/stories/2010091355630400.htm

3 Elephant Habitats in the Periyar-Agasthyamalai Landscape

3.1 Introduction

India holds about 60 % of the global population of Asian Elephants *Elephas maximus* in the wild (Baskaran et al. 2011, Riddle et al. 2010). The country hosts three of the 34 global 'biodiversity hotspots' (Myers et al. 2000, Mittermeier et al. 2005), with diverse vegetation types and a significant number of endemic fauna and flora (Gadgil and Meher-Homji2003). In the recent decades (between the 1970sand 2010), the country has enacted several laws to establish National Parks and Wildlife Sanctuaries(Protected Areas – referred as PAs) as well as to conserve forest cover and protect its wildlife (Bist2002). Nevertheless, such a PA network itself is still inadequate to conserve a wide-ranging species such as the elephant. Elephants have large home ranges that extend across PAs and other land use categories including privately-owned lands (Desai 1991; Baskaran et al. 1995). Asian Elephants still occur in isolated populations across much of their historical ranges. Many of these are still threatened by habitat loss and degradation, poaching for ivory and other products, and direct conflict with humans especially in cultivated lands (Daniel 1980; Sukumar 1989; Riddle et al. 2010). The species is currently listed as 'endangered' (IUCN Red List 2011), and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES: UNEP-WCMC 2003).

The Indian government launched 'Project Elephant' in 1992 to initiate comprehensive measures for elephant conservation in the wild and in captivity (Project Elephant: Gajatme 1993). Under this scheme, traditionally important elephant habitats have been designated as Elephant Ranges across the country with most of them spread across more than one state. Elephant Range areas falling within each state have been notified as Elephant Reserves (Bist 2002).There are presently 11 Elephant Ranges and 25 Elephant Reserves in 12 states, spread across 58,000 km^2,harbouring more than 20,000 elephants or nearly two-third of the wild elephant population of the country (Project Elephant 2004). More recently, the government carried out a review of Project Elephant through a task force that suggested several measures to correct ongoing efforts with a view to strengthening the conservation of the species (Gajah 2010). The need for maintaining the overall integrity of an entire landscape over which the species is distributed has been recognized as the key management option for the long-term conservation of the species.

3.2 Project Elephant Reserve 10 (5,700 km^2)

Project Elephant Reserve 10 (5,700 km^2) popularly known as the Periyar plateau and Agasthyamalai-Mahendragiri hills ('Periyar-Agasthayamalai Landscape') is located in the southern part of the Western Ghats (Figure 13).

The landscape on the northern side (Periyar plateau) maintains the most intact elephant range in southern India. This area is believed to harbour about 2,000 elephants (Sukumar et al. 1998; Bist 2002) and is one of the potential landscapes for the long-term conservation of the species. This population is genetically more diverse and distinct from the much larger elephant population further north in the Ghats (Vidya et al.2005). This region is also known for its rich biodiversity (Ramesh et al. 1997). On the other hand, the landscape has also witnessed a variety of developmental activities including commercial plantations, hydroelectric and irrigation projects and other forms of infrastructural development that impede the movement of elephants.

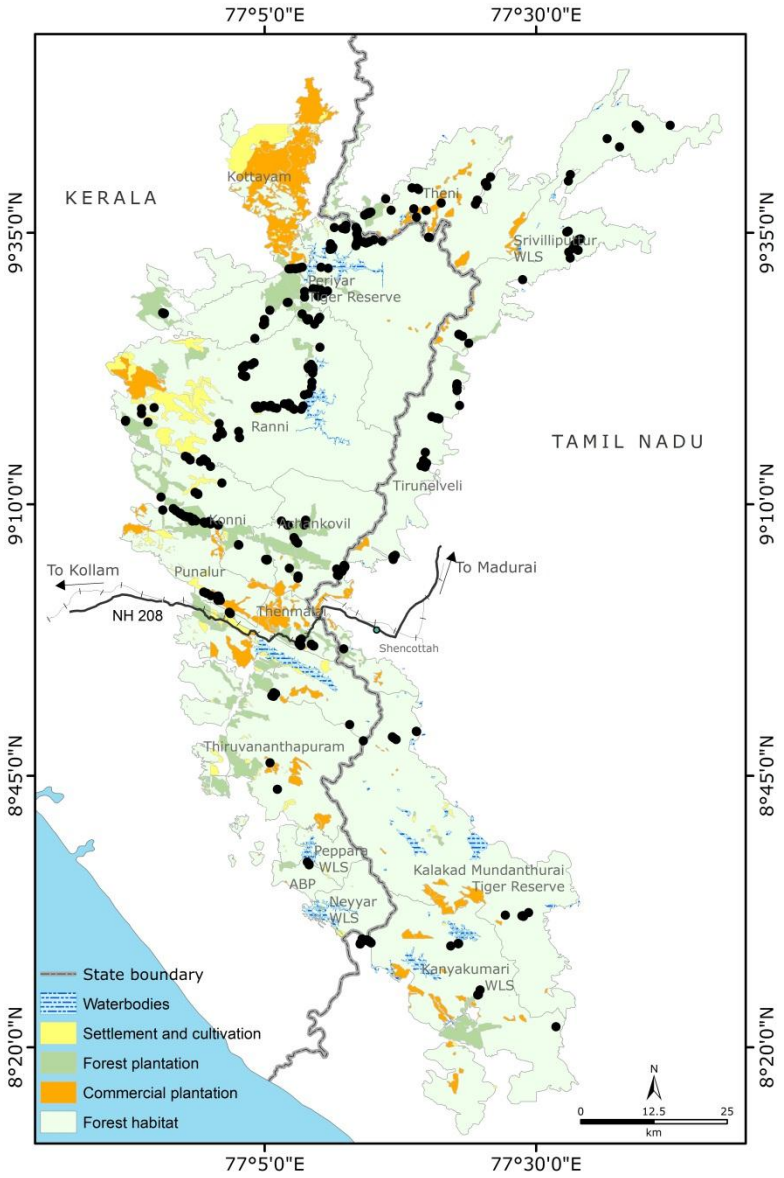


Figure 13: Elephant sightings recorded in the current project

Although the landscape is highly suitable for elephants, there are threats facing the long-term survival of elephants in this landscape. Information on the status of the elephant habitats and its land-use and vegetation patterns are scanty and comprehensive data necessary for the long term planning for elephant conservation does not exist.

3.3 Methods

Mapping of elephant habitats and corridors

To identify and map elephant habitat and "corridors" (Venkataraman 2005), a systematic field survey was carried out in all forest divisions across the landscape. During the survey, boundaries of forest divisions and ranges were marked on1:50,000 scale topographic maps in consultation with the Forest Department. Elephant habitat and their corridors were identified through direct sightings, and indirect evidence (such as elephant trails and footprints, dung

piles, and feeding signs), and incorporated along with other variables(division and range boundaries, elephant habitats and corridors) into topographic maps (Figure 14)that were digitized using Geographical Information System (GIS) software (Arc View 3.3, ESRI Inc.).

In addition, layers such as major rivers, highways, contour lines, settlements and cultivation obtained from the maps were overlaid.

3.4 Results

Status of Elephant habitats

Overall, the landscape extends over 6700 km^2 under 17 forest divisions in which elephants are distributed over 6150 km^2 (Table 4). Nearly, half(46%) of the forested area in the landscape is under the Protected Area network consisting of Wildlife Sanctuaries and Tiger Reserves and the rest is with territorial designation (Table 4). The landscape on the northern side (Periyar plateau) is probably maintaining the most intact elephant range in southern India (Gajah 2010, Baskaran et al. 2011).Nevertheless, the developmental activities such as National Highway along with established railway line, and commercial plantations (like tea *Camelliasinensis*, coffee *Coffea arabica*, cardamom *Elettaria cardamomum* and rubber *Hevea brasiliensis*),hydroelectric power and irrigation projects and human settlements/agriculture along the Shenkottah Gap have almost cut-off the habitat contiguity (Figure 14), impeding large mammal movement between the northern and southern parts of the landscape. Local people residing in the Shenkottah Gap reported to the study team that elephant movement between the two parts of the landscape was taking place till the early seventies. But there was no report of elephant movement across the Shenkottah Gap in recent decades.

Elephant Corridors in the landscape

Photo 15: Elephants *Elephant maximus* disturbed by human activity moving away

The elephants in the area ranged across the landscape in the past. Nevertheless, the ANCF field survey and interaction with local people established that no elephant movement was taking place between northern (Periyar plateau, Meghamalai and Achankoil hill ranges) and southern (Agasthyamalai, Mahendragiri hills) parts of the landscape since1970. The development of various non-forest elements along the Shenkottah Gap such as (i) The establishment of Madurai-Kollam National Highway 208 and (ii) Railway line cutting across the landscape on the east-west axis, and (iii) Development of the settlement/cultivations and (iv) Large scale commercial plantations all along NH 208have broken the forest contiguity to a large extent, especially in areas with gentle altitudinal gradient (Figure14), where elephants and other animal movement was taking place previously. Although, there exists a few places with forest habitats on either side of the NH free of human settlement/cultivation (Figure 14), no large mammal moves across the NH due to steep altitudinal gradient and/or high traffic load in the NH. One such

location present in the eastern side of the landscape at a place called Kottavasal near the interstate border cutting across the NH, where the railway line goes underground. The conversion of meter gauge line into broad-gauge, which is going on at present, would further aggravate the disturbance level. The Kerala Forest Department has proposed to establish a corridor for the elephants and other wild animals near Ariyankavu at a place called Kalturrt. An underpass construction for the NH at Kottavasal could increase the chances of elephant and other animal movement between the two parts of the landscape.

Table 4: Extent of area and legal status of forest divisions in the Periyar–Agasthaymalai landscape

Division name	Extent of area in km^2				
	Total	Elephant Habitat	Tiger Reserve	Wildlife Sanctuary	Territorial Area
Eastern side of Landscape					
Kanniyakumari WLS	502.7	502.7	-	502.7	-
KMTR	892.8	840.8	892.8	-	-
Srivilliputtur WLS	410.0	410.0	-	410.0	-
Theni	543.0	435.3	-	115.8	319.5
Tirunelveli	352.2	352.2	-	-	543.00
Tamilnadu	2700.7	2541.0	892.8	1028.5	862.5
Western side of landscape					
ABP	44.5	44.5	-	44.5	-
Achankovil	268.3	268.3	-	-	268.30
Cendurni WLS	171.8	171.8	-	171.8	-
Konni	330.7	284.6	-	-	387.9
Kottayam	387.9	225.5	-	-	330.7
Neyyar WLS	113.0	113.0	-	113.0	-
Pepara WLS	64.4	64.4	-	64.43	-
Periyar TR	777.0	758.4	777	-	-
Punalur	280.0	242.7	-	-	280.00
Ranni	923.0	923.0	-	-	923.00
Thenmalai	210.3	145.3	-	-	210.30
Thiruvanathupuram	433.5	369.0	-	-	369.00
Kerala	4004.4	3610.6	777.0	393.7	2769.2
Overall	6705.1	6151.6	1669.8	1422.2	3631.7

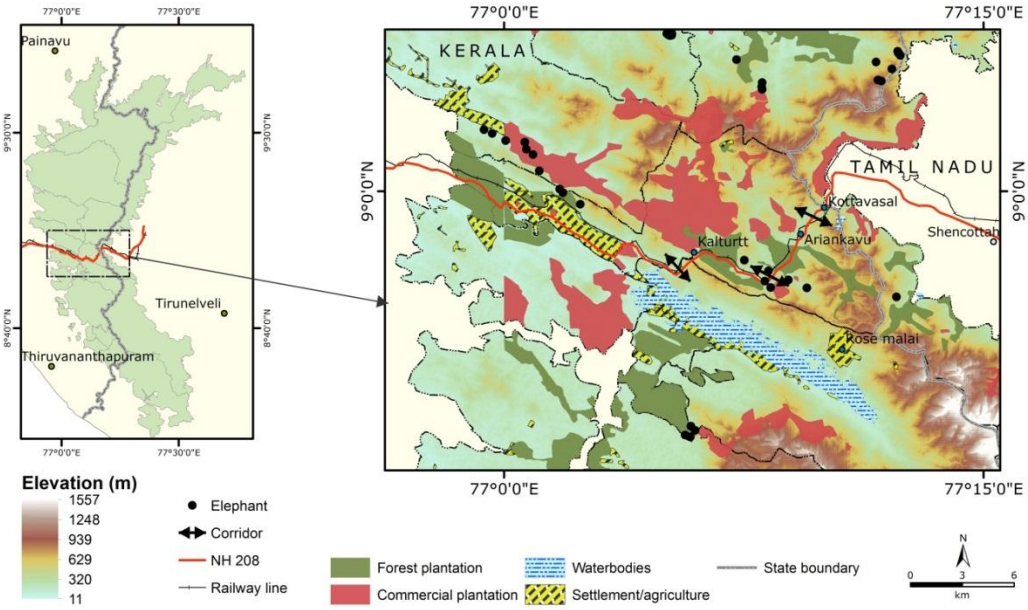


Figure 14: Map showing the Elephant Corridors in the Shenkottah Gap of the Periyar-Agasthyamalai landscape

3.5 Human-Elephant conflict

Out of 17 forest divisions with elephant distribution in the landscape, data on human-elephant conflict was available from the Forest Department (Table 5) for eleven forest divisions. The available data show that on average the landscape has experienced 36±1.5 conflict incidences/year between 2003 and 2010.The forest divisions like Kalakad-Mundanthurai

Table 5: Human-Elephant conflict incidences reported in different Forest Divisions of the Periyar-Agasthyamalai landscape in different years

Division name	2003	2004	2005	2006	2007	2008	2009	2010	Mean ±SE
Kanniyakumari WLS	5	5	5	5	5	5	5	5	5 ± 0.0
KMTR	7	7	7	7	10	8	9	9	8 ± 0.4
Konni	-	-	1	1	-	1	6	2	2 ± 1.0
Punalur	-	-	-	-	-	-	-	1	IS
Ranni	8	5	7	1	-	5	-	-	5 ± 1.2
Cendurni WLS	-	-	-	-	1	-	1	1	1 ± 0.0
Srivilliputtur WLS	4	4	4	4	4	4	9	6	5 ± 0.6
Theni	6	6	6	6	6	6	6	6	6 ± 0
Thenmala	1	1	1	1	1	1	1	-	1 ± 0
Trirunelveli	4	4	6	4	15	4	4	4	6 ± 1.4
Thiruvanathupuram	-	-	-	-	-	-	-	2	2 ± 0
Overall	35	32	37	29	42	34	41	36	36±1.5

IS=insufficient sample

Tiger Reserve, Tirunelveli, Theni, Srivilliputtur, Ranni Forest Division and Kanyakumari WLS experienced annually higher conflict incidences than the rest of the divisions in the landscape. The human-elephant conflict incidences were more frequent during January and July months (Table6). Data on compensation or ex-gratia payment show that most of the payment was towards human casualty (Table 7).

Table 6: Human-elephant conflict incidences reported in different Forest Divisions of the Periyar-Agasthyamalai landscape in different month during 2003-2010

Month	2003	2004	2005	2006	2007	2008	2009	2010	Mean ±SE
January	-	-	2	-	8	1	1	1	4.33±2.1
February	-	-	4	-	-	-	1	3	4±1.4
March	-	-	1	-	3	-	-	-	2.6±0.9
April	-	-	1	-	-	-	-	-	IS
May	1	-	-	-	-	1	2	-	2±0.7
June	2	-	-	-	-	-	4	1	3.5±1.3
July	4	3	2	-	-	2	-	1	4±1.6
August	-	1	-	-	-	-	2	-	2±0.6
September	-	-	-	1	-	-	1	2	2±0.7
October	-	1	-	-	-	1	1	2	2±0.8
November	-	-	2	1	1	-	1	-	2±0.8
December	-	-	-	-	3	-	1	1	2.5±1
Overall	7	5	12	2	15	5	12	11	

Table 7: Compensation amount paid towards human-elephant conflict incidences in different Forest Divisions of the Periyar–Agasthyamalai landscape (crop loss & human death/injury compensation separately)

Division name	2003	2004	2005	2006	2007	2008	2009	2010	Mean±SE
Kanniyakumari WLS	-	-	-	-	-	-	-	-	-
KMTR	-	-	-	-	5800	15000	200000	30000	62700 ± 46037
Konni	-	-	3420	3080	-	15250	34639	13654	14009 ±5739
Punalur	-	-	-	-	-	-	-	136260	IS
Ranni	98315	22250	30274	1399	-	19906	-	-	34428 ± 16656
Cendurni WLS	-	-	-	-	50000	-	100000	950	50316 ±28593
Srivilliputtur WLS	-	-	-	-	-	-	-	-	-
Theni	-	-	-	-	-	-	-	-	-
Thenmala	15279	923	18375	17400	10125	49450	108224	-	31397 ± 14002
Trirunelveli	-	-	55000	-	142775	-	-	15000	70925 ± 37735
Thiruvanathupuram	-	-	-	-	-	-	-	44600	IS
Overall	**113594**	**23173**	**107069**	**21879**	**208700**	**99606**	**442863**	**240464**	

IS=insufficient sample

4 Vegetation and Land Use Patterns in the Periyar-Agasthyamalai Landscape

4.1 Mapping of vegetation and land use patterns

During the field surveys, different landscape elements (LSE) were identified using differences in land-use pattern and vegetation composition. The earlier classification of the French Institute (Pascal et al. 1982) was used as the basis for this exercise. For enchase, ground truthing was carried out at multiple locations by laying 20m x 20m plots (Ground Truthing Plots) for natural forest areas and no plots were enumerated in non-forest areas and forest plantations. For all the ground-truthing plots and points, the latitude and longitude were recorded using Global Positioning System-GPS. The ground data on LSE were then used as a reference for generating a land use map from satellite imageries. Satellite images from multispectral scanner LISS 3 (with spatial resolution of 23.5m obtained in Feb 2005, with the following paths and rows, 100-066, 100-067, 101-066, 101-067) on board IRS P6 were used for land use/land cover mapping. Image processing was carried out in ERDAS Imagine 8.3.1 by the following steps:

- Preliminary processing of satellite images: Satellite images of the Periyar-Agastyamalai ranges were selected and unclear portions enhanced through either sharpening or smoothing (Jensen 2007). The images were georeferenced using control points, obtained from topographic sheets and field surveys and resample using nearest neighbourhood algorithm (Lilles and Kiefer 2000).

- Spectral Unmixing: We adopted a novel methodology to classify the various landscape element types in the Periyar-Agastyamalai landscape. We applied spectral unfixing procedures (Figure 15) and selected three end members to classify the landscape into its various landuse landcover types. Prior to conducting the spectral mixture analysis, principal components transform was applied on the dataset.

- Accuracy assessment: A set of 1235 ground truth points collected across the landscape was used as reference points for assessing the accuracy of the classification using standard method. The overall accuracy was computed by dividing the total number of correctly classified pixels by the total number of reference pixels (Lilles and Kiefer 2000).The average overall accuracy for the land cover classification of landscape was 72.5%, relatively higher accuracy was obtained for land cover types such as semi evergreen (73%) and plantation (71%) types. Misclassification was higher in the degraded forests and the tropical dry deciduous forests.

Linear Spectral Unmixing:

In conventional remote sensing classification methods, a pixel is considered to have homogenous spectral information of the remotely sensed land surface. However, very often a pixel could have more than one land surface type within the spatial bounds of the pixel. In order to accurately characterise this information, the spectral information within the pixel can be split into its various components, through linear spectral unmixing. In linear spectral unmixing (Figure 15) the spectral signature of a pixel is a linear combination of the pure spectra of the land surface materials located in the pixel area, weighted by their fractional abundance. This method has been shown to improve classification accuracies of remote

sensed data. However, it is computationally more intensive and requires at least 4 bands of remotely sensed data to conduct the analysis. Figure 15 shows an illustration of the concept.

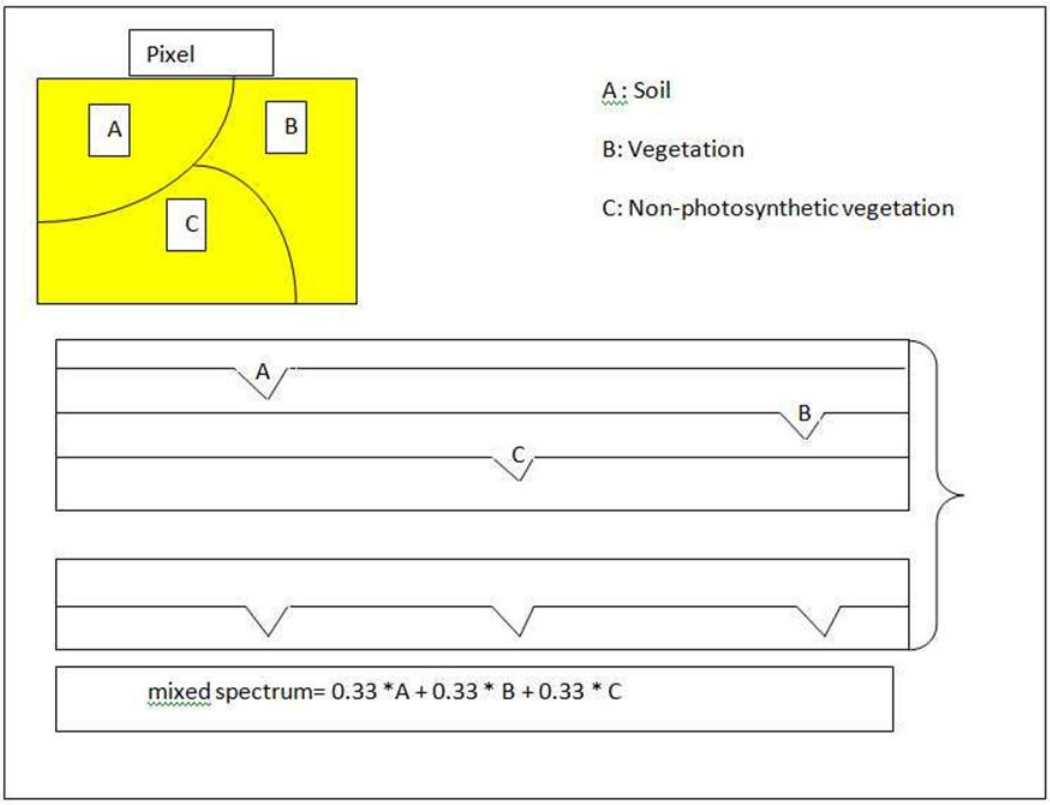


Figure 15: Linear Spectral Unmixing

4.2 Status of forest and non-forest elements in the landscape

The landscape consists of both forest elements that include natural forests and monoculture forest plantations, spreading across 92% of the landscape and non-forest elements occupying 8% of the landscape area in the form of Settlements/Agriculture and Commercial Plantations. Divisions like Kottayam, Ranni and Theni have large non-forest elements, while forest divisions like Periyar and Kalakad-Mundanthurai Tiger Reserves have large tract of natural habitat on their own (Table 8a and 8b).

Table 8a: Details of non-forest land use attributes in different forest divisions of Eastern side of landscape in the Periyar-Agasthyamalai landscape

Division	Settlements /Agriculture			Commercial plantation			Forest plantation			Nature Forest		
	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)
Easter side of landscape												
Kanniyakumari WLS	3	1.1	10	25	29.6	137.6	8	27	70.4	2	503	411
KMTR	3	3.1	27.9	22	22.1	99.4	6	4.5	34.8	1	841	436.6
Srivilliputtur WLS	0	0		18	5	53.3	9	4.8	28.9	1	410	416.1
Theni	5	2	24.9	27	34.1	160.3	10	15.2	66.9	1	435	396.1
Tirunelveli	0	0		13	12.3	70	7	11.8	66.7	1	352	314.5
Tamilnadu	11	6.2	62.8	105	103.2	520.5	40	63.4	268	6	2541	1974

Table 8b: Details of non-forest land use attributes in different forest divisions of Western side of landscape in the Periyar-Agasthyamalai landscape

Western side of landscape												
Division	Settlements /Agriculture			Commercial plantation			Forest plantation			Nature Forest		
	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)	n	Area (km^2)	Perimeter (km)
ABP	1	0.1	2	4	0.2	4.7	4	1.9	14.8	1	44.5	395.8
Achankovil	1	0.3	4.2	5	2.2	16	5	42.4	124	1	268	401.2
Cendurni WLS	1	11.5	42.6	5	5.7	25.2	4	0.1	28.9	1	172	204.9
Konni	3	7.3	45.7	11	4.5	49.1	18	57.7	193	1	285	180.9
Kottayam	4	45.9	161	17	169.7	379.3	9	25	61.1	3	226	324
Neyyar WLS	1	2.3	14	1	0	0.2	3	1.9	12.2	1	113	92.2
Peppara WLS	1	1.2	14.4	2	0.9	6.4	0	0		1	64.4	166.7
Periyar TR	4	1.1	23.5	15	1.2	22.9	18	47.5	162	1	758	143.9
Punalur	3	15.7	158	14	36.8	112.9	13	19.1	82.3	3	243	42.01
Ranni	3	77.7	269	5	25.8	54.6	19	36	127	1	923	187.6
Thenmalai	3	10.6	51.9	24	28.1	130.6	14	34.9	132	2	145	169.3
Thiruvananthapuram	6	9.7	104	15	16.8	95.4	13	38.3	148	7	369	324.7
Kerala	31	184	891	118	292	897.4	120	304.8	1086	23	3611	2633
Overall	42	190	953	223	395	1418	160	368	1353	29	6152	4608

Table 9: Extent of various altitudinal gradients found in different Forest Divisions in the Periyar-Agasthyamalai Landscape (km^2)

Division	0-250	250-500	500-750	750-1000	1000-1250	1250-1500	>1500
Eastern side of landscape							
Kanniyakumari WLS	175	112.2	70.8	43.4	25.4	53.8	21.9
KMTR	144.4	188.9	181.7	117	118.5	125.2	17.1
Srivilliputtur WLS	71.9	106.4	102.5	60.5	44.5	19.2	5.2
Theni	39	63.4	126.5	131.8	66.3	51.1	64.8
Tirunelveli	41.5	107.4	79.8	63.4	41.1	16.7	2.4
Tamilnadu	**471.8**	**578.4**	**561.4**	**416.1**	**295.8**	**266**	**111.4**
Western side of landscape							
ABP	36.4	6.3	1.7				
Achankovil	41.5	72.8	63.6	42.7	30.1	14.5	3.1
Cendurni WLS	50.9	40	30.2	25.6	16.1	7	1.8
Konni	189.6	121.5	15.6	3.9	0	0	0
Kottayam	43.3	57.9	37.6	109.5	135.2	4.4	0
Neyyar WLS	49.4	28.4	16.2	8	6.1	3.6	1.4
Pepara WLS	25.5	19.6	8.2	5.1	3.4	2.1	0.1
Periyar TR	19.5	54.3	44.3	204.4	278.9	129.2	46.5
Punalur	234.5	34.2	10.1	1.7	0	0	0
Ranni	205.5	192	104.7	91.3	235.2	74.2	20.1
Thenmalai	58.4	62.2	37.2	9.1	41.1	0	2.4
Thiruvanathupuram	206.7	79.5	58.2	45.7	30.3	11.4	2
Kerala	**1161.3**	**768.6**	**427.7**	**547**	**776.4**	**246.3**	**77.4**
Overall	**1633.1**	**1347**	**989.1**	**963**	**1072.3**	**512.3**	**188.9**

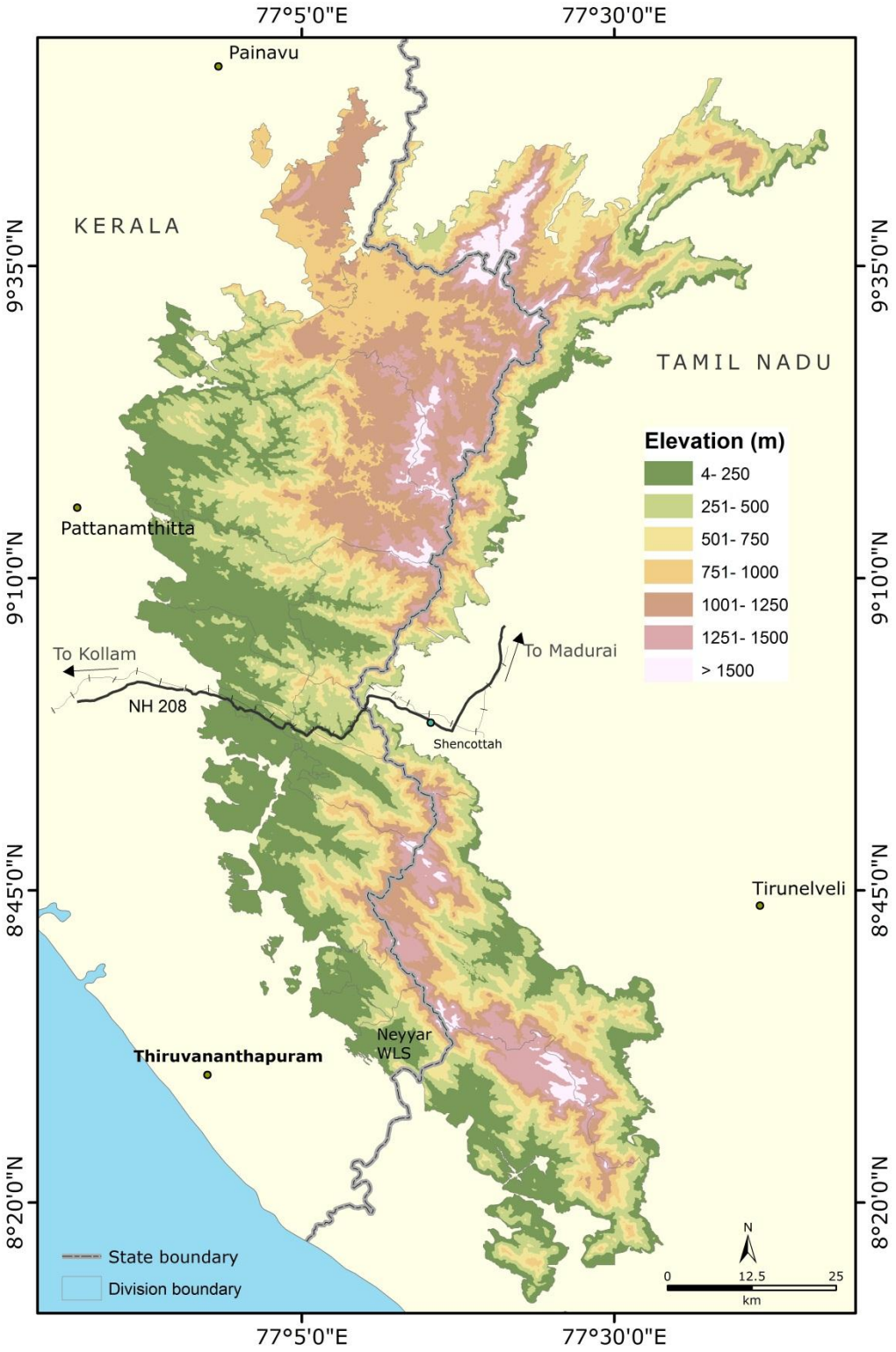


Figure 16: The landscape depicted with the altitude gradients

4.3 Altitudinal gradient of the Forest Divisions (Figure. 16)

In general, the largest area of the landscape lies in the altitude range between 250m and 500m elevation. The extent of area gradually decreases with increasing altitude except in the case of 1250-1500m elevation (where it has marginally larger areas: 1073 km^2 as compared to its preceding category 1000-1250m elevation: 963 km^2). The least area lies above 1500m elevation. Greater the area at high altitude in any given forest division, more is the inaccessibility of the terrain and more is the area under evergreen forest, meaning lower density of large mammals like elephants (Table 9).

4.4 Land use and vegetation patterns

In total, the landscape is categorized into 10 land use / land cover types which include

Seven forest elements
(1) Tropical dry thorn forest (DTF)
(2) Dry deciduous forest (DDF)
(3) Moist deciduous forest (MDF)
(4) Semi-evergreen (SEG)
(5) Evergreen forest (EGF)
(6) Grassland (GL) and
(7) Monoculture Forest Plantation (FPL)

One non-forest natural element
(8) Water Body (WB) and

Two non-forest artificial elements
(9) Commercial Plantation (CPL) and
(10) Settlement/Agriculture (Set/Agr).

Of the 6700 km^2 total area, over 85% of the landscape consists of forest elements representing various vegetation types and water bodies, and the rest (c. 15%)with human made elements (Figure 18) mostly in the form of commercial plantations (11%) and settlement/agriculture (3%). It is interesting to note that the landscape has very diverse vegetation types, starting from tropical dry thorn forest at the lower elevation lying mostly in the rain shadow areas of eastern sides to dry and moist deciduous forests, semi-evergreen at the middle elevation, evergreen forests including patches of montane shola forests at the higher elevation and grasslands along the crest line of the Ghats. Overall, the evergreen (semi evergreen & evergreen) vegetation dominates the landscape occupying 38% of the area and 44% of the natural elements. The moist deciduous forest is the second largest in extent followed by grasslands among the natural elements.

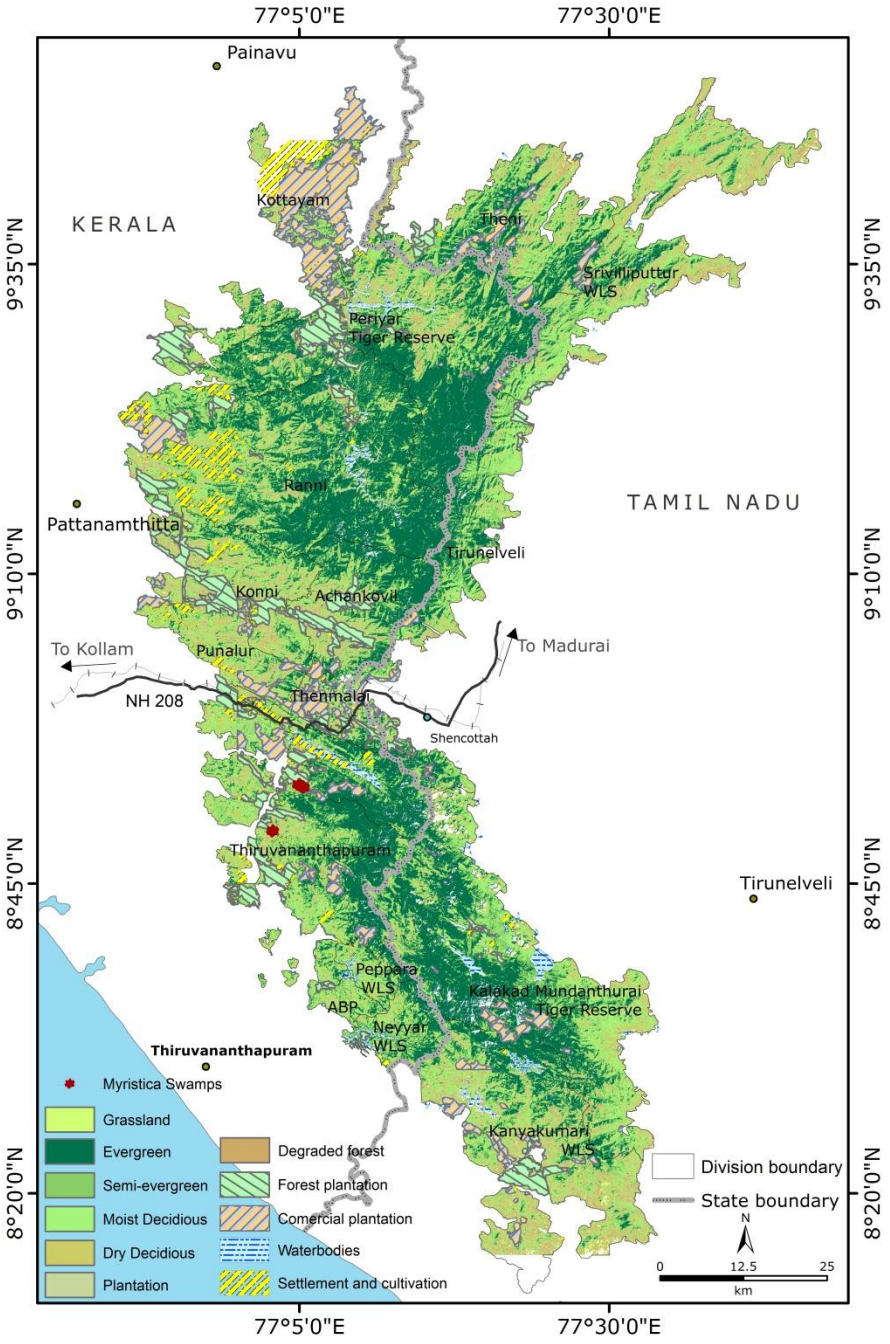


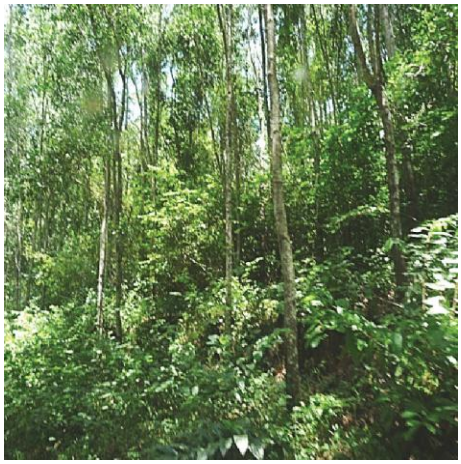
Figure 17: Spatial pattern of Landuse and Landcover in the Periyar-Agasthyamalai landscape

The Seven Forest Elements

Dry Thorn Forest: Dry Thorn Forests occur between 300m and 900m altitude and these extend over 297 km^2 (5%) of landscape with highest species richness (252 species). The dominant tree species include *Dipterocarpusindicus, Tamarindus indica, Gyrinops walla, Albizzia amara, Mallotus philippensis, Terminaliapaniculata, Dichrostachys cinerea, Albizzialebbeck, Gyrocarpus americanus.*

Dry Deciduous Forest: Dry Deciduous Forests occur from 300 to 900 m altitude and is contiguous with the Dry Thorn Forests at the lower elevation and Moist Deciduous Forests at the higher elevations. It occupies 77 km^2 (1%) of the landscape. Dominant tree species includes *Terminalia paniculata, Tectona grandis, Anogeissus latifolia, Zizyphus xylopyrus, Bauhiniaracemosa, Xylia xylocarpa, Dipterocarpus indicus* are among the 55 tree species recorded in this type.

Moist Deciduous Forest: Moist deciduous forest occurs in altitude range between 500-900m. The moist deciduous type is very narrow. It occupies 1388 km^2 (20%) of the total landscape. In total, 136 tree species we rerecorded and the dominant tree species are *Terminally pediculate, Lagerstroemia lanceolata, Aporusa fusiformis, Grewia tiliifolia, Cylicodaphnewightiana, Litsea wightiana, Pistacia oleosa, Pterocarpus marsupium, Macaranga indica*



Semi-evergreen Forest: Semi-evergreen forest occurs in altitude between 300-900m. This forest type includes secondary evergreen, dipterocarp forests, lateritic semi-evergreen forests, bamboo brakes, and riparian forests as described. It occupies the largest area (1888 km^2 or 31%) within the landscape with 225 tree species. Tree species like *Terminalia paniculata, Aporusa fusiformis, Lagerstroemia lanceolata, Macaranga indica, Pterocarpus marsupium* are the dominant species of this vegetation type.

Evergreen Forest: These forests occur between200-1,500m altitude ranges with second highest tree species richness (231 spp.). The tropical evergreen forests also include the wet mountain evergreen forests. It occupies 441 km^2 (7%) of the landscape. Dominant tree species includes: *Terminalia paniculata, Pistacia oleosa, Aporusa fusiformis, Macaranga indica, Mallotus philippensis, Otonephelium stipulaceum.*

Grasslands: These grasslands occur between 200and 1500m altitude range. It extends over 958 km^2 (14 %) of the landscape and is the high rainfall area with grasses, sedges and mosses: *Carex, Cyanotis, Cyperus and Eriocaulon* with very low tree species richness (3 spp.).

Myristica Swamps: Myristica swamps are a unique fresh water ecosystem confined to low altitude, flat bottomed valleys drained by sluggish streams of the Western Ghats river systems. Myristica swamps are known to exist in small patches over fifty locations on the Kerala side in Thiruvananthapuram, and Punalur Territorial Divisions and Chendurni WLS. *Gymnacranthera anarica and Myristica fatua varmagnifica* are the dominant tree species

Non-Forest elements of the landscape

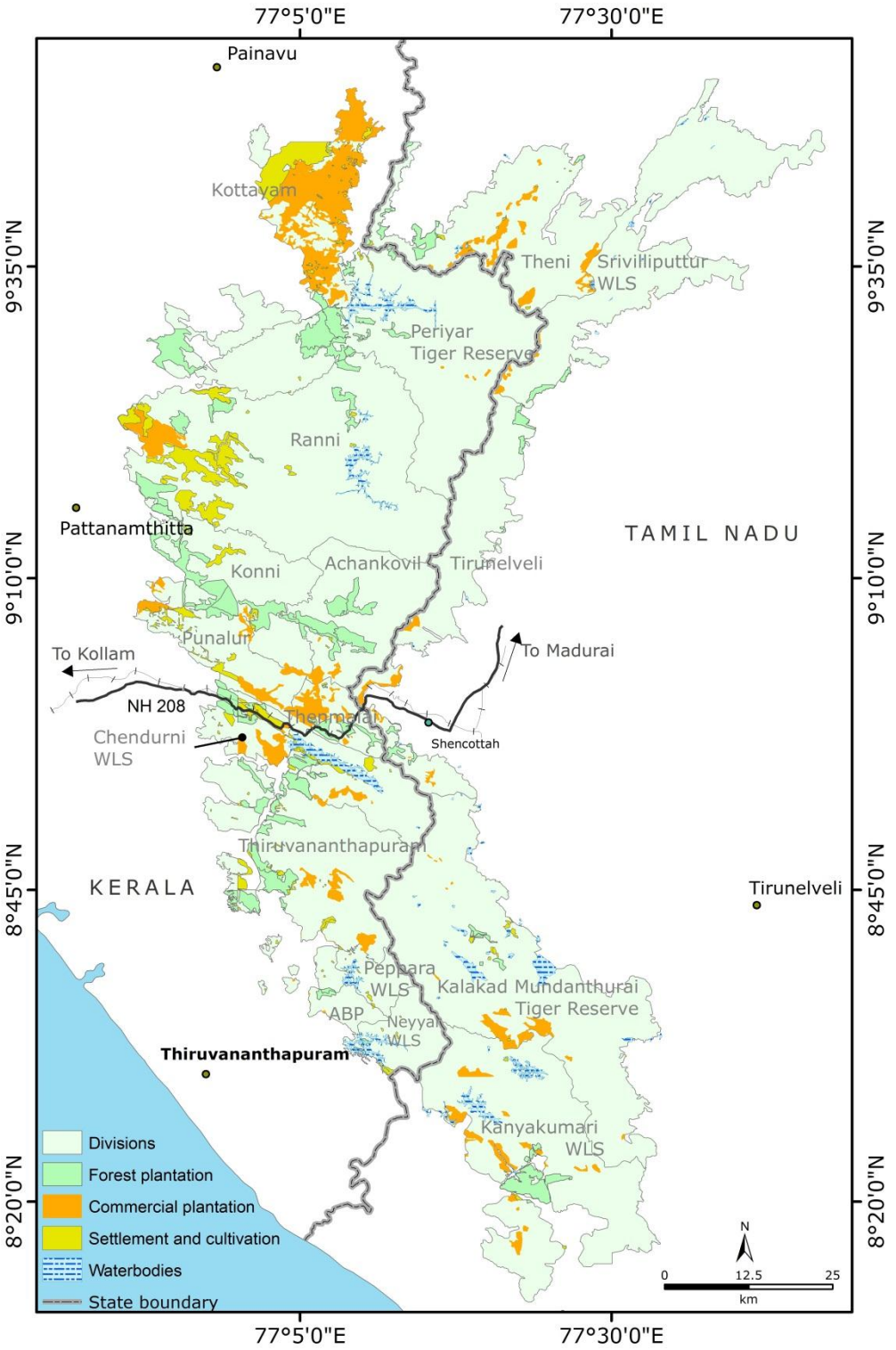


Figure 18: Non-forest elements in the landscape

Water Body (WB)

Two non-forest artificial elements (Figure 18)
(9) Commercial Plantation (CPL) and
(10) Settlement/Agriculture (Set/Agr).

Tapioca plantation by communities living in the landscape

Tarred road with mono-culture plantation on either side

A non-forest element

Mono-culture plantation

Table 10: Extent of various land use elements recorded in different Forest Divisions of the Periyar-Agasthyamalai landscape (Fig. 18)

Division name	Forest Habitat (km^2)							Non-Forest Habitat (km^2)			
	DTF	DDF	MDF	SEGF	EGF	GL	WB	FPL	CPL	Set/Agi	Overall
Tamilnadu											
Kanayakumari WLS	50.3	18.4	93.3	96.1	53	104.1	16.5	31.7	37.9	1.1	502.3
KMTR	18.7	9.4	183.3	337.2	36.8	96.8	45	14.7	147.7	3.1	892.7
Srivilliputtur WLS	36	10.7	122.6	54.4	42.3	97.1	2.3	7.7	37.6	0	410.7
Theni	46	12.9	117.6	134.3	61	78.8	3.2	15.8	71.4	2	543
Tirunelvelli	9.4	3.1	91.2	118.2	16.2	44	4.4	13.4	52	0	351.9
Tamilnadu	**160.3**	**54.5**	**608**	**740.1**	**209.3**	**420.8**	**71.4**	**83.3**	**346.6**	**6.2**	**2701**
Kerala											
ABP	0.3	0	18.4	17.1	1.5	9.8	3.2	11.1	5.5	0.1	67.1
Achankovil	16.4	2.8	42.2	104.8	20.9	37.3	3.1	37	2.6	0.3	268.3
Chendurani WLS	1	0.2	15.6	91.4	2	5.9	18.5	0.8	25	11.5	171.8
Konni	37.3	4.2	72.9	32.6	39.4	81.7	0	48.9	3.4	7.3	330
Kottayam	18.7	3.9	87.9	72.8	23.3	54.5	0.9	25.4	54.3	45.9	387.7
Neyyar WLS	0.4	0	14	5.3	1.9	8.5	0.3	10.2	0	2.3	42.9
Peppara WLS	0.5	0	20.8	31.6	2.5	11.7	7.3	12.2	25.1	1.2	113
PerriyaTR	26.9	5.2	114.1	373.7	41.2	68.8	17.4	47.8	80.6	1.1	776.6
Punalur	16.7	3.2	86.8	21.3	22.1	65.3	1.2	19.6	28.1	15.7	280.1
Ranni	18.4	2.6	143.6	397.3	35.7	102	19	36.1	90.8	77.7	923.3
Thenmalai	12.7	4.4	58.2	21.7	18.6	29.3	3.3	36.7	14.6	10.6	210.1
Thiruvananthapuram	6.7	0.6	99.4	154.3	21	59.4	4.3	38.3	40	9.7	433.8
Kerala	**136.6**	**22.1**	**616.3**	**1148**	**190.4**	**445.6**	**71**	**249.1**	**315.5**	**163.3**	**4005**
Overall	**296.9**	**76.5**	**1224.3**	**1888.1**	**399.7**	**866.4**	**142.4**	**332.5**	**662.1**	**169.5**	**6705**

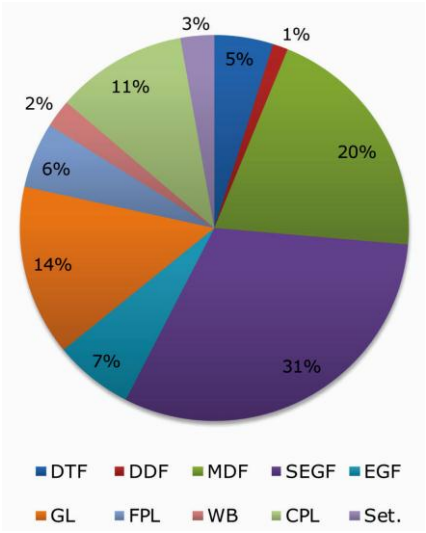


Figure 19: The different landscape elements

Note: DTF: Tropical Dry thorn Forest, DDF: Dry Deciduous Forest, MDF: Moist Deciduous Forest, SEG: Semi-Evergreen, EGF: Evergreen Forest, GL: Grassland, WB: Water Body, FPL: Forest Plantation, CPL: Commercial Plantation (CPL) and Set./Agr.: Settlement/Agriculture

Vegetation types in different forest divisions

Among 17 forest divisions, the forest divisions located on the eastern side or Tamil Nadu part of the landscape as compared to those on the western part of the landscape have proportionately more open or semi open canopied vegetation types (tropical dry thorn, and dry, and moist deciduous vegetations and grassland) (eastern side: 1243 km^2 (46%) and western side: 1220 km^2 (30%). The higher extent of open canopied forests is likely to support higher density of elephant and other large mammals such as gaur, sambar and chital due to higher biomass of fodder availability at ground level as compared to closed canopy forests. On the other hand, the Forest Divisions on the western side of the landscape have more close canopied vegetation types (semi-evergreen and evergreen)as compared to those on the eastern side (western side: 1338 km^2 (33%) and eastern side: 949 km^2 (35%)), which is likely to support more arboreal mammalian species. Similarly, the forest divisions on the western side of the landscape have more area under human settlement/cultivation (163 km^2) but less monoculture commercial plantations (315 km^2) than those on the eastern side (human settlement/cultivation 6 km^2 commercial plantations 347 km^2).Nevertheless, the western part of the landscape has more area of forest plantations (249 km^2) than the eastern side (83 km^2).

Vegetation type in relation to altitudinal gradient

Commercial plantations largely occupy the lower elevation range (0-250 m) (Figure 20 and 21), while moist deciduous and semi-evergreen habitats predominating the elevation ranges between250 and 750m. The grassland habitat gradually increases with altitude and dominating areas >1000m altitude. These results indicate the availability of potential elephant habitats (browse with grass dominated areas) in the landscape like the deciduous forests or grassland interspaced with semi-evergreen or evergreen patches that cater to the needs of fodder and day light shelter for the large herbivore.

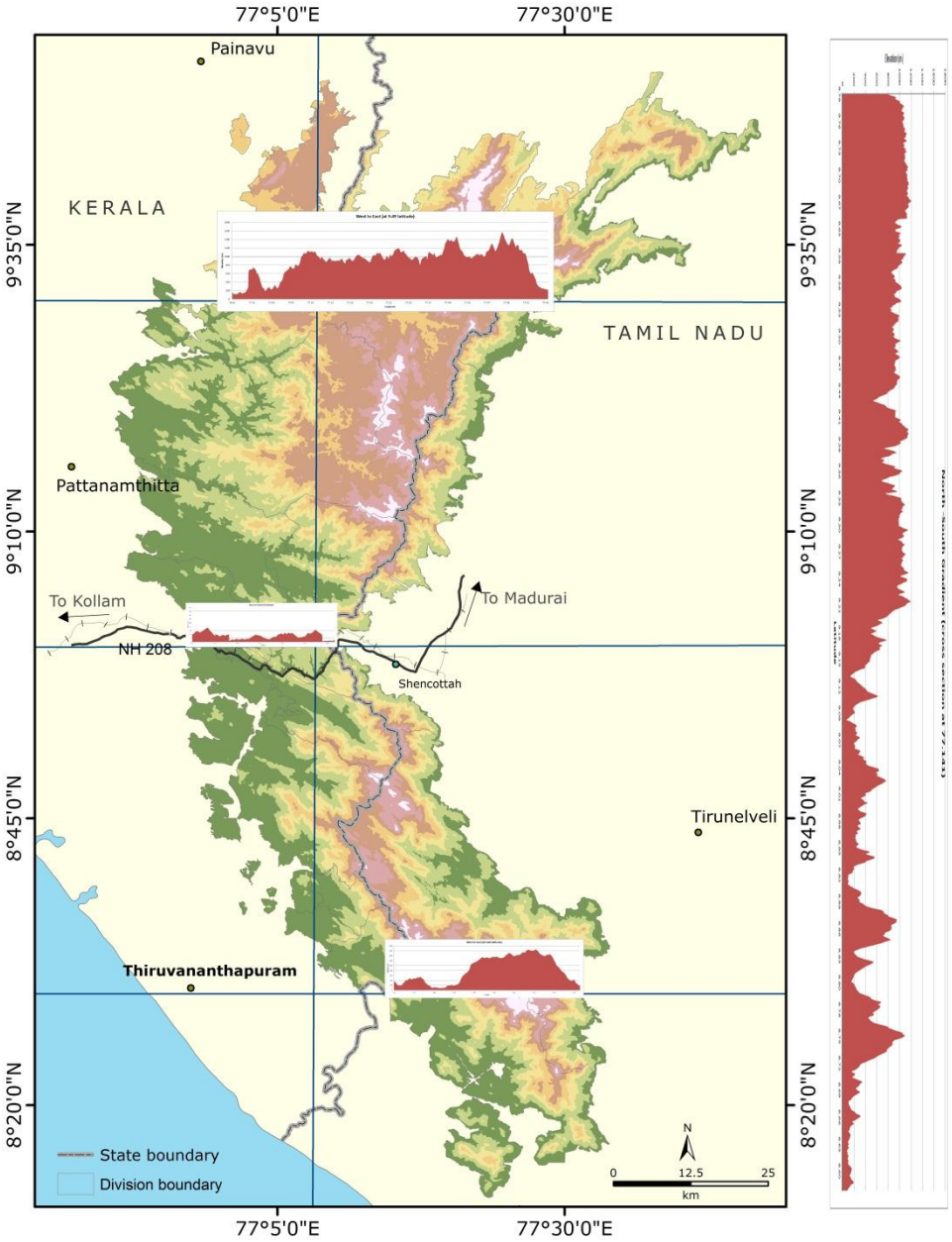


Figure 20: Landscape map along with cross sections giving an idea of the elevations

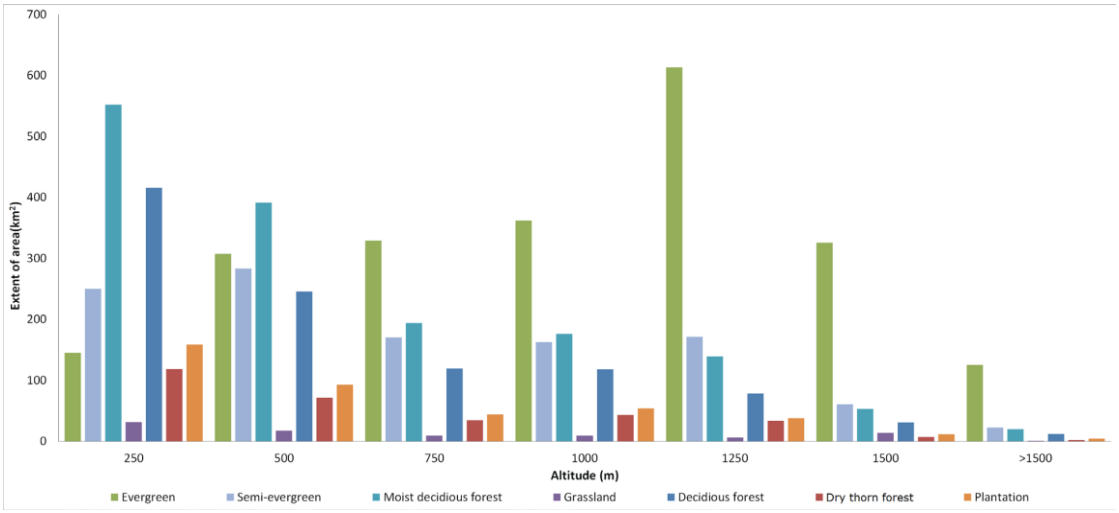


Figure 21: Extent of various land use vegetation types in different altitudinal gradients in the Periyar-Agasthyamalai landscape

4.5 Tree species GBH, density, diversity and richness indifferent vegetation type

Tree species density: To identify the vegetation types of the landscape, in total we sampled 855, 20x20 plots covering 34.3 ha area (Table 11) and enumerated15,906 stems (>20 cm GBH). Overall, the landscape harboured 427± 24.5 stems/ha. The stem density varied considerably across the vegetation types with tropical dry thorn forest supporting the highest number of stems (533/ha) per unit area, followed by deciduous forest (moist deciduous: 500/ha and dry deciduous: 498/ha) and riparian habitats (475/ha).Evergreen and semi-evergreen had a moderate tree density, while the grassland with sparse tree cover harboured the lowest number of stem per unit area than all other habitats in the landscape.

Tree species GBH: Mean GBH estimated from15, 906 stems across the landscape was 83±0.8cm (Table 11). The girth class varied considerably among habitat types for example tree species in semi-evergreen forest were relatively with thickest stems (103 ± 1.7 cm) than those in any other habitats followed by moist deciduous forest(94 ± 1.5 cm) and it was lowest (46 ± 3.7 cm) in the grass land habitats.

Tree species diversity: Overall, tree species diversity across the landscape was 4.8903 and diversity per plot was 1.6890 ± 0.0168. Among the eight vegetation types, tree species composition was the most diverse in evergreen (4.6076) followed by deciduous forest (4.5477) and it was less diverse in the plantations (1.9235) and grassland (0.6390). The tree diversity per plot in various vegetation types also varied considerably with evergreen supporting the highest diversity per plot (1.9454 ± 0.0289) followed by moist deciduous (1.8533 ± 0.0403) and riparian habitat (1.8336 ± 0.1079) (Table 11), which is different from the trend observed in tree diversity in a given habitat (Table 11).

Tree species richness: Overall the landscape sheltering a minimum of 421 tree species (Figure 22)and the species richness was the highest in the dry deciduous (252 spp.) followed by evergreen(231 spp.), semi-evergreen (225 spp.), while the grassland habitat had the lowest species richness (3spp.) in the landscape.

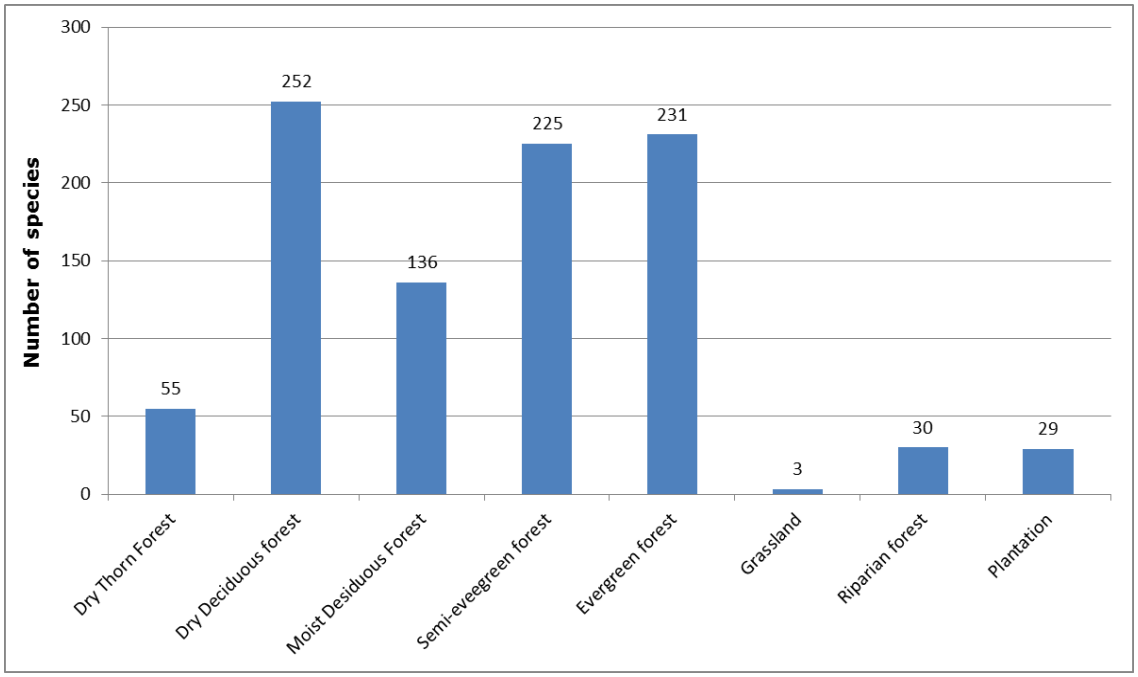


Figure 22: Species richness in each of the forest type

Table 11: Tree species density, diversity, richness and GBH in different vegetation types of the Periyar-Agasthyamalai landscape

Forest type	Area sample in ha	# stems	Mean ± SE			Species richness	Overall diversity
			Density/ ha	GBH/stem	Diversity/plot		
Dry deciduous forest	14.76	7217	498 ± 8.1	70 ± 1.3	1.63 ± 0.02	252	4.55
Dry thorn forest	1.16	618	533 ± 31.1	71 ± 2.5	1.34 ± 0.11	55	3.10
Moist deciduous forest	3.28	1639	500 ± 18.6	94 ± 1.5	1.85 ± 0.04	136	3.99
Semi evergreen forest	8.16	3394	416 ± 8.7	103 ± 1.7	1.71 ± 0.03	225	4.28
Evergreen forest	5.88	2655	452 ± 11.1	69 ± 1.3	1.94 ± 0.03	231	4.61
Grass land	0.12	20	167 ± 22.6	46 ± 3.7	0.02 ± 0.12	3	0.64
Riverian forest	0.16	76	475 ± 89.0	69 ± 5.0	1.83± 0.11	30	3.17
Plantation	0.76	286	376 ± 7.1	68 ± 2.9	0.74 ± 0.12	29	1.92
Over all	**34.28**	**15905**	**427± 24.5**	**83 ± 0.8**	**1.68 ± 0.02**	**421**	**4.89**

Tree species GBH, density, diversity and richness in different elevation ranges

Tree density increased positively with altitude from0-250 until 500-750 m elevation range and thereafter declined gradually, except in the case of 1500-1750m elevation range (Table 12). A similar trend was also observed in tree species gbh, species diversity/plot (Table 12), while the species richness and overall tree species density/ habitat have mostly show a declining trend with altitude. The results indicate that the medium elevation range (500-1000m) favouring dense and diverse tree species with higher gbh, while the lower elevation range (0-750 m) conducive for tree species richness and overall tree diversity

Table 12: Tree species density, diversity, richness and GBH in different altitudinal gradient

Altitude	Sample size (ha)	Mean ± SE			Species richness	Overall diversity/ altitude range
		Density/ ha	GBH/stem (cm)	Diversity/plot		
0-250	12.88	469±7.9	77.±0.8	1.60±0.03	268	4.54
250-500	9.72	471±10.6	79.±2.0	1.67±0.03	255	4.60
500-750	4.32	479±13.8	92±1.5	1.71±0.04	220	4.52
750-1000	4.08	431±15.1	108±2.0	1.98±0.03	154	3.96
1000-1250	2.04	458±20.3	94±1.9	1.71±0.05	110	4.06
1250-1500	0.76	398±21.1	70±13.3	1.76±0.08	28	2.42
1500-1750	0.48	495±30.7	80±2.7	1.67±0.12	33	2.98
Overall	34.28	427± 24.5	83 ± 0.8	1.69 ± 0.01	421	4.89

Tree species GBH, density, diversity and richness in different forest divisions

In general the forest divisions on the eastern side showed marginally higher tree species density (minimum: 455 ± 12.61 and maximum: 569 ± 17.7) compared to those on the western side (minimum: 343±33.8 and maximum: 539± 22.7) (Table 13). While the forest divisions on the western side of the landscape showed mostly higher girth class, and tree diversity/plot but less species richness (Table 13). Overall tree diversity showed the highest (Theni Forest Division 4.18), as well as the lowest (Kanyakumari 1.2421) on the eastern side of the landscape, while the western side forest divisions showed moderate overall tree diversity without much fluctuation.

Among the 17 forest divisions, Srivilliputtur WLS (569±17.7) represented the highest and Neyyar (343± 33.8) the lowest density of stem per unit area (Table13). On the other hand, tree girth (gbh) was the highest in Kottayam Forest Division, (113 ± 2.6) followed by Konni (108 ± 4.5), and Achankovil (107 ± 2.7) and lowest in Srivilliputtur (53 ± 5.5) and Punalur (84 ± 1.9). In general there seem to be a negative relationship between tree density and girth. In the case of tree species diversity per plot, Thiruvananthapuram Forest Division had the highest (2.52 ± 0.57) and Konni the lowest (1.07 ± 0.06). But when it comes to overall tree diversity in the forest division, Theni Forest Division with third highest species richness (128) showed the highest diversity (4.18) and the southernmost Forest Division Kanyakumari with the highest the species richness (136) had the lowest diversity (1.24).

Table 13: Tree species density, diversity, richness and GBH in different forest divisions of the Periyar-Agasthyamalai landscape tree density versus gbh a chart

Forest division		Mean ± SE				Overall diversity
	Sample size	Density/ ha	GBH/ stem	Diversity / plot	Richness	
Eastern side of landscape						
Kanniyakumari WLS	93	455 ± 12.61	81 ± 18.0	1.65 ± 0.05	136	1.24
KMTR	119	503 ± 11.3	57 ± 7.7	1.65 ± 0.04	134	1.35
Srivilliputtur WLS	63	569 ± 17.7	53 ± 5.5	1.65 ± 0.07	73	3.53
Theni	77	503 ± 15.6	86 ± 6.6	1.60 ± 0.06	128	4.18
Tirunelveli	66	484 ± 18.5	70 ± 9.7	1.46 ± 0.07	76	3.66
Western side of landscape						
ABP	14	418 ± 21.5	101 ± 3.6	1.92 ± 0.11	43	3.13
Achankovil	29	403 ± 25.0	107 ± 2.7	1.91 ± 0.06	57	3.44
Cendurni WLS	18	449 ± 25.9	100 ± 3.2	2.04 ± 0.05	50	3.59
Konni	30	357 ± 15.7	108 ± 4.5	1.07 ± 0.06	49	3.19
Kottayam	76	401 ± 17.3	113 ± 2.6	1.49 ± 0.07	74	3.15
Neyyar WLS	14	343 ± 33.8	104± 3.9	1.53 ± 0.07	58	3.34
Peppara WLS	14	347 ± 18.7	87 ± 4.2	2.02 ± 0.13	24	2.37
Periyar TR	68	500 ± 18.3	102 ± 8.4	1.78 ± 0.05	109	3.78
Punalur	32	539 ± 22.7	84 ± 1.9	1.81± 0.07	62	3.16
Ranni	69	469 ± 19.2	90 ± 1.4	1.83 ± 0.05	124	3.99
Thenmalai	29	460 ± 17.7	93 ± 2.2	1.92 ± 0.07	62	3.46
Thiruvananthapuram	44	369 ± 22.7	102 ± 2.3	2.52 ± 0.57	71	3.51
Overall	**855**	**427± 24.5**	**83 ± 0.8**	**1.69 ± 0.02**	**421**	**4.89**

4.4 Spatial pattern analysis

As an indication of degree of fragmentation for different land-cover types below given indices were calculated

- Largest patch index (LPI): area of the largest patch in each class, expressed as a percentage of total landscape area.
- Number of patches (NP): total number of patches in this class.
- Patch density (PD): number of patches per unit area.

The indices of LPI and NP correspond to area metrics. NP is an excellent measure of the fragmentation of a given class within the landscape since the landscape size is constant. Quite simply, the greater the number of patches, the greater the degree of fragmentation. Because this statistic is not an average (rather it is a count and so not skewed by outliers), it is a good indicator of the entire landscape, and not just the extremes. Patch density (PD) The density of

patches in the entire landscape mosaic could serve as a good heterogeneity index because a landscape with greater patch density would have more spatial heterogeneity.

Table 14: Spatial patterns for various forest elements in Periyar-Agasthyamalai landscape

Type	Area (km^2)	PLAND	NP	PD (#/km^2)	LPI
Evergreen	2180.86	32.26	48850	7.22	13.25
Semi evergreen	1132.23	16.78	128130	18.95	0.18
Moistdecidious	1491.98	22.07	96531	14.28	0.85
Drydecidious	1000.78	14.80	90615	13.40	0.16
Drythorn	300.42	4.44	36814	5.45	0.04
Grassland	74.50	1.10	14096	2.08	0.01
Plantation	403.73	5.97	84806	12.54	0.01
Water	150.45	2.22	13074	1.93	0.25

PLAND : Percentage of landscape, NP: Number of patches, PD: Patch density, LPI: Largest patch index

From the table 14 it can be seen that LPI of Evergreen forest is which is 13.25 clearly highlights the continuity of Evergreen forest. Grasslands by nature which are confined only to the highlands are most discreet and also have very few patches and patch density. Plantation which is an artificial vegetation cover (commercial and forest plantation) is also discreet as grassland but with higher patch density.

5 Documentation of Mammalian Diversity in the Periyar-Agasthyamalai Landscape

5.1 Background

Knowledge about the diversity of wild species, their distributional range and population status at the landscape level is vital for planning the conservation of regional biodiversity and for protecting its potential to support sustainable development of the region. Over the past two decades, a large number of studies have looked at distribution and biogeography of different vertebrate taxa, with special emphasis on lower taxonomical orders. However, such past studies or surveys in India have either been conducted in isolation and have been restricted or biased towards Protected Area (PA) networks. Although mammalian taxa has been studied or surveyed for a longer period than any other taxa, yet no comprehensive updated quantitative data on mammalian diversity is available for the forest divisions of the P-A landscape or at landscape level. The PA network is discontinuous and covers less than half of the total forest cover of the landscape, On their own the PAs may or may not support viable populations of habitat specific endemic/endangered species like Nilgiri Tahr, Lion tailed Macaque or wide-ranging landscape species like the Asian Elephant.

Simultaneously, these PAs have all the micro/macro habitats of a landscape /region within it that is required to support the large assemblage of species diversity found in the region. Further, the much larger forest areas encompassed by territorial forest divisions, with no detailed data on biodiversity, are subjected to a wide range of anthropogenic pressures including threats from large-scale developmental projects. The territorial forest divisions have compromised the value of biodiversity conservation, as they are legally open to human activities unlike the PAs. Yet as a first step, baseline data or check lists of various taxa and as a second step, fine-tuned data on species of concern if any, are vital for effective conservation planning and management. The present study aimed to prepare a comprehensive documentation of mammalian species of the Periyar- Agasthyamalai landscape, as part of the landscape level survey of elephant habitats.

5.2 Methods

One of the objectives of the study was the preparation of a comprehensive documentation of the mammalian species of the Periyar-Agasthyamalai landscape. Three different methods were used: Literature survey, Rapid field survey and Camera trap based field survey.

Literature Survey

Since the late 1990s, forest divisions like Kalakad-Mundanthurai, and Periyar Tiger Reserves and Sivilliputtur Wildlife Sanctuary in the landscape have been the subject of long term research (Johnsingh 2001, Joshua 1988, Raman2006, Mudappa, 2002 Sukumar et al. 2007) as well as a large number of short term studies or anecdotal observations. Most of these efforts have actually produced valuable scientific information essential for the management of areas concerned. Compiling such secondary information and incorporating them into our database using a GIS framework would supplement or close the gap in our primary data collection on mammalian diversity. Secondly, such secondary data would also be useful in planning the field surveys for mammalian species documentation. The secondary data sources include

published literature (scientific papers, short notes and research communications published in journals, newsletters and books) as well as unpublished documentation (project technical reports, graduate/doctoral dissertations, official management plans reports). To obtain the secondary data from the existing literature on the mammalian species of the Periyar-Agasthyamalai landscape, the ANCF team surveyed more than500 pieces of scientific documentation. This was accomplished through direct visits to key research/academic institutions in south India as well as web based searches. The team procured and scrutinised the electronic version of the Journal of the Bombay Natural History Society (100 Volumes). Through the literature survey, 84 papers/documents were identified that had relevance to the presence and distribution of mammalian species of the Periyar–Agasthyamalai landscape.

Rapid survey

Photo 16: Droppings of a small mammal and Tiger pugmark

To document the mammalian species and their abundance found in different forest divisions of the Periyar-Agasthyamalai landscape, systematic rapid survey method was adopted, taking into account both direct sighting of mammalian species and their indirect evidences. The indirect evidences such as the droppings, pug/hoof/pad marks and feeding signs were mainly used to identify presence or absence of mammal species.

Photo 17: Indian Muntjac *Muntiacus muntjak* Captured during the rapid survey

The forest ranges, whose boundaries marked on 1: 50,000 topographic maps during habitat survey in different forest divisions were treated as sampling units for the rapid survey. In each range, an average four man days of sampling was carried out and in case of larger ranges (>100 km^2) sampling effort increased by two additional man days. On the day of the survey, the survey team consisting of three persons (two researchers and one local staff) walked 6-10 km distance along the available game roads or truck paths between 07:00 and 10:00 h and again between 15:00 and 18:00 h. Data on direct sightings of mammalian species was recorded by one researcher, while the second researcher recorded the indirect evidences. At every direct sighting or indirect evidence of mammal species, the subject was first photographed (when possible), and the species name, number of individuals, the sighting location (latitude and longitude) and microhabitat information was recorded in the datasheets supplied.

Later, incorporating the location data into study area maps using Geographical Information System software (ArcGIS10) the team prepared distribution maps for various order, family and species levels. Using the data on direct sighting and indirect evidence and the total distance covered in each forest division, encounter rate was computed to arrive at the mammalian taxa abundance.

Camera trap sampling

This method was employed mainly to document the nocturnal mammals. The camera trap sampling was done using systematic random sampling. First, the Survey of India 1:50,000topographic maps of the landscape was digitized and overlaid with 50 km^2 grids. All the grids were assigned a serial number resulting in a total 240 grids. By marking the odd numbered grids, a total of 120 grids were selected for sampling (Figure 23). The sampling took into account various factors like vegetation type, altitude and disturbance gradients etc. that may have some influence on the mammalian fauna of the landscape. Within a selected grid, a camera trap was randomly placed, in locations such as track road junctions, waterholes etc. where probability of capturing mammalian fauna is high. The trap was placed late evening between 18:00 – 18:30 and removed the next day morning between 06:00–06:30 h to maintain 12 h time interval. After placing the trap, parameters such as the forest division, and range name, type of major and microhabitat, altitude, latitude and longitude (using a Global Positioning System), distance to water, human settlements, and road and the target grid number were noted down in a data sheet. Next day after removing the camera from the sampling site, the trap was attached to a computer and screened for mammalian photographs.

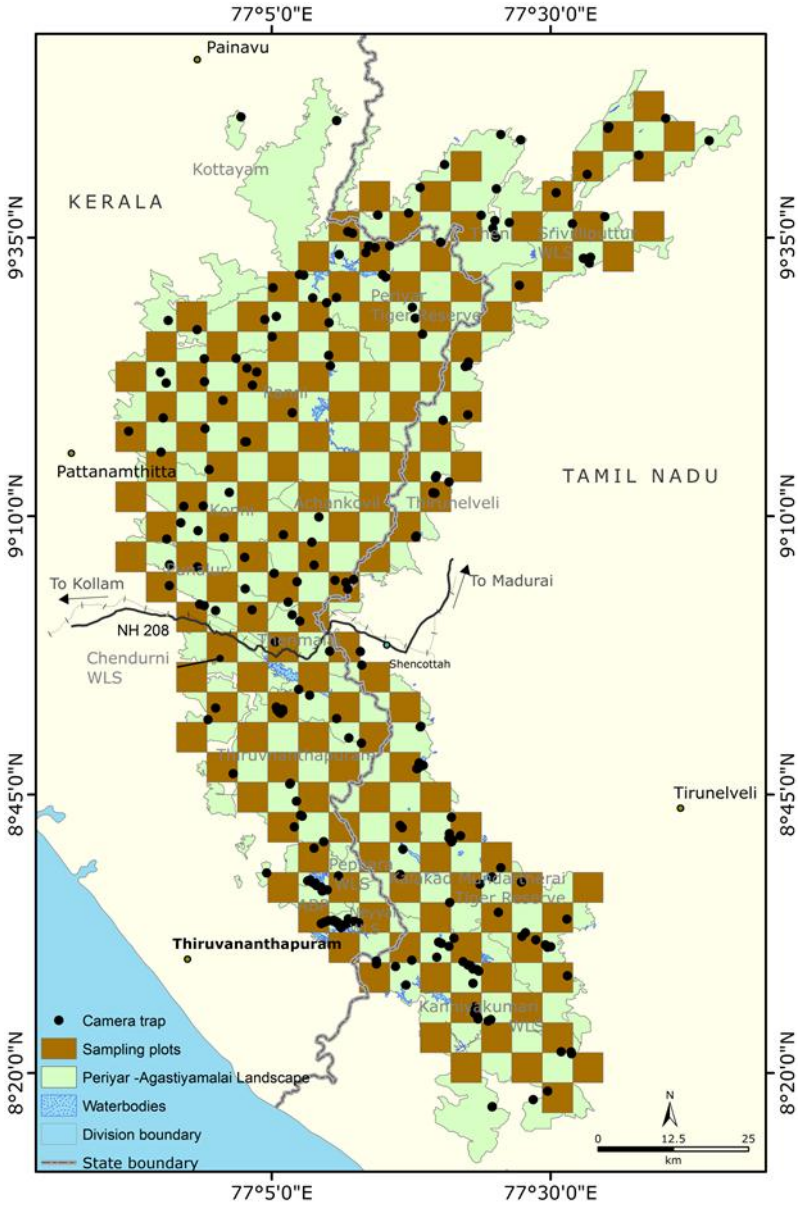


Figure 23: Map showing the use of grids to determine camera trap sampling

Analysis

The camera trap data was analyzed to arrive at mammalian species capture rate in different forest divisions, habitat types and altitudinal ranges. The mammalian species capture rate in each forest division, habitat type and altitudinal gradient was juxtaposed with independent parameters collected at the camera trap sampling location (such as the major and micro habitat, altitude, distance to water, human settlements and roads) and extent of various landscape elements including forest versus non-forest areas, total area and perimeter of each forest division to understand the influence of these factors on the mammalian species distribution pattern.

Gaur *Bos gaurus* on a camera trap in the Periyar Tiger Reserve

A camera trap capture of a Leopard *Panthera pardus* in the landscape

5.3 Results

Mammalian fauna check list (species inventory)

Overall the study documented 48 mammal species belonging to nine orders and twenty five families in the landscape (Table 15) out of 137 species found in Western Ghats (Das et al. 2006). The 48species included one critically endangered species (Malabar Civet - *Viverra civettina*), 11 endangered (IUCN Red List 2012) and 14 species endemic to the Western Ghats. Number of mammal species recorded using ground survey (based on direct sighting method was 26 species and indirect evidence 25 species) and literature survey (28species) were almost the same (Table 15), while number of species recorded through camera trapping was relatively lower (16 species).

Faunal diversity in Forest Divisions

Among the 17 forest divisions, Kalakad-Mundanthurai (36 species) and Periyar (32 species) Tiger Reserves, the two Tiger Reserves and also fairly well studied parks in the landscape, harboured the highest species richness (Table 16& Figure24). The forest divisions like the Agasthyavanam Biological Park, Kottayam FD and Punalur FD had the lowest species richness (<10 species). The Ranni Forest Division with relatively large forest area still supported less diverse mammal species (15 spp.). The forest divisions like Tirunelveli, Theni, Srivilliputtur and Kanyakumari had moderate species richness (> 20 species). No doubt that the Kalakad-Mundanthurai and Periyar Tiger Reserves are the potential biodiversity rich forest divisions due to their better protection with special financial support from Project Tiger. However, a few more forest divisions like Srivilliputtur and Kanyakumari Wildlife Sanctuaries, Theni and Tirunelveli forest divisions are likely to have more number of species than listed here or equal to that of the Kalakad-Mundanthurai and Periyar Tiger Reserves. Such incomplete information could be due to inadequate studies in the past and /or insufficient field survey time available to the present project.

Table 15: List of mammal species of the Periyar–Agasthyamalai landscape recorded using rapid survey, camera trapping and literature survey

S. No	Common name	Source (type of survey)				
	Scientific name	Ground	Camera-trap	Literature	IUCN status	Endemic to
1	Asian Small-Clawed Otter *Amblonyx cinereus*	-	-	yes	Vulnerable	-
2	Blackbuck *Antelope cervicapra*	-	-	yes	Endangered	-
3	Indian Spotted Deer *Axis axis*	yes	yes	-	Least concern	-
4	Gaur, Indian Bison *Bos gaurus*	yes	yes	-	Vulnerable	-
5	Sambar Deer *Cervus unicolor*	yes	yes	-	Vulnerable	-
6	Wild Dog *Cuon alpinus*	yes	yes	yes	Endangered	-
7	Asian Elephant *Elephus maximus*	yes	yes	yes	Endangered	-
8	Jungle Cat *Felis chaus*	yes	yes	-	Least concern	-
9	Indian Palm Squirrel *Funambulus palmarum*	yes	yes	-	Least concern	-
10	Dusky Palm Squirrel *Funambulus sublineatus*	yes	-	-	Vulnerable	-
11	Madras Hedgehog *Hemiechinus nudiventirs*	-	-	yes	Least concern	WG

12	Nilgiri Tahr *Hemitragus hylocrius*	yes	-	yes	Endangered	WG
13	Indian Grey Mongoose *Herpestes edwardsii*	yes	-	-	Least concern	-
14	Indian Brown Mongoose *Herpestes fuscus*	yes	-	yes	Vulnerable	-
15	Stripe-necked Mongoose *Herpestes vitticollis*	yes	-	-	Least concern	-
16	Leafleted leaf-nosed bat *Hipposideros hypophyllus*	-	-	yes	Endangered	WG
17	Indian Crested Porcupine *Hystrix indica*	yes	yes	-	Least concern	-
18	Salim Ali's Fruit Bat *Latidens salimali*	-	-	yes	Endangered	-
19	Slender Loris *Loris tardigradus*	-	-	yes	Endangered	-
20	Common Otter *Lutra lutra*	yes	-	yes	Near threatened	-
21	Smooth-coated Otter *Lutrogale perspicillata*	-	-	yes	Vulnerable	-
22	Bonnet Macaque *Macaca radiata*	yes	-	-	Least concern	-
23	Lion-tailed Macaque *Macaca silenus*	yes	-	yes	Endangered	WG
24	Indian Pangolin *Manis crassicaudata*	yes	yes	-	Least concern	-
25	Nilgiri Marten *Martes gwatkinsii*	-	-	yes	Vulnerable	WG
26	Sloth Bear *Melursus ursinus*	yes	yes	yes	Vulnerable	-
27	Muntjac – Barking Deer *Muntiacus muntjac*	yes	-	-	Least concern	-
28	Servant Mouse *Mus famulus*	-	-	yes	Endangered	WG
29	Leopard *Panthera pardus*	yes	yes	-	Near threatened	-
30	Tiger *Panthera tigris*	yes	yes	yes	Endangered	-
31	Asian Palm Civet *Paradoxurus hermaphroditus*	yes	-	-	Least concern	-
32	Brown Palm Civet *Paradoxurus jerdoni*	yes	-	yes	Least concern	WG
33	Travancore Flying Squirrel *Petinomys fuscocapillus*	yes	-	yes	Near threatened	WGSL
34	Malabar Spiny Dormouse *Platacanthomys lasiurus*	-	-	yes	Vulnerable	-
35	Rusty-spotted Cat *Prionailurus rubiginosus*	yes	-	yes	Vulnerable	-
36	Pale Field Rat *Rattus tunneyi*	-	yes	-	Least concern	-
37	Indian Giant Squirrel *Ratufa indica*	yes	-	yes	Least concern	WG
38	Grizzled Giant Squirrel *Ratufa macroura*	yes	-	yes	Near threatened	WGSL
39	Common Langur *Semnopithecus entellus*	yes	-	-	Least concern	-
40	Day's Shrew *Suncus dayi*	-	-	yes	Endangered	WG
41	Hill Shrew *Suncus montanus*	-	-	yes	Vulnerable	WGSL
42	Wild Boar *Sus scrofa*	yes	yes	-	Least concern	-
43	Indian Gerbil *Tatera indica*	-	-	-	Least concern	-

44	Four-horned Antelope *Tetracerus quadricornis*	-	-	yes	Vulnerable	-
45	Nilgiri Langur *Trachypithecus johnii*	yes	-	yes	Vulnerable	WG
46	Indian Mouse Deer *Tragulus meminna*	yes	yes	-	Least concern	-
47	Malabar Large-spotted Civet *Viverra civettina*	-	-	yes	Critically endangered	WG
48	Small India Civet *Viverricula indica*	yes	yes	-	Least concern	-

Table 16: Mammalian fauna species richness recorded in different forest divisions of the Periyar-Agasthyamalai landscape

	Sample (n)		Sighting(n)		
Division	**No. of transects**	**Distance walked (km)**	**Direct**	**Indirect**	**Species richness**
Eastern side of the landscape					
Kanniyakumari WLS	12	128	37	33	15
KMTR	18	134	37	115	19
Srivilliputtur WLS	38	254	86	97	22
Theni	20	176.5	46	104	20
Tirunelveli	10	78	15	26	8
Western side of the landscape					
Achankovil	8	58	11	19	10
Agasthyavanam Biological Park	1	6	0	2	2
Cendurni WLS	9	80	24	28	7
Konni	11	93	9	7	8
Kottayam	5	35	6	16	7
Neyyar WLS	1	12	1	2	2
Peppara WLS	1	16	2	1	2
Periyar TR	33	236.5	167	138	22
Punalur	6	47	10	3	8
Ranni	20	182.5	46	12	14
Thenmalai	9	39	10	9	6
Thiruvananthapuram	7	51	5	14	4
Overall	**209**	**1626.5**	**512**	**626**	**28**

It is quite evident from the map that mammal species richness is relatively higher in forest divisions located along the eastern part of the landscape as compared to those on the western side. One possible reason for this could be the diversity of major and microhabitats available on the eastern side as compared to western side due to varied topographical features and its consequences on precipitation. Nevertheless, land use practices in the past on the western side, large scale conversion of natural habitats into monoculture forest and commercial plantations could have contributed its negative impact on the biodiversity.

Mammalian fauna diversity

Among 48 species reported to exist in the landscape, 13 species viz
Asian Small-Clawed Otter *Amblonyx cinereus,*
Blackbuck *Antelope cervicapra,*
Nilgiri Tahr *Hemiechinus nudiventirs,*
Kolar Leaf-nosed Bat *Hipposideros hypophyllus,*
Salim Ali's Fruit Bat *Latidens salimali,*
Slender Loris *Loris tardigradus,*
Nilgiri Marten *Martes gwatkinsii,*
Servant Mouse *Mus famulus,*
Malabar Spiny Dormouse *Platacanthomys lasiurus,*
Day's Shrew *Suncus dayi,*
Hill Shrew *Suncus montanus,*
Four-horned Antelope *Tetracerus quadricornis* and
Malabar Large-spotted Civet *Viverra civettina*

Have been identified to exist in the landscape through secondary data from existing literature (Table 15) but have not been recorded in our primary data collection. An intensive camera trapping study to document Malabar Civet *V. civettina* (WTI Study) has not yielded any positive results indicating their critical status or likely extinction in the wild. To a large extent, inadequate time (one and half year period)and limited funding for such a large scale study have been the reasons for being unable to confirm the existence of some of these species. Therefore intensive focused studies would close some of these gaps.

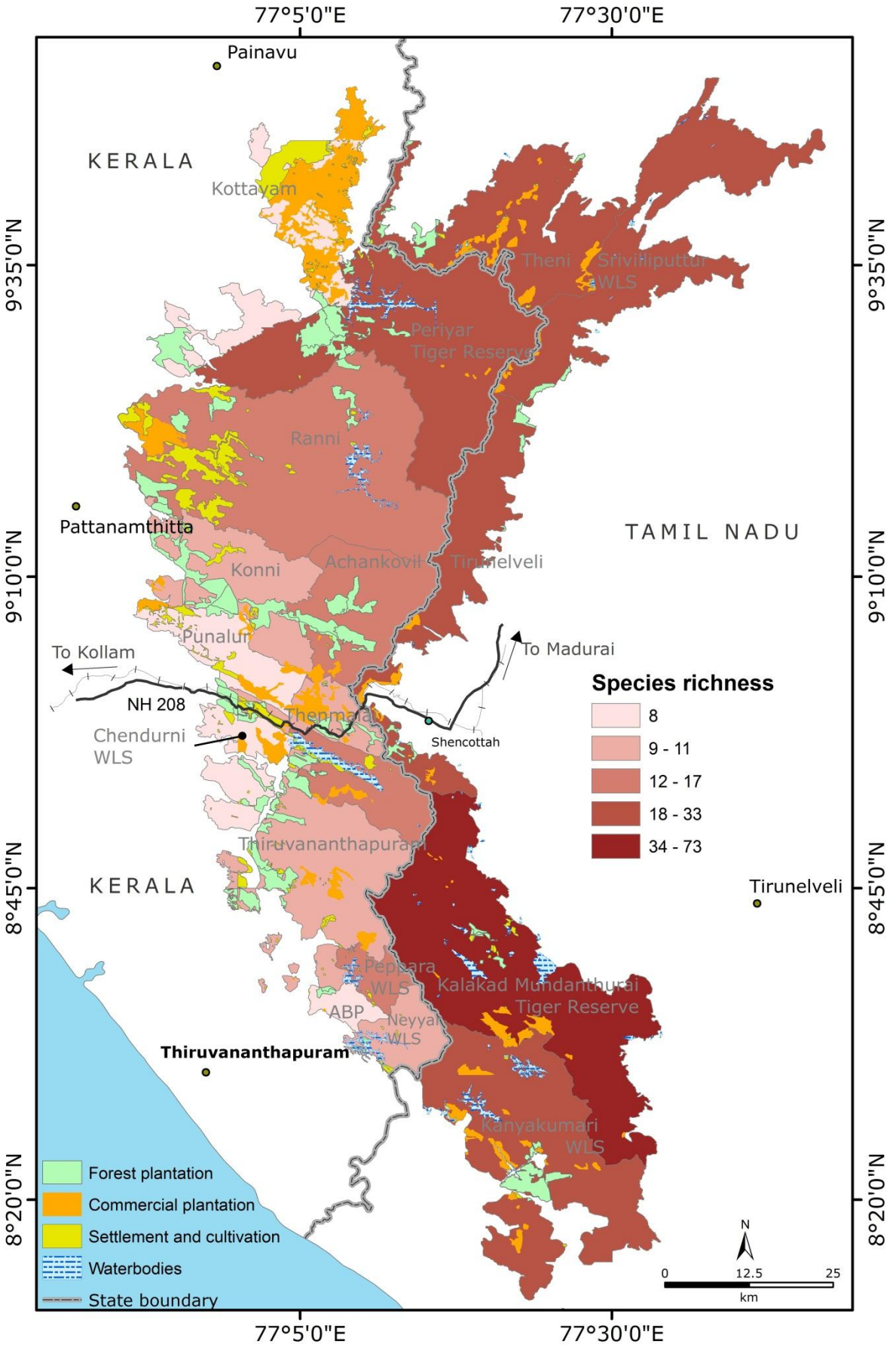


Figure 24: Map showing the mammalian species richness found in different forest divisions of the Periyar-Agasthyamalai landscape

Overall and habitat-wise: In total 209 transects covering 1627 km distance were sampled among the eight habitat types

Among the 17 forest divisions (Figure 25), mammalian encounter rate recorded was the highest in the Periyar Tiger Reserve (1.68 ± 0.27), followed by Kalakad-Mundanthurai Tiger Reserve (1.46 ± 0.22) (Table 16, 17). Forest divisions such as Theni and Thenmalai had >1 mammal or their sign per km. On the other hand, in terms of species richness the Periyar Tiger Reserve and Srivilliputtur Wildlife Sanctuary experienced the highest.

Overall, based on direct sighting and indirect evidences, we encountered 0.9 mammals or their signs per km walked that belong to the 28 species. The encounter rate of mammalian fauna recorded using direct sighting method (0.42± 0.03) was marginally lesser than those recorded using indirect evidences (0.52 ± 0.05).

Table 17: Summary of mammal species richness recorded in different Forest Divisions of the Periyar-Agasthyamalai and their IUCN status (CE: Critically Endangered, EN: Endangered, NT: Near Threatened, VU: Vulnerable)

	Rapid survey					IUCN status				
Forest Division	Direct	Indirect	Camera trap	Literature survey	Species richness	CE	EN	NT	VU	Endemic to WG
ABP	-	4(4)	-	2	8	-	2	-	1	2
Achankovil	4 (11)	8 (39)	3 (4)	2	15	-	3	1	4	1
Cendurni WLS	6 (27)	7 (29)	1 (1)	13	17	-	5	2	4	5
Kanniyakumari WLS	11 (34)	14 (61)	5 (5)	8	21	-	5	-	7	3
KMTR	13 (37)	14 (129)	7 (20)	23	36	-	8	3	11	11
Konni	5 (9)	4 (63)	-	4	11	-	3	-	3	2
Kottayam	5 (6)	5 (28)	-	1	8	-	2	-	2	1
Neyyar WLS	1 (1)	3 (3)	-	6	11	-	1	2	4	1
Peppara WLS	2 (2)	2 (3)	-	14	16	-	5	2	7	5
Periyar TR	18 (167)	13 (226)	8 (21)	18	32	-	7	4	9	7
Punalur	6 (10)	3 (17)	-	0	8	-	2	-	2	1
Ranni	10 (46)	7 (77)	1 (1)	3	15	-	3	-	6	3
Srivilliputtur WLS	16 (86)	22 (114)	4 (4)	3	22	-	5	3	4	5
Theni	14(46)	15 (126)	2 (3)	7	25	-	6	2	8	6
Thenmalai	5 (10)	3 (21)	1 (2)	6	11	-	4	-	2	3
Tirunelveli	5 (13)	9 (63)	4 (4)	21	25	1	9	-	11	8
Thiruvananthapuram	3 (5)	5 (42)	3 (3)	9	10	-	5	-	4	5
Overall	26 (510)	25 (1044)	16 (71)	28	48	1	11	4	13	14

Mammalian species in different habitat types

Among different habitat types, the encounter rate of mammalian species was highest in grassland (1.45 ±0.24) followed by riparian habitats (1.39 ± 0.45) and lowest in moist deciduous habitat (0.34 ± 0.1). The dry deciduous forest that had moderate encounter rates of

mammals had the highest species richness (25species). Evergreen and semi-evergreen habitats had >20 species of mammalian fauna. The mammalian species like Sambar Deer *Cervus unicolor*, Common Langur *Trachypithecus johnii*, Indian Giant Squirrel *Ratufa indica*, AsianElephant *Elephas maximus* and Gaur *Bos gaurus* among herbivores and the carnivores like Wild Dog *Cuon alpinus* have been found in almost all the forest habitats indicating their ability to adapt to different habitat niches. On the other hand, species like Nilgiri Tahr *Hemitragus hylocrius*, Grizzled Giant Squirrel *Ratufa macroura* have been restricted to one or two habitats indicating their habitat specific nature. Some of the habitat generalists like Wild Boar *Sus scrofa*, Sloth Bear *Melursus ursinus* and Leopard *Panthera pardus* though known to exist in all habitat types, were not recorded in our survey in some habitat types, which could be due to inadequate sampling.

Table 18: Species richness of mammals recorded in different habitat types of the Periyar-Agasthyamalai landscape

	Sample size		Sighting(n)		
Land use element	**No. of transects**	**km walked**	**Direct**	**Indirect**	**Species richness**
Dry deciduous forest	69	504	115	175	25
Dry thorn forest	3	16	4	4	5
Moist deciduous forest	13	141	20	24	12
Semi evergreen forest	33	235.5	93	89	21
Evergreen forest	46	416	174	149	22
Grass land	26	162	42	128	13
Riverian forest	6	41	21	47	10
Plantation	13	111	43	10	13
Overall	**209**	**1626.5**	**512**	**626**	**28**

Mammalian fauna encounter rate and species richness in different altitudinal gradients:

The mammalian species encounter rate showed an increasing trend with altitude from 0-250melevation. The rate reached the highest at 500-750m. Thereafter, the encounter rate showed a declining trend. The species richness was the highest at 750-1000 m elevation range and richness declined with altitude from 0-250 m to 500-750 m altitude. Richness was highest at 750-1000 m but then again showed a declining trend (Table 19).

Table 19: Mammalian encounter rate by altitude

	Sample size		Sighting(n)		
Altitude interval	**No. of transects**	**km walked**	**Direct**	**Indirect**	**Species richness**
0 - 250	49	418	120	117	20
250 - 500	34	284	66	70	16
500 - 750	32	208.5	52	99	14
750 - 1000	48	366	118	181	23
1000 - 1250	22	185	63	60	14
1250 - 1500	8	48	41	29	7
1500 - 1750	15	63	5	14	5

Mammalian fauna by Order

Among the six orders of mammalian fauna recorded based on direct sightings or signs **proboscidea** waste most frequent one followed by **carnivora** (cats, dogs, bears, others). **Pholidota** (pangolin) waste very rarely seen order across the landscape. Of the 17 forest divisions, the Periyar Tiger Reserve harboured the highest abundance of **artiodactyla** (pigs, deer, antelope) and **primate** (loris, macaque, langur) and second highest signs or sightings of **proboscideans**. The Mundanthurai-Kalakad Tiger Reserve had more carnivore abundance with moderate artiodactyla abundance. Thenmalai and Theni Forest Divisions represented most abundant rodent species. Konni Forest Division experienced the highest abundance of Proboscideans sightings/signs in the landscape.

Mammalian fauna encounter rate and species richness recorded using camera traps

In total, 264 trap nights sampling across the landscape, 143 captures (n = 71) and recaptures (n = 72) yielded 0.27 capture/trap (Table 20).Total number of mammalian species recorded was 16. Among 17 forest divisions sampled in the landscape, the Periyar Tiger Reserve had the highest capture rate (0.64 capture/trap) and species richness (n = 8). Srivilliputtur Wildlife Sanctuary and Thenmalai Forest Division followed the Periyar Tiger Reserve in terms of capture rate. On the other hand, in terms of species richness, Kalakad-Mundanthurai Tiger Reserve experienced the second highest with relatively larger sampling effort. The success rate of camera trap (mammalian capture rate and species richness) was comparatively less as compared to the success rate (mammalian encounter rate and species richness) of rapid survey method based on direct sighting or indirect evidences.

Mammalian fauna recorded in different habitats and elevation gradients.

Table 20: Camera trap sampling efforts and mammalian species recorded in different forest divisions of Periyar-Agasthyamalai landscape

Forest division	Month	No. of trap nights	Capture	Re-capture	Species inventory
ABP	March	9	0	0	0
Achankovil	Feb, May	10	4	3	3
Cendurni WLS	October	10	1	0	1
Kanniyakumari WLS	November	21	5	3	5
KMTR	Dec, April	53	20	16	7
Konni	Feb, May	11	0	0	0
Kottayam	Jan	8	0	0	0
Neyyar WLS	March	10	0	0	0
Peppara WLS	March	10	0	0	0
Periyar TR	Dec - Jan	33	21	28	8
Punalur	February	11	0	0	0
Ranni	February	19	1	2	1
Srivilliputtur WLS	October	16	7	5	4
Theni	October	12	3	5	2
Thenmalai	March	5	2	8	1
Tirunelveli	October	15	4	0	4
Thiruvananthapuram	March	11	3	2	3
Overall		**264**	**71**	**72**	**16**

Table 21: Camera trap sampling effort and mammalian species recorded in different vegetation types in the Periyar-Agasthyamalai landscape

Major habitat	No. of trap nights	Capture	Recapture	Species richness
Dry deciduous forest	86	19	11	10
Dry thorn forest	8	3	2	2
Moist deciduous forest	79	14	22	9
Semi evergreen forest	16	0	0	0
Evergreen forest	17	15	13	6
Grass land	9	4	6	0
Riverian forest	5	0	0	0
Plantation	44	14	13	8
Over all	**264**	**69**	**67**	**15**

Table 22: Camera trap sampling efforts and mammalian species by altitude

Altitude	No. of trap nights	Capture	Recapture	Species richness
0 - 250	131	25	34	10
250 - 500	47	14	9	10
500 - 750	15	4	1	4
750 - 1000	41	20	22	7
1000 - 1250	16	3	2	2
> 1250	14	2	0	2
Over all	**264**	**68**	**68**	**15**

Camera trap capture rate was highest in evergreen forest followed by grassland and no capture in semi-evergreen and riparian habitats (Table 21).On the other hand, species richness was highest in the deciduous (dry deciduous 10 species and moist deciduous 9 species) forests. The capture rate of mammalian species increased with altitude up to 750-1000 m elevation and then declined gradually (Table 22). On the other hand, the mammalian species richness generally decreased with altitude gradient.

5.4 Mammals in the Landscape

The documented mammal species by rapid survey and supplemented by those captured in camera traps was populated into 2 km x 2 km grids for the entire landscape. From the field data number of sightings, richness and presence of endemic species was mapped (Figures 25, 26 and 27).

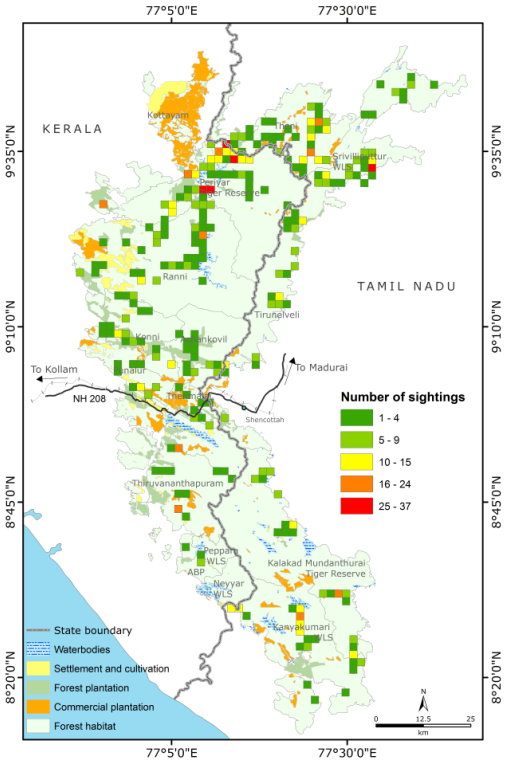


Figure25: Number of sightings of species in P-A landscape

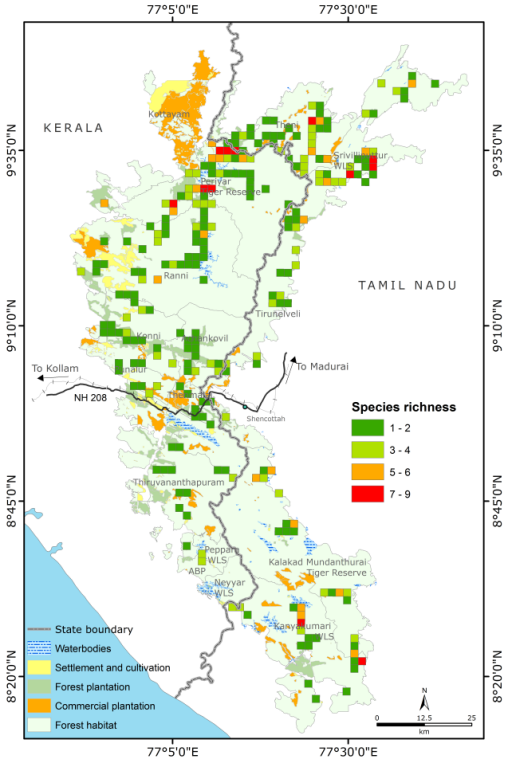


Figure 26: Species richness across P-A landscape

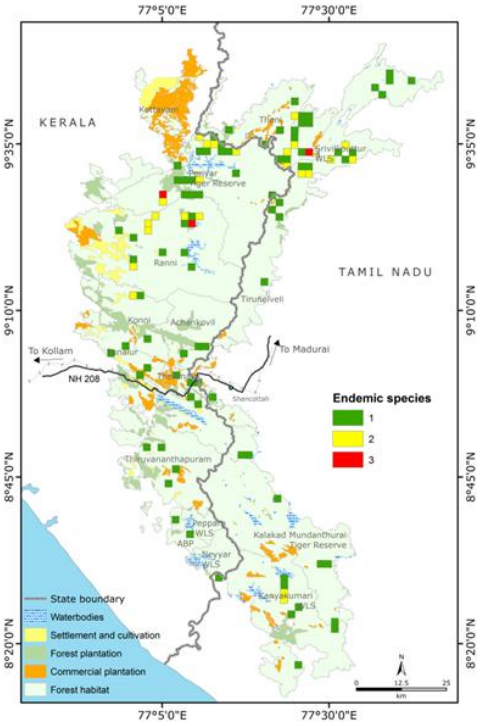


Figure 27: Sighting of endemic species across P-A landscape

Suitability of landscape for mammal species

We fitted MAXENT models to our data using 70% of the species occurrences (training points). We then assessed the predictive power of models by cross-validations using the 30% remaining occurrences (test points) not used to fit the model (Guisan and Zimmerman 2000; Deblauwe *et al.* 2008; Renard et al. 2012) and a set of 10 000 random locations representing background (or pseudo-absence) points (Phillips *et al.* 2006). In our case, a high value of MAXENT function at a particular location indicates that it is suitable for a species. We used default values of the regularisation parameters for all models (more details can be found in Phillips 2005; Phillips *et al.* 2006; Phillips and Dudik 2008). Model performance was evaluated by the ROC (Receiver Operating Characteristic) analysis commonly used for evaluating species distribution models (Fielding and Bell 1997). The method is based on the probability for positive (test points) and negative (pseudo-absence points) instances to be correctly predicted by the model. It provides an AUC (Area Under Curve) value as a general measure of model performance, which we used to compare the efficiency of various sets of environmental variables to predict fire occurrence. Note that in the case of pseudo-absences, AUC values of 0.5 (random predictions) and 1 (perfect predictions) are no longer valid references because they are dependent on the area of distribution (Jimenez-Valverde 2011).

Data of species sighting was used to depict/map distribution of selected species. Species which represent at least five per cent of total species count were selected (Elephant was excluded for calculation as it contributed 30 per cent of the sighting and would skew the data). For these selected species suitability maps were generated. For generation of this model MAXENT modeller was used. In this model, categorical data of Vegetation, continuous data of altitude, slope, Population Count Grid Future Estimates (GPW)(CIESIN 2005) and 19 Bioclimatic variables from WorldClim Global Climatic Data (Hijmans et .al, 2005) were used. PCA was done to layers which correlated among the 19 BIOCLIM layers to compensate for over-parameterisation. Following PCA in ArcGIS 10, we retained layers for the three axes with the largest eigen values. These axes represent 99.7% of the variation in the correlated layers within P-A landscape whereas other axes with smaller eigen values represented less than 0.2% each. Fused principal component were used along with other non-correlated and other layers.

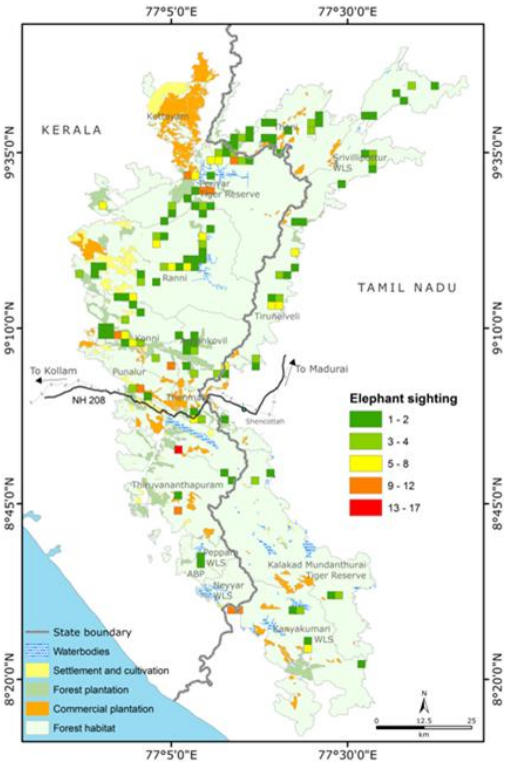
The model generated from presence records gives a suitability score ranging from 0 - 100. Accuracy is measured by the area under the Receiver Operating Characteristic curve (ROC curve). The area under curve range from 0.5-1. (0.90-1 = excellent, 0.80-0.90 = good, 0.70-0.80 = fair, 0.60-.70 = poor, 0.50-0.60=fail).

Maps were created for 10 species listed, Elephant (figure 28), Grizzled giant squirrel (GGS) (figure 29), Indian gaur (figure 30), Malabar giant squirrel (MGS) (figure 31), Nilgiri langur (figure 32), Nilgiri tahr (figure 33), Porcupine (figure 34), Sambar (figure 35), Sloth bear (figure 36) and Wild dog (figure 37).

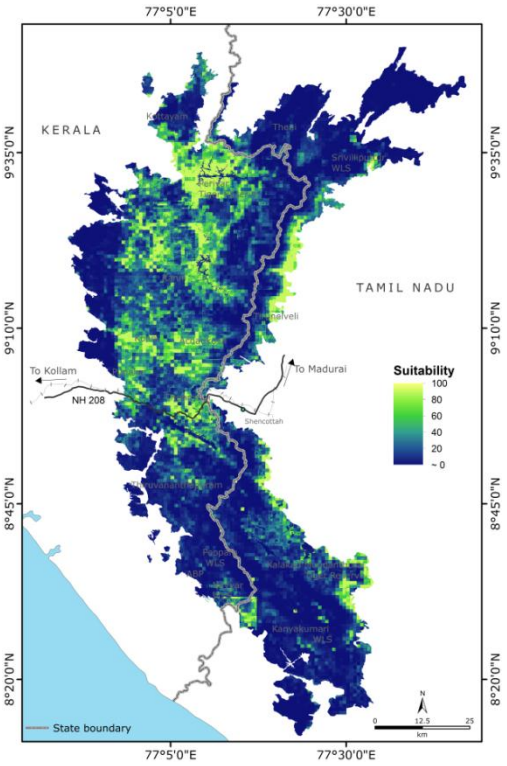
Table 23: Variables used in the MAXENT model of species distributions

Parameters	Correlated/non correlated	Units	Defination
Annual Precipitation	Non correlated	mm	
Precipitation of Driest Month	Non correlated	mm	
Precipitation Seasonality	Non correlated		(coefficient of variance)
Precipitation of Driest Quarter	Non correlated	mm	
Precipitation of Warmest Quarter	Non correlated	mm	
Precipitation of Coldest Quarter	Non correlated	mm	
Mean Diurnal Range	Non correlated	°C * 10	
Isothermality	Non correlated		Mean Diurnal Range /Temperature Annual Range*100
Temperature Seasonality	Non correlated	°C * 10	standard deviation*100
Annual Mean Temperature	Correlated	°C * 10	
Max Temperature of Warmest Month	Correlated	°C * 10	
Min Temperature of Coldest Month	Correlated	°C * 10	
Temperature Annual Range	Correlated	°C * 10	maximum temperature of warmest month - minimum temperature of coldest month
Mean Temperature of Wettest Quarter	Correlated	°C * 10	
Mean Temperature of Driest Quarter	Correlated	°C * 10	
Mean Temperature of Warmest Quarter	Correlated	°C * 10	
Mean Temperature of Coldest Quarter	Correlated	°C * 10	
Precipitation of Wettest Month	Correlated	mm	
Precipitation of Wettest Quarter	Correlated	mm	
Altitude	Not considered	m	
Population Count Grid Future Estimates (GPW)	Not considered		
Vegetation	Not considered		
Slope	Not considered	degrees	

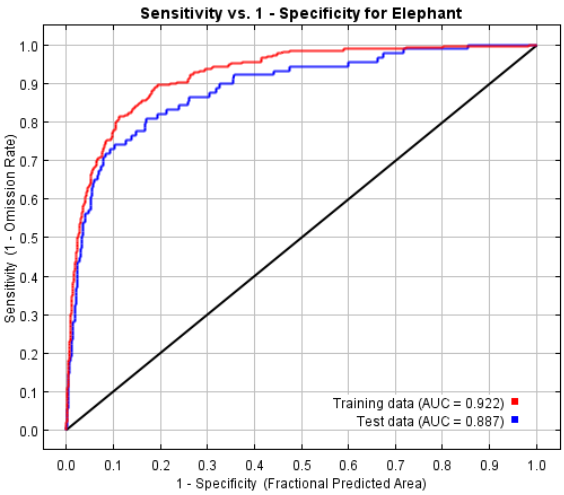
Figure 28:Elephant



Elephant sightings in the P-A landscape



Suitability map for elephant in the P-A landscape



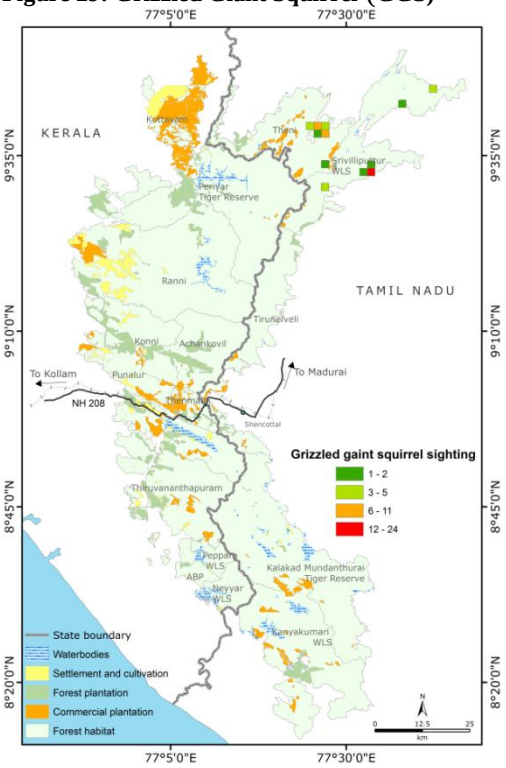
ROC curve of the suitability model for elephant

Variable	*% contribution*
Annual Precipitation	5.2
Precipitation of Driest Month	0.6
Precipitation Seasonality	0.2
Precipitation of Driest Quarter	6.3
Precipitation of Warmest Quarter	4.1
Precipitation of Coldest Quarter	10.7
Mean Diurnal Range	1.4
Isothermality	0.4
Temperature Seasonality	12
PCA 1st component*	8.5
PCA 2nd component*	18.6
PCA 3rd component*	3.5
Altitude	4
GPW	6
Vegetation	4.9
Slope	13.7

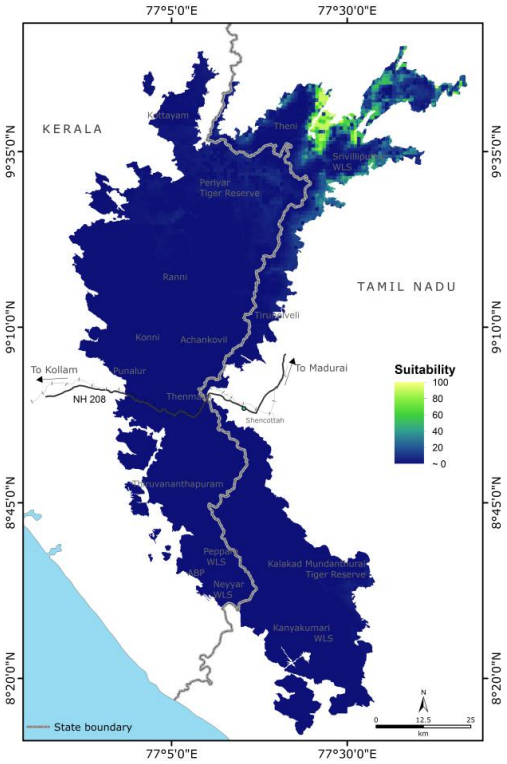
Relative contributions of environmental variables to the Suitability model for elephant

For modelling the suitability of the landscape for elephants 357points were considered, of this 268 presence records used for training, 89 for testing. 500 iterations were run to produce the final model. The models accuracy was AUC is 0.922. Validation using the test data provided AUC of 0.887± 0.019.

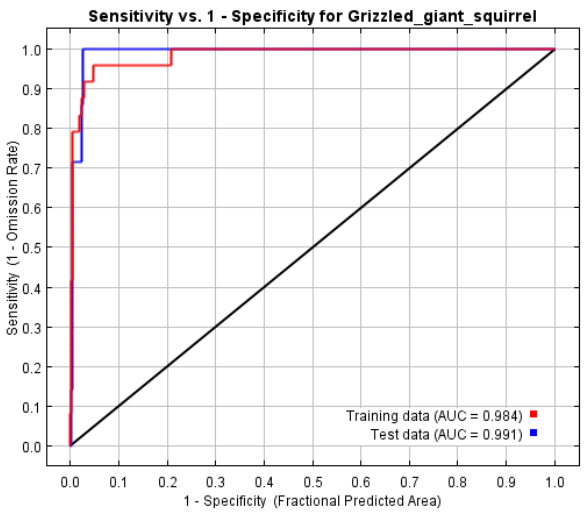
Figure 29: Grizzled Giant Squirrel (GGS)



GGS sightings in the P-A landscape



Suitability map for GGS in the P-A landscape



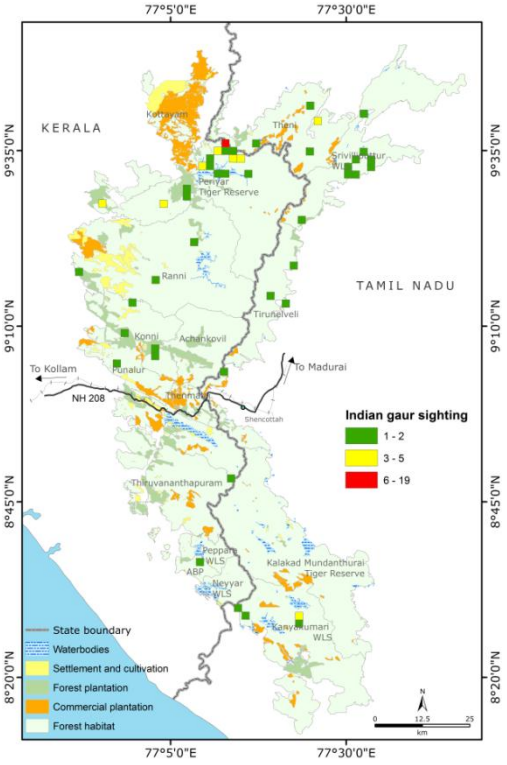
ROC curve of the suitability model for GGS

Variable	*% contribution*
Annual Precipitation	0.1
Precipitation of Driest Month	0.1
Precipitation Seasonality	3.1
Precipitation of Driest Quarter	1.7
Precipitation of Warmest Quarter	0
Precipitation of Coldest Quarter	0.3
Mean Diurnal Range	40.6
Isothermality	4.2
Temperature Seasonality	32.3
Altitude	0.9
GPW	9.8
Vegetation	0.2
Slope	6.5

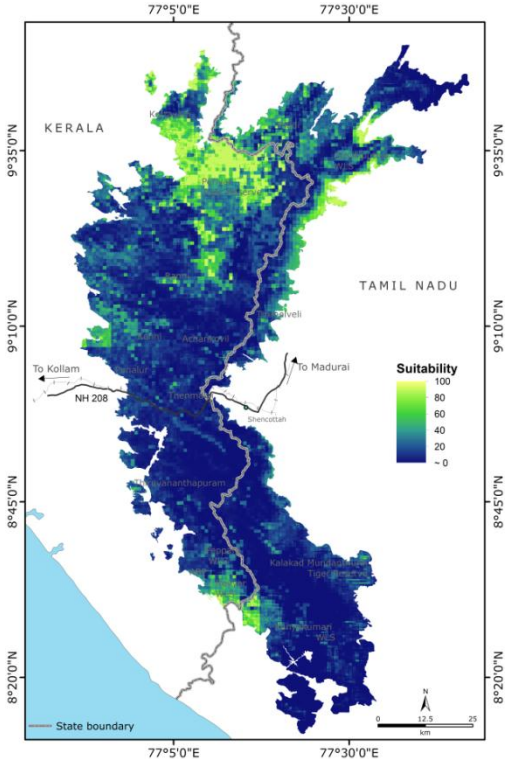
Relative contributions of the environmental variables to the Suitability model for GGS

The modelling for Grizzled giant squirrel 24 presence records were used for training and 7 for testing and 440 iterations were run. The accuracy of the models is 0.984 measured from AUC. The AUC for validation is 0.991 ± 0.004.

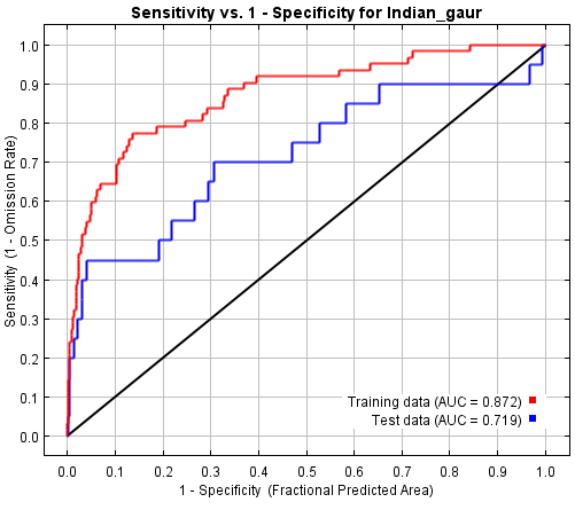
Figure 30: Indian gaur



Indian gaur sightings in the P-A landscape



Suitability map for Indian gaur in the P-A landscape



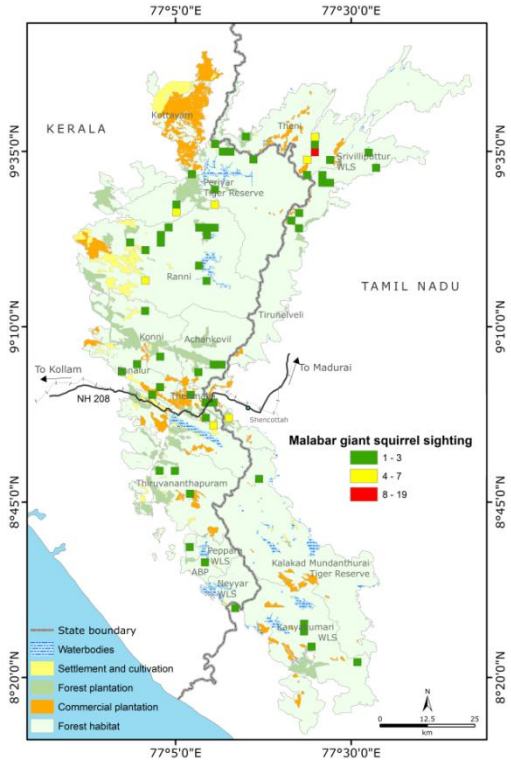
ROC curve of the suitability model for Indian gaur

Variable	*% contribution*
Precipitation Seasonality	14.5
Precipitation of Driest Quarter	11.6
Precipitation of Warmest Quarter	3.8
Precipitation of Coldest Quarter	30.1
Mean Diurnal Range	8
Isothermality	0.7
Temperature Seasonality	5.4
PCA 1st component*	0.7
PCA 3rd component*	0.8
Altitude	11.3
GPW	10.3
Vegetation	1.6
Slope	1.2

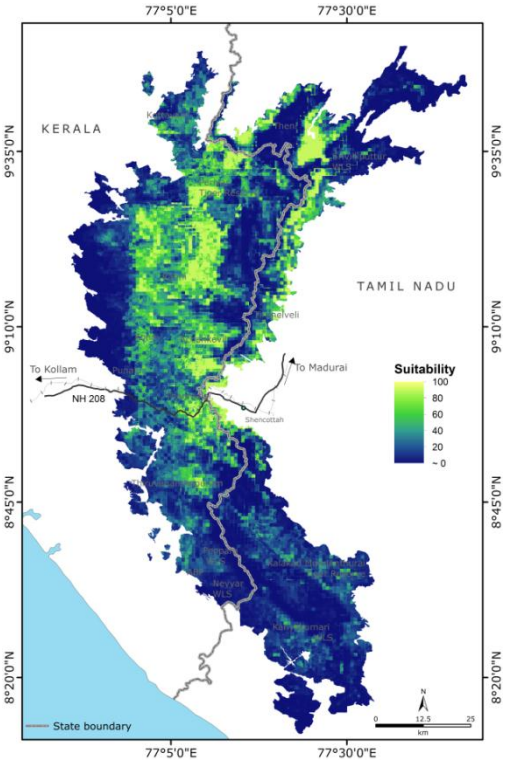
Relative contributions of the environmental variables to the Suitability model for Indian gaur

For constructing suitability model for Indian gaur Maxent model did 500 iterations with 62 presence records and accuracy was 0.872 as per AUC. For validation of the model 20 points were used and AUC for this is 0.719±0.07.

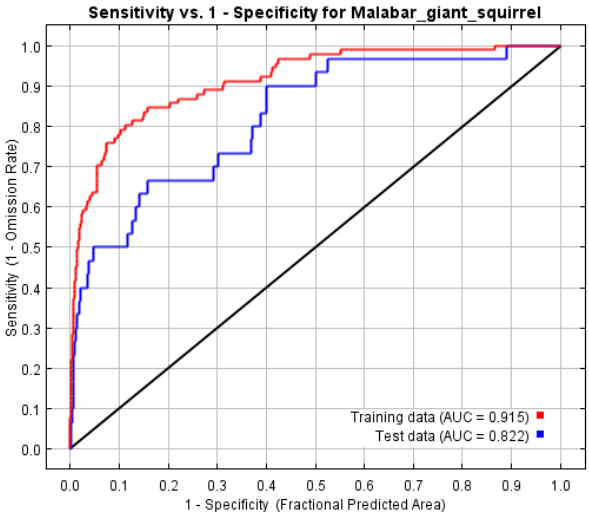
Figure 31:Malabar Giant Squirrel (MGS)



MGS sightings in the P-A landscape



Suitability map for MGS in the P-A landscape



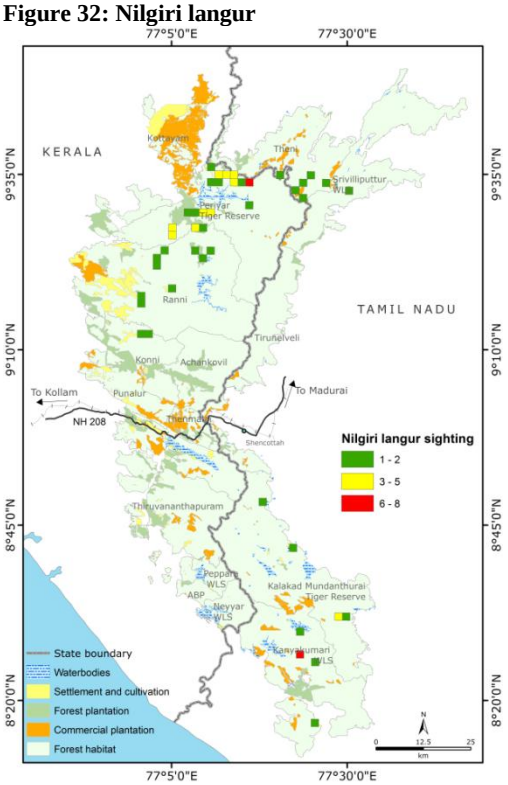
ROC curve of the suitability model for MGS

Variable	*% contribution*
Annual Precipitation	2.6
Precipitation of Driest Month	11.5
Precipitation Seasonality	3.4
Precipitation of Driest Quarter	5.6
Precipitation of Warmest Quarter	9.4
Precipitation of Coldest Quarter	4.6
Mean Diurnal Range	7
Isothermality	0.5
Temperature Seasonality	22.6
PCA 1st component*	2.1
PCA 2nd component*	10.7
PCA 3rd component*	1.9
Altitude	2.5
GPW	6.3
Vegetation	1.7
Slope	7.5

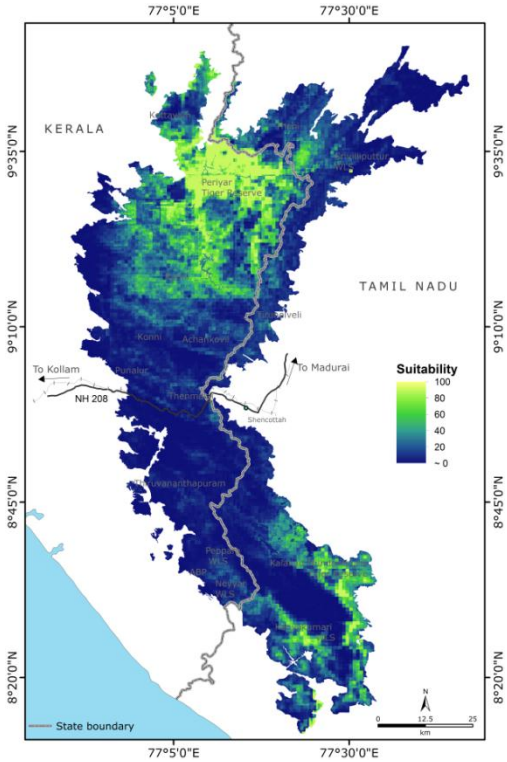
Relative contributions of the environmental variables to the Suitability model for MGS

For modelling MGS total of 121 locations were considered, of which 91 presence records, 30 for validation. Model had good fit with AUC of 0.915, and Validation AUC of 0.822±0.039.This was done after 500 iterations.

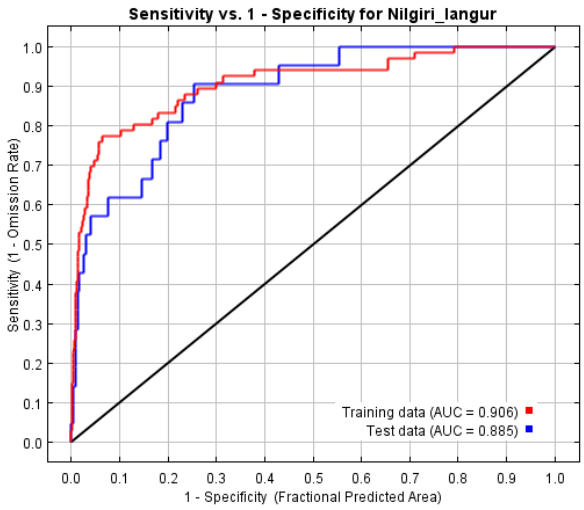
Figure 32: Nilgiri langur



Nilgiri Langur sightings in the P-A landscape



Suitability map for Nilgiri Langur in the P-A landscape



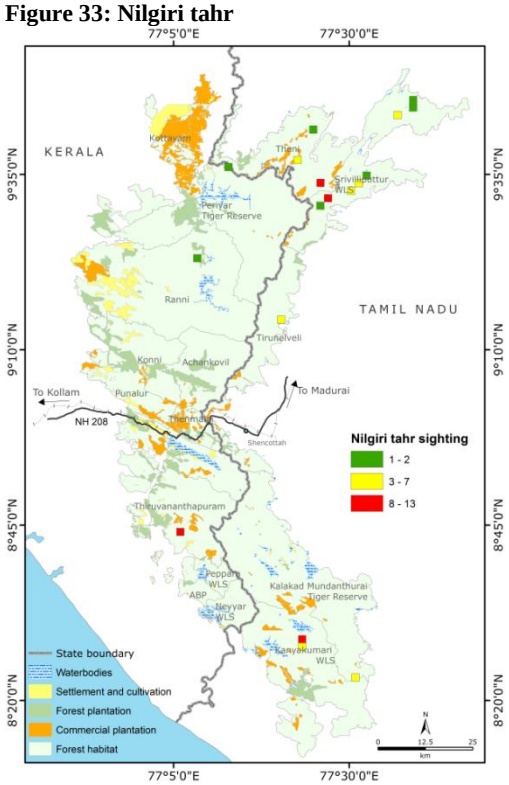
ROC curve of the suitability model for Nilgiri langur

Variable	% *contribution*
Precipitation of Driest Month	0.2
Precipitation Seasonality	19.4
Precipitation of Driest Quarter	1.6
Precipitation of Warmest Quarter	0.4
Precipitation of Coldest Quarter	0.4
Mean Diurnal Range	6.4
Isothermality	0.1
Temperature Seasonality	18
PCA 1st component*	2.6
PCA 2nd component*	10.9
PCA 3rd component*	0.1
Altitude	11.5
GPW	19.5
Vegetation	2.7
Slope	6.3

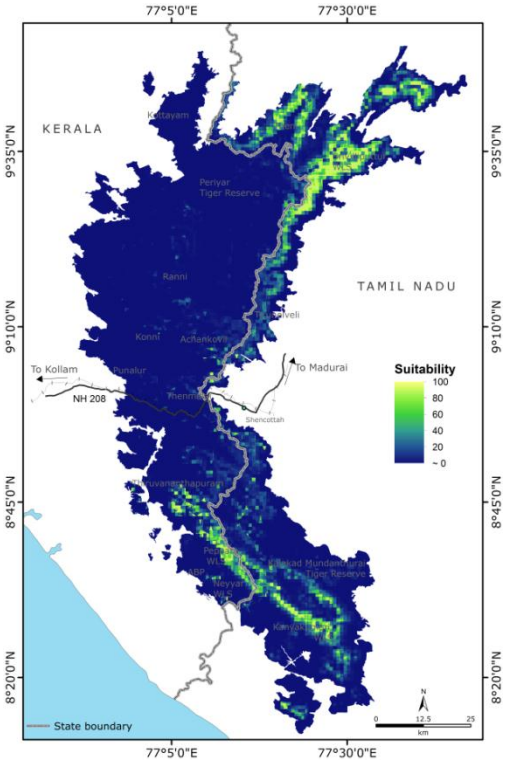
Relative contributions of the environmental variables to the Suitability model for Nilgiri langur

Nilgiri langur's 66 sightings was used for modelling, and 21 for validating, running 500 iterations. Accuracy for the model predicted is 0.906, and for validation is 0.885±0.032 AUC.

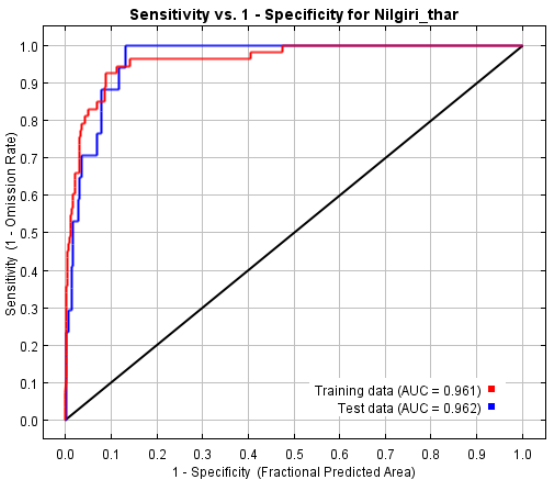
Figure 33: Nilgiri tahr



Nilgiri tahr sightings in the P-A landscape



Suitability map for Nilgiri tahr in the P-A landscape



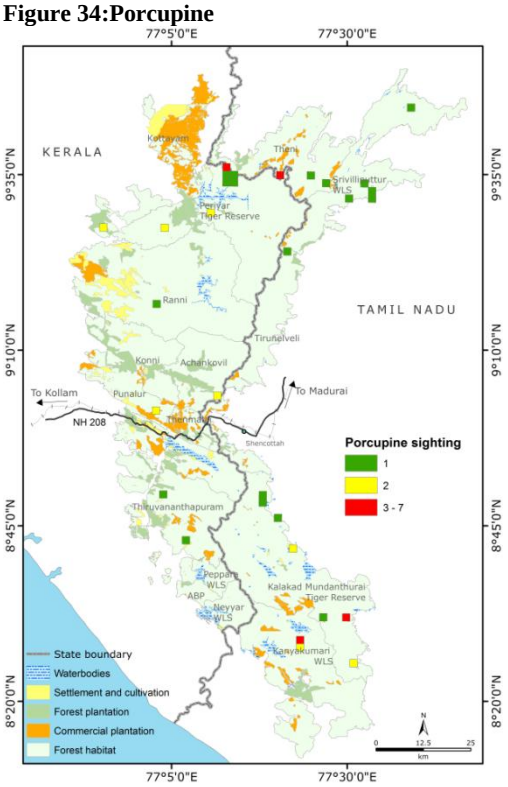
ROC curve of the suitability model for Nilgiri tahr

Variable	*% contribution*
Annual Precipitation	5.7
Precipitation of Driest Month	0.6
Precipitation Seasonality	0.1
Precipitation of Driest Quarter	2
Precipitation of Warmest Quarter	4.6
Mean Diurnal Range	1.1
Isothermality	12.2
Temperature Seasonality	1.7
PCA 2nd component*	5.7
PCA 3rd component*	1.1
Altitude	8
GPW	12.2
Vegetation	0.2
Slope	44.6

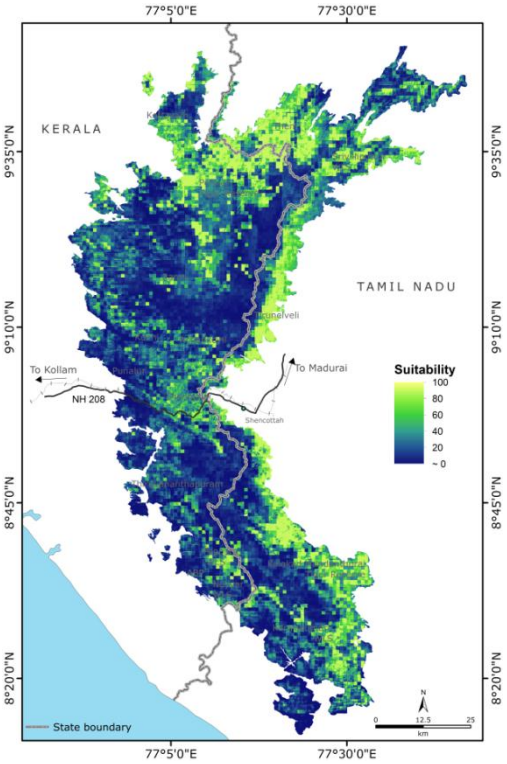
Relative contributions of the environmental variables to the Suitability model for Nilgiri tahr

For this model also 500 iterations were run with 53 sighting records used for modelling and 17 validation. The AUC for model is 0.961, and for validation is 0.962± 0.

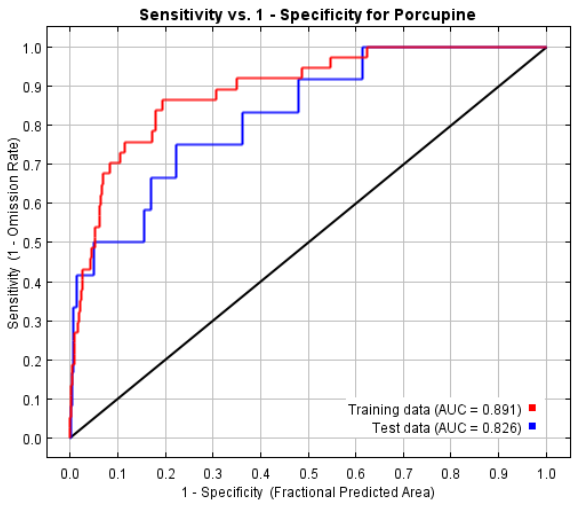
Figure 34:Porcupine



Porcupine sightings in the P-A landscape



Suitability map for Porcupine in the P-A landscape



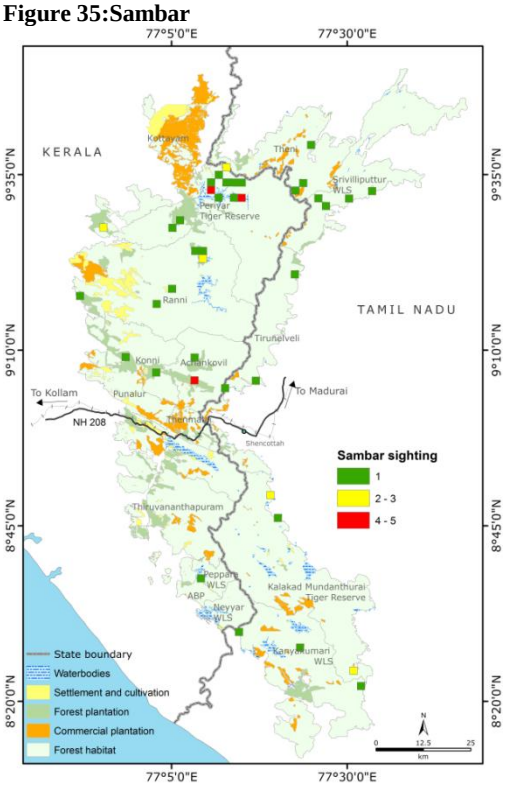
ROC curve of the suitability model for Porcupine

Variable	*% contribution*
Precipitation of Driest Month	1.6
Precipitation Seasonality	8.5
Precipitation of Driest Quarter	0.3
Precipitation of Warmest Quarter	24.9
Precipitation of Coldest Quarter	1
Mean Diurnal Range	6
Isothermality	0.4
Temperature Seasonality	19.6
PCA 1st component*	2.6
PCA 3rd component*	7.2
Altitude	10.6
GPW	12.4
Vegetation	3.1
Slope	1.9

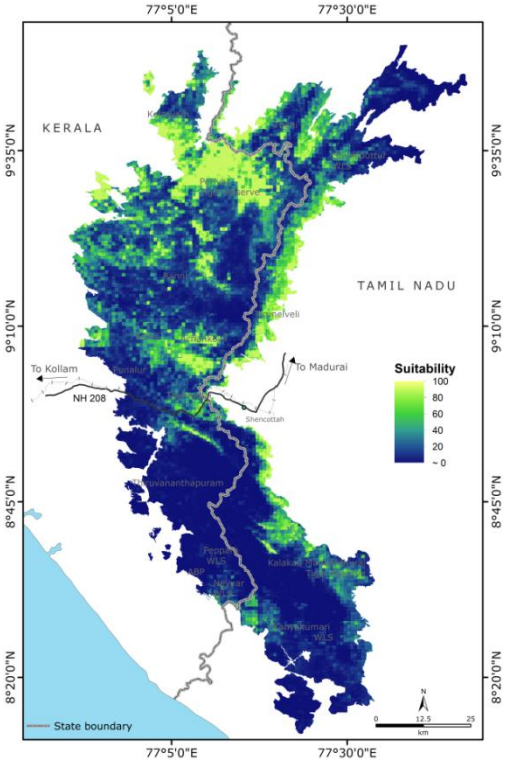
Relative contributions of the environmental variables to the Suitability model for Porcupine

Landscape suitability model for Porcupine iterated 500 times for 37 presence records. This was used for training, 12 for testing. The AUC for training is 0.891, and for test AUC is 0.826± 0.058.

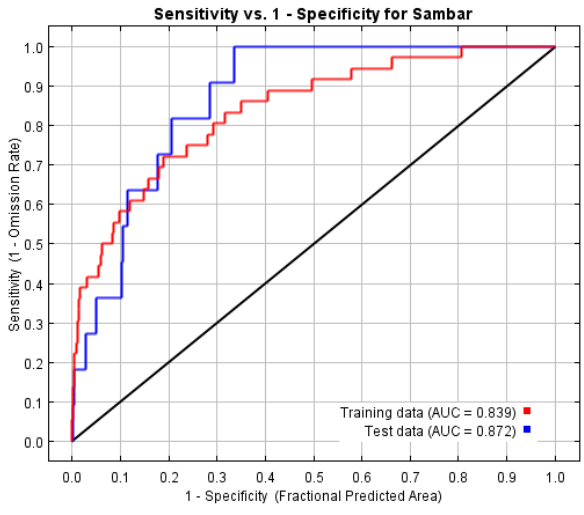
Figure 35:Sambar



Sambar sightings in the P-A landscape



Suitability map for Sambar in the P-A landscape



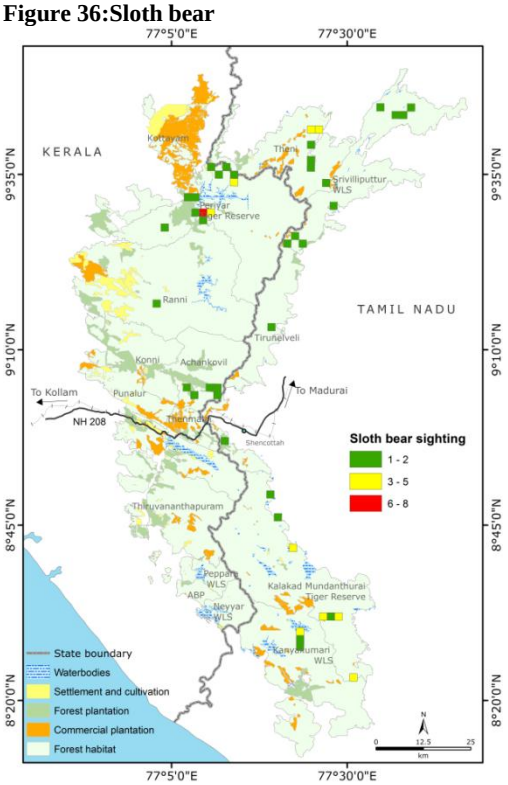
ROC curve of the suitability model for Sambar

Variable	*% contribution*
Annual Precipitation	1.7
Precipitation of Driest Month	0.4
Precipitation of Driest Quarter	2.9
Precipitation of Warmest Quarter	0.1
Precipitation of Coldest Quarter	1.4
Mean Diurnal Range	29.1
Temperature Seasonality	9
PCA 1st component*	1.5
PCA 2nd component*	9
PCA 3rd component*	1.6
Altitude	0.1
GPW	15
Vegetation	15.3
Slope	12.8

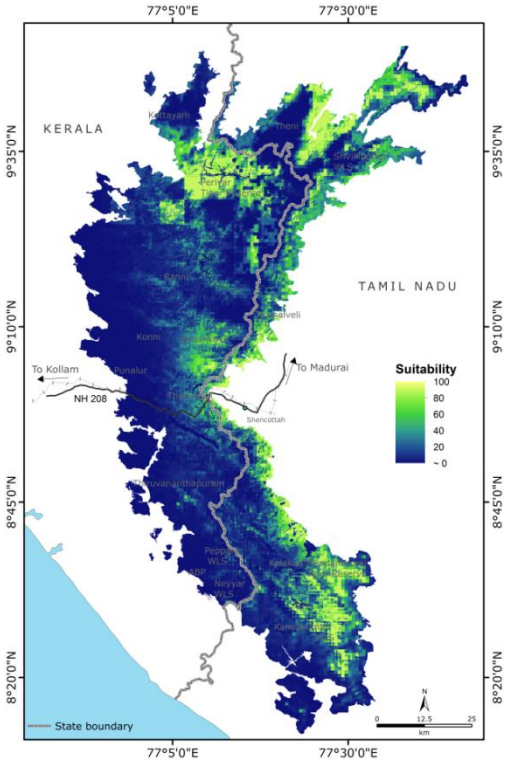
Relative contributions of the environmental variables to the Suitability model for Sambar

The model for landscape suitability for Sambar has an accuracy of AUC is 0.839, model validation has AUC is 0.872±0.032. For this model 500 iterations with 36 presence records used for training, 11 for testing.

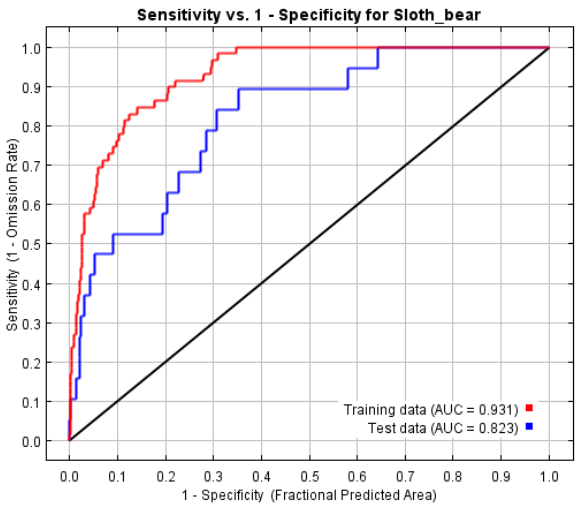
Figure 36:Sloth bear



Sloth bear sightings in the P-A landscape



Suitability map for Sloth bear in the P-A landscape



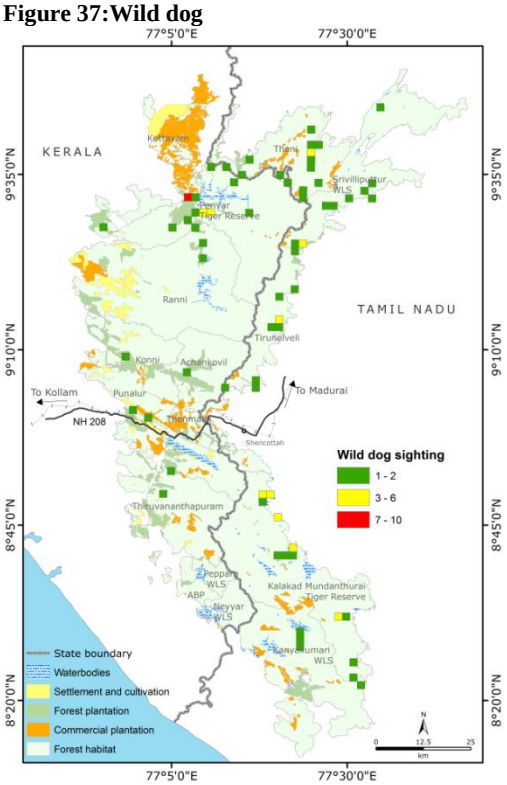
ROC curve of the suitability model for Sloth bear

Variable	*% contribution*
Annual Precipitation	2.8
Precipitation of Driest Month	0.2
Precipitation Seasonality	17.1
Precipitation of Driest Quarter	0.6
Precipitation of Warmest Quarter	11
Precipitation of Coldest Quarter	3.7
Mean Diurnal Range	3
Isothermality	4.9
Temperature Seasonality	1
PCA 1st component*	1.5
PCA 2nd component*	7.4
Altitude	5.3
GPW	24.3
Vegetation	13.4
Slope	3.8

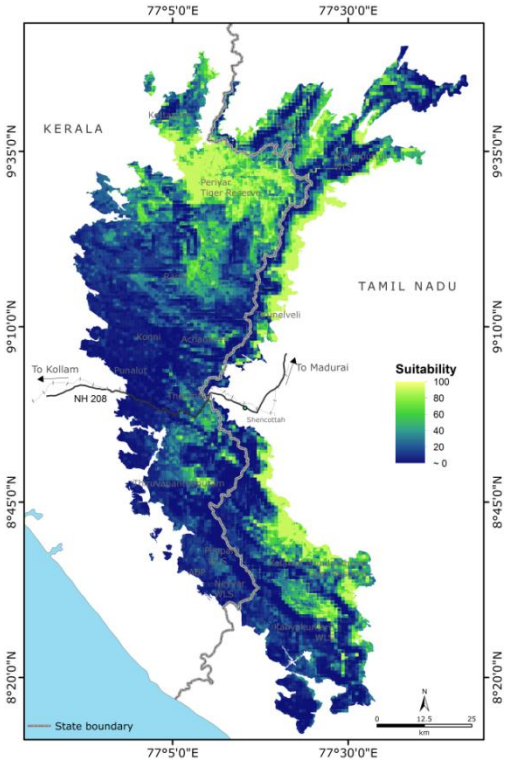
Relative contributions of the environmental variables to the Suitability model for Sloth bear

For modelling the suitability of landscape for Sloth bear 78 points were considered, of this 59 for training, 19 for testing. 500 iterations were run for to produce the final model. The models accuracy was AUC is 0.931, validation using the test data provided AUC of 0.823± 0.043.

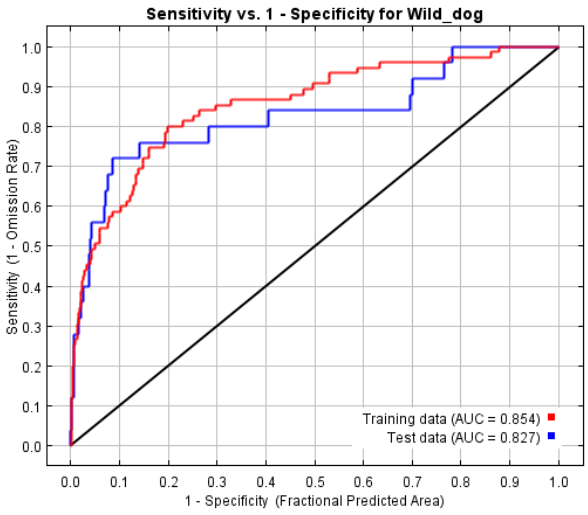
Figure 37:Wild dog



Wild dog sightings in the P-A landscape



Suitability map for Wild dog in the P-A landscape



ROC curve of the suitability model for Wild dog

Variable	*% contribution*
Annual Precipitation	1
Precipitation of Driest Month	16.3
Precipitation Seasonality	4.3
Precipitation of Driest Quarter	4.6
Precipitation of Warmest Quarter	0.6
Precipitation of Coldest Quarter	3.7
Mean Diurnal Range	4.2
Isothermality	10.4
Temperature Seasonality	15.5
PCA 2nd component*	1.3
PCA 3rd component*	2.3
Altitude	3.7
GPW	13.6
Vegetation	1.1
Slope	17.4

Relative contributions of the environmental variables to the Suitability model for Wild dog.

Landscape suitability model for Porcupine iterated 500 times for 75 presence records used for training, 25 for testing. The AUC for training is 0.854, and for test AUC is 0.827± 0.052.

Determination of species concentration and priority conservation areas

For developing species concentration and priority conservation areas the above discussed 10 species i.e., Elephant, Grizzled giant squirrel (GGS), Indian gaur, Malabar giant squirrel (MGS), Nilgiri langur, Nilgiri tahr, Porcupine, Sambar, Sloth bear and Wild dog were considered. The distribution model generated for all species were assembled to produce wildlife concentration map and the range was from 18.26 to 1083.52. For ease of reading it is presented as percentage w.r.t highest value (Figure 38).

To generate priority conservation areas, a weighted summation was used. For assigning the weights the IUCN red list and endemism was used as criteria. From the IUCN red list species in Endangered category were assigned 4, vulnerable were assigned 3, for near threatened and Least concerned were assigned 2 and 1 respectively. Endemism was given a value of 2 and non-endemic was given 1. The IUCN and endemic values were multiplied for individual species and finally all layers of species were summed to produce priority conservation areas (Table 24). The range of the layer was from 4.98 - 2234.86, and for ease of reading range was presented as percentage w.r.t highest value (Figure 39).

Table 24:Weightage assigned to mammal species in P-A landscape

Species	IUCN rank	Endemic rank	Weightage
Porcupine	1	1	1
Sambar	3	1	3
Grizzled giant squirrel	2	2	4
Sloth bear	3	1	3
Nilgiri that	4	2	8
Nilgiri langur	3	2	6
Indian gaur	3	1	3
Wild dog	4	1	4
Malabar giant squirrel	1	2	2
Elephant	4	1	4

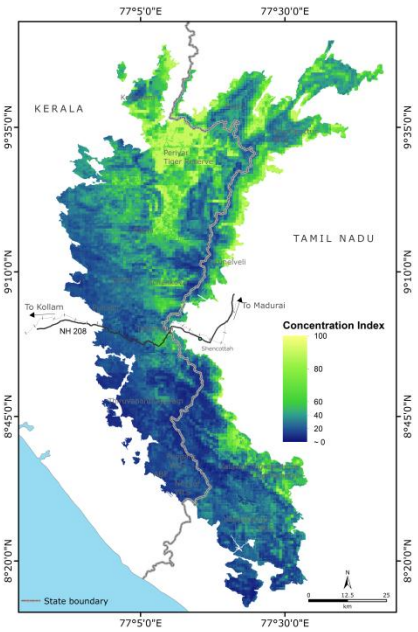


Figure 38: Species concentration

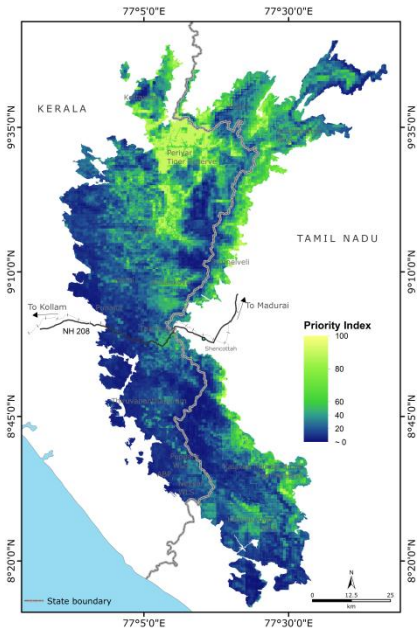


Figure 39:Conservation priority index

6 Landscape Level Approach for the Conservation of Biodiversity in the Periyar-Agasthyamalai Landscape

6.1 Introduction

Long term conservation of biodiversity requires, firstly, large areas with diverse micro and macro habitats, which suit diverse life forms. Secondly wide ranging species like Asian elephant, Royal Bengal Tiger etc. require larger areas to meet their resource requirements. Thirdly the maintenance of genetically viable populations of such wide ranging species needs minimum viable areas that demands larger areas. The lack of conservation programmes that go beyond Pas into the broader landscape is a major weakness of India's conservation planning. As wild species distribution range widely in nature and areas of high biodiversity values do not necessarily fall within PA boundaries, conservation planning at larger landscape level is essential for conservation to be successful in the long run.

6.2 The Asian Elephant

The Asian Elephant is a wide ranging species in the biologically rich tropical forests of India (Sukumar1995, Baskaran et al. 1995, Sukumar 2003) and thus securing adequate natural habitats for the species would ensure the successful conservation of regional biodiversity. Therefore conservation planners often see the Asian Elephant as the flagship species for guiding strategies for the conservation of biological diversity. With an estimated population of ~ 28000 individuals in the wild, survival of this wide-ranging species is highly threatened in India due to the continued loss of natural habitats and the sharply rising incidence of elephant human conflict. The Periyar-Agasthyamalai landscape with an estimated population of 2000elephants distributed across 6000 km^2 comprises the southern part of the Periyar plateau, and its eastern spur, the Varushnad and Meghamalai Hill ranges, the Achankovil Valley, the Agasthyamalai and Mahendragiri hill ranges on the southern side. Like any other landscape in the Western Ghats, the eastern parts of the landscape with low rainfall have more tropical dry deciduous and thorn forests, while the hill ridges and the western sides with high rainfall have more tropical evergreen and moist deciduous forests. The landscape on the northern side is probably the most intact elephant range in southern India (Gajah 2010). Nevertheless, developmental activities like human settlements and cultivation and vehicular movements along the Madurai–Kollam National Highway 208 have cut off the habitat contiguity to a large extent between Agasthyamalai–Mahendragiri hill ranges and Periyar plateau. Therefore, about 250 elephants ranging in the southern part of the landscape are

Asian Elephant *Elephas maximus* captured on camera during the rapid survey

almost isolated from the larger landscape on the northern side. Further, the Periyar Tiger Reserve that harbours the major chunk of the elephant population in the landscape is the most affected one in the country due to ivory poaching. The sex ratio at adult stage was extremely skewed to the tune of1: 100 (Ramakrishnan et al. 1998), which changed marginally to 1: 80 during 2005 (Arivazhagan and Sukumar 2005).

Tiger *Panthera tigris tigris* captured on a camera trap in the Periyar Tiger Reserve

Further, the present study also shows that the two Tiger Reserves, one each located on the northern (Periyar Tiger Reserve in Kerala) and southern parts of the landscape (Kalakad-Mundanthurai in Tamil Nadu) have the richest mammalian biodiversity and abundance in the landscape and also with growing tiger population (NTCA). Besides the above the landscape is the only source of water for the southern parts of Tamil Nadu and Kerala. Therefore, taking the above conservation strengths and weaknesses of this region into account, an integrated landscape level conservation planning across all the forest divisions of the landscape and linking the northern and southern parts of the landscape through establishing wildlife corridor is essential not only to ensure the long-term conservation of the umbrella species and the biodiversity of the landscape, but also for the ecological functions to safeguard economic growth, social stability of the several hundred thousand people living in and around the landscape.

6.3 Maintaining habitat contiguity in the landscape

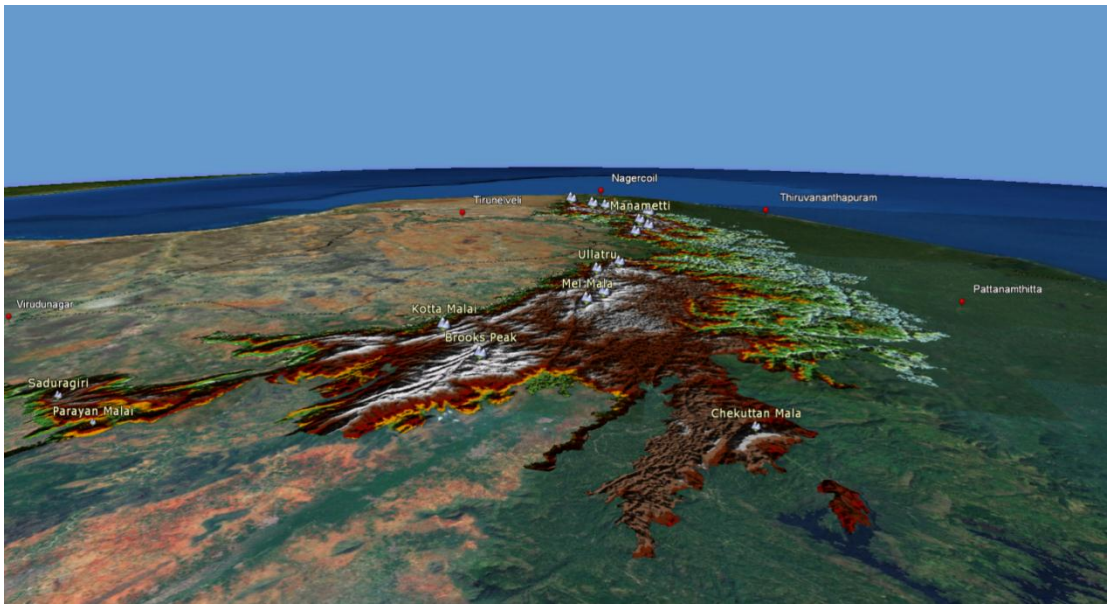
The Asian Elephants live in social groups with a strong social bond among females; the group consists of related females and their dependent offspring of both sexes (Moss 1988, Vidya and Sukumar 2005), and is led by the matriarch, the oldest female. Males leave the maternal herd at puberty around the age of 15and lead mostly solitary life and at times, join female herds for breeding; alternatively, or when not sexually active they may join other males to form bachelor herds with weak social bonds (Douglas–Hamilton1972, Sukumar 1989, Desai and Johnsingh 1995).Their large body mass and poor digestive ability make them spend as much as 60–70% of the time on feeding/day (Baskaran et al. 2010b) to consume plant matter equal to 5% of their body mass (160–300 kg)and up to 225 l of water every day (Sukumar 2003).Therefore, a matriarchal group needs nearly 700 km^2 of natural habitat in landscape with secondary forest domination to lead a reasonably natural life (Desai1991, Baskaran et al. 1995, 1998).

Beside the wide-ranging nature, the elephants have long life spans like human beings and show strong fidelity to their home and seasonal ranges and the corridors within. Thus, they use the same range over several generations (Baskaran et al. 1995, Baskaran1998). Although elephants, especially herds (clans),overlap extensively in space, the hierarchy and resource defence among clans and its resultant spacing mechanisms do not permit those elephant clans that have lost their habitats to developmental activities to move into adjoining undisturbed habitats that are already inhabited by high density of elephants(Baskaran 1998). Therefore, such clans with significant loss of traditional ranges (including their corridors) by agriculture/settlements will continue to stay in their home ranges conflicting with humans (Balasubramanian et al. 1995, Baskaran 1998). If the traditional ranges turn out to be unsustainable, stray out in search of newer habitats to settle down(as seen in the cases of elephants straying into Belgaum–Maharashtra–Goa in 2004–05 and from Hosur–Dharmapuri to Andhra Pradesh, Daniel et al. 1988). In the absence of newer habitats without elephants they settle down in areas with very few elephants (as reported in Baskaran 1998). If the newly settled forest is suboptimal, the herd starts sustaining partially from agricultural crops available in the adjoining newer habitats (Baskaran 1998, Daniel et al. 2006).

The Periyar–Agasthyamalai landscape especially the northern part is the most intact elephant habitat in India. Thus the landscape is experiencing lower conflict than any other similar landscape in India. However, loss of contiguity between northern and southern parts of the landscape is still a major threat to the elephant population. Though the landscape is presently experiencing very low human–elephant conflict is likely to rise in the future considering the growing elephant population and human population and their dependence on the natural habitats. Secondly as mentioned earlier, the elephant population in the Periyar Tiger Reserve is most affected by ivory poaching (Ramakrishnan et al. 1998, Arivazhagan and Sukumar 2005). The situation is likely to be the same all over the northern part of the landscape. In case, if the southern part of the landscape without much ivory poaching pressure maintains normal sex ratio (1:2 or 1:3), re-establishing habitat contiguity between northern or southern part would enhance gene flow or reduce the consequences of inbreeding. Even otherwise too, maintaining habitat contiguity between the two parts of the landscape would reduce the genetic and demographic consequences of isolated elephants found on the southern side.

The complex social life along with large spatial and temporal scales over which the elephants live their life and the demand on land for the growing human population imply that the long-term conservation and management of elephant populations requires an integrated and ecologically sound approach among government departments and conservation agencies. Equally essential is the long-term conservation policy for each elephant population.

Besides the above reasons, the Periyar Tiger Reserve in the northern part of the landscape and Kalakad-Mundanthurai Tiger Reserve in the southern part have rich mammalian species diversity. Therefore, linking the two parts of the landscape would enhance species richness, accommodate the growing tiger population in the two Tiger Reserves and maintain the genetic viability of wild species found in the entire landscape through seasonal movement and dispersal.

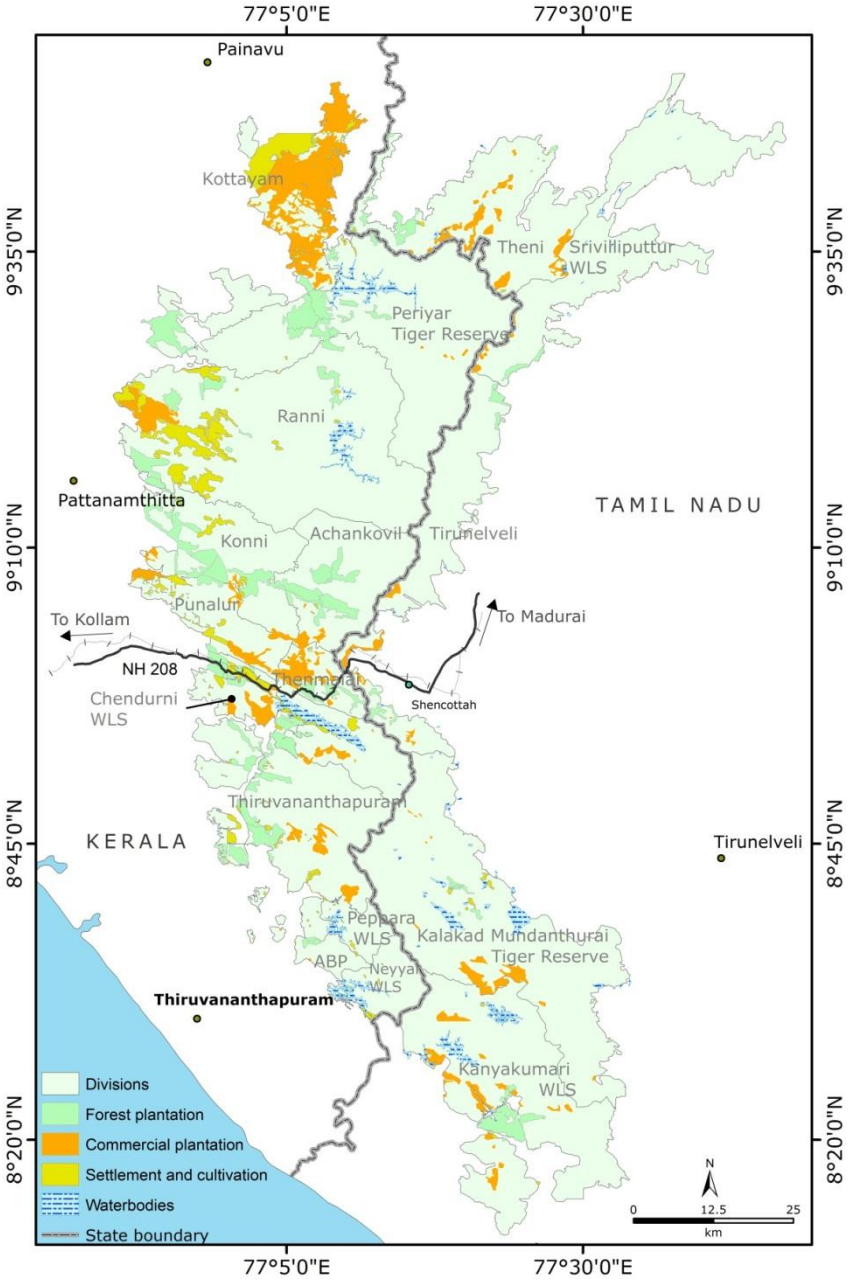


6.4 Integrated land use and developmental planning at landscape level

The Asian Elephant being a wide-ranging species is facing continued threats from habitat loss due to absence of integrated and planned developmental activities (Figure 40) that takes into account conservation needs. It is now confined to smaller fragmented habitats in the landscapes. The fragmented or isolated populations, often with poor quality of habitats and genetically unsuitable for long-term conservation, are increasingly coming in contact with human beings leading to escalating human–elephant conflict. With much of the remaining elephant habitats surrounded by rural areas, where most of the families live below the poverty line, depend on forests for their livelihood, resulting in degradation of habitat that further leads to increase in human–elephant conflict besides loss of biodiversity. The existing management practice in isolation at forest division/park level, with lack of coordinated management approach within the department among wildlife and territorial divisions of the same state or between states and lack of integrated planning with other governmental departments for land use, and developmental activities would further aggravate the habitat fragmentation and degradation leading to greater human–elephant conflict. Therefore, an integrated land use and developmental planning that takes into account the conservation needs perhaps on priority basis, at landscape level (Sukumar and Baskaran 2007,Gajah 2010), would not only be ecologically sound for the elephant population, but would also safeguard the biodiversity and economic growth, and the quality of livelihood of the several million people living in and around the Western Ghats.

6.5 Conservation planning

Establishing a comprehensive database on elephant habitats including the corridors and land use and vegetation patterns at landscape level is a basic but vital step. Superimposing the other data on elephant population, human–elephant conflict and other conservation issues like biotic pressure, ivory poaching, etc. along with data on socio-economic status of the people, rainfall, topography and soil type, etc. on to the elephant distribution map, one could visualize the existing scenario and devise management policies in regard to land use and developmental planning at landscape level integrating conservation needs of the elephant population and other biodiversity. Such a plan with the involvement of government officials and policy-makers representing forest, revenue, animal husbandry, and agriculture, electricity boards, highways and railways along with experts from elephant ecology, biodiversity, and conservation and sociology could put together the plan.



Since the prospect of restoring connectivity among fragmented patches or consolidation of habitat on a large scale is unlikely, given the demands of growing population, maintaining the integrity of existing habitat and corridors is essential. The corridors are narrow strips of forests connecting two major habitats, which the wild animals use traditionally or in recent years owing to the loss of surrounding habitats. Such corridors play vital role in maintaining landscape connectivity, by facilitating the movements of organism between habitat fragments and thus minimize the risk of inbreeding and extinction, increase local and regional wild animal population persistence (Simberloff 1988).Above all, the Asian Elephant being a wide ranging species has been highly affected by habitat loss and ivory poaching particularly in southern India, corridors are very crucial not only for their survival but also to minimize conflict with the people with negative effect on natural ecosystems and thereby on the biodiversity. Although, one of the corridors in the landscape (Kottavasal corridor) lies within the Reserved Forests (Figure 40), the traffic intensity along with topographical constraints have blocked the large mammal movement. Therefore a properly planned passage for the vehicular traffic would minimize their disturbances to animal movement.

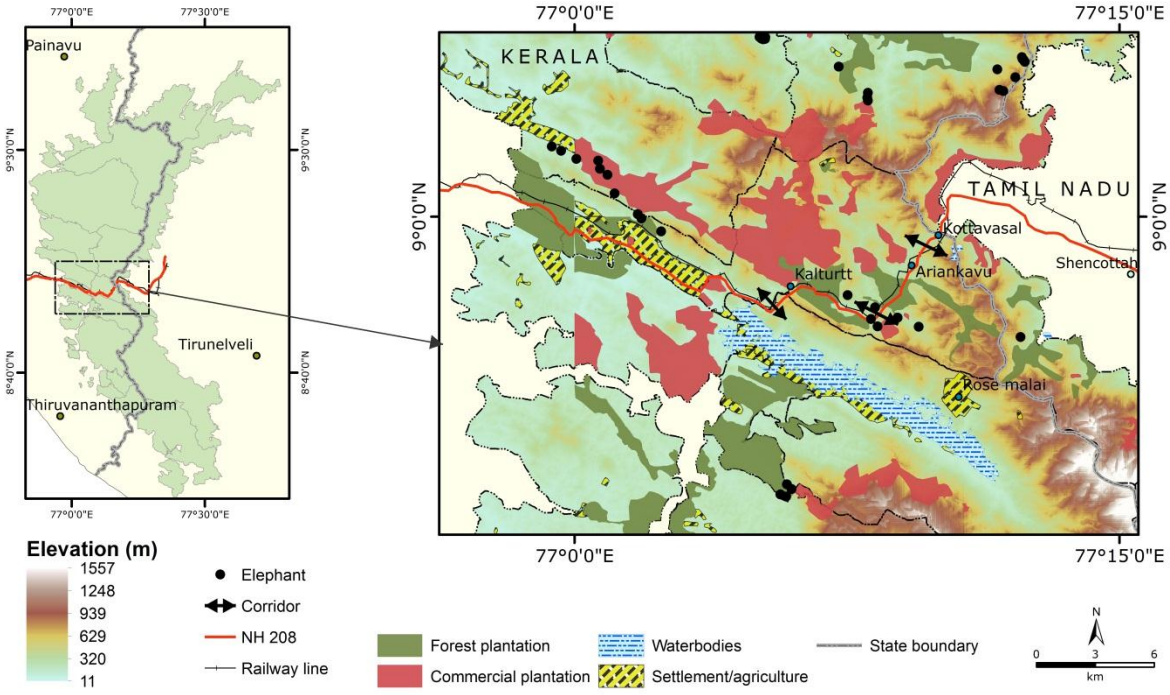


Figure 40: Corridors for planning in the Periyar-Agasthyamalai landscape

Similarly, there are two more locations on the western side of the landscape (Figure41) whereby establishing the corridors and preserving them legally from threats of developmental activities would maintain the integrity of the Western Ghats elephant landscape and enhance biodiversity conservation.

One of the locations has been identified as the past elephant corridor and the second one has been proposed as corridor for establishment by Kerala state forest department. Detailed guidelines to maintain the integrity of elephant landscape and to protect elephant corridors legally through various legislations including declaring them as "Ecological Sensitive Areas" are suggested by Government of India's elephant task force (Gajah 2010).

Tamil Nadu Forest Department is proposing Theni and Srivilliputtur Forest Divisions to be declared as a Tiger Reserve. In fact, it is appropriate for the Central Government to accept the proposal. These two divisions are contiguous with the Periyar Tiger Reserve that belongs to

Kerala. Declaring this contiguous habitat as a Tiger Reserve would strengthen the growing tiger population of the Periyar Tiger Reserve. The proposed Theni Srivilliputtur Tiger Reserve will provide more protection to this contiguous habitats for dispersal, and improved protection against poaching, ganja cultivation etc. through increased patrolling and anti-poaching. Apart from the improved tiger conservation in the Periyar Tiger Reserve, declaration of Theni and Srivilliputtur as a Tiger Reserve would also enhance the biodiversity value of the region that harbours other habitat specific endangered and endemic fauna like Nilgiri Tahr and Grizzled Giant Squirrel found in these forest divisions.

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7 References

Agasthiyarmalai Landscape Indicative Plan. PEACE Consortium, New Delhi.

Baskaran, N. (1998). Ranging and resource utilization by Asian Elephant (*Elephas maximus* Linnaeus) in Nilgiri Biosphere Reserve, South India. Ph.D., Thesis. India: Bharathidasan University.

Baskaran, N. S. Varma, C.K. Sar and R. Sukumar. (2011). Current status of Asian elephant in India. Gajah35: 47–54.

Baskaran, N., V. Kannan, K. Thiyagesan and Ajay A. Desai.(2011). Behavioural ecology of four-horned antelope (*Tetracerus quadricornis* Blainville, 1816) in the tropical forests of southern India. Journal of Mammalian Biology 76: 741–747.

Baskaran,N., M. Balasubramanian, S. Swaminathan, A.A. Desai. 1995. Home range of elephants and its implications for the management of Nilgiri Biosphere Reserve, South India. Pp. 296-313 in A week with elephants, ed J.C.Daniel and H. Datye. Bombay: BNHS, and New Delhi: Oxford University Press.

CEPF (2007), Ecosystem Profile – Western Ghats and Sri Lanka Biodiversity Hotspot, Western GhatsRegion,Critical Ecosystem Partnership Fund document. Conservation International.

Centre for International Earth Science Information Network (CIESIN), Columbia University; United Nations Food and Agriculture Programme (FAO); and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World: Future Estimates (GPWFE). Palisades, NY: Socioeconomic Data and Applications Centre (SEDAC), Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw. (22/06/2012).

Christopher, G. (1997) Human Wildlife Interaction in Peppara Wildlife Sanctuary and Adjacent areas,
Agasthiamalai Region. Unpublished PhD Thesis submitted to FRI Deemed University, Dehra Dun.

Das A, Krishnaswamy J, Bawa KS, Kiran MC, Srinivas V, Kumar NS, Karanth KU (2006). Prioritization of conservation areas in the Western Ghats, India. Biological Conservation 133,16-31.

Desai AA, Johnsingh AJT (1995) Social organization and reproductive strategy of the male Asian elephant(*Elephas maximus*). Abstract in:Daniel JC, Datye HS (eds) A week with elephants. Bombay Natural History Society and Oxford University Press, Bombay, pp 532

Desai, A. A. (1991). The home range of elephants and its implications for management of the Mudumalai Wildlife Sanctuary, Tamil Nadu. J. Bombay Nat. Hist. Soc. 88: 145–156.

Dey Gautam (2005) Reconnaissance Report for Tirunelveli Division, Tamil nadu Forest Department.

Douglas-Hamilton, I., 1972. On the ecology and behaviour of the African elephant: the elephants of Lake Manyara: DPhil, Oxford University, 268 p.

Govt of Kerala (2002) Working Plan Ranni Forest Division

Govt of Kerala (2005) Management Plan Neyyar Wildlife Sanctuary

Govt of Kerala (2005) Management Plan Peppara Wildlife Sanctuary

Govt of Kerala (2005) Management Plan, Periyar Tiger Reserve

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

http://gim.unmc.edu/dxtests/roc2.htm (visited on 12/11/2012)

IMG (2009) Service Delivery and Poverty Status in the Tribal Settlements of Tiruvananthapuram district.Institute of Management in Government, Thiruvananthapuram

IUCN 2011.The IUCN Red List of Threatened Species. Version 2012.1. http://www.iucnredlist.org.
Jensen, J R., 2007, Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Ed., Upper Saddle River, NJ: Prentice Hall, 592 pages.

Johnsingh, A.J.T. 2001. The Kalakad-Mundanthurai Tiger Reserve: A global heritage of biological diversity. Current Science. 80 (3): 378-388.

Lilles and and Kiefer, 2000: Remote sensing and image interpretation (4th Ed.) John Wiley & Sons, 724pp.

Malik, V. S. (2005) Working Plan for Theni Forest Division. Tamil Nadu Forest Department.

Menon, S., and Bawa, K.S. 1997. Applications of geographic information systems, remote-sensing, and a landscape ecology approach to biodiversity conservation in the Western Ghats. Current Science 73:134-144.

MGU (1998) Periyar Tiger Reserve-Fringe area Activities Study Report, School of Social Sciences, Mahatma Gandhi University, Kottayam.

MGU (1998) Periyar Tiger Reserve-Fringe area Activities Study Report, School of Social Sciences, Mahatma Gandhi University, Kottayam.
MGU (2000) A Socio-Economic Analysis of Paliyakudy Tribal Settlement. School of Social Sciences, Mahatma Gandhi University, Kottayam.

MGU (2000) A Socio-Economic Analysis of Vanchivayal Tribal Settlement in PTR. School of Social Sciences, Mahatma Gandhi University, Kottayam

MGU (2000) A Study on Socio-Economic Status of Mannakkudy Tribal Settlement, Thekkady.School of Social Sciences, Mahatma Gandhi University, Kottayam.

MGU (2000) A Study on Socio-Economic Status of Mannakkudy Tribal Settlement, Thekkady.School of Social Sciences, Mahatma Gandhi University, Kottayam.

MGU (2000) A Study on Socio-Economic Status of Mannakkudy Tribal Settlement, Thekkady. School of Social Sciences, Mahatma Gandhi University, Kottayam

MGU (2003) Ecological and Socio-economic studies related to Eco-development in Neyyar/ Peppara, Chinnar and Parambikulam Wildlife Sanctuaries. Report submitted to the CCF wildlife. School of Social Sciences,MGU, Kottayam.

Mittermeier, R.A., P.R. Gil, M. Hoffman, J. Pilgrim, T. Brooks, C.G. Mittermeier, J. Lamoreux, and G.A.B. DaFonseca. 2005. Hotspots Revisited: Earth's Biologically Richest and most Endangered Terrestrial Ecoregions,Cemex Mexico.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. Da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Nair, S. C (1991) The Southern Western Ghats: a biodiversity conservation Plan. INTACH, New Delhi.P 92.

PEACE Consortium (2007) Biodiversity Conservation and Rural Livelihood Improvement Project.

R. Sukumar. The living elephants: Evolutionary ecology, behaviour and conservation. Oxford University Press,New York (2003)

Ramakrishnan, U., Santosh, J.A., Ramakrishnan, U. and Sukumar, R. (1998).The population and conservation status of Asian elephants in the Periyar Tiger Reserve, southern India. Current Science 74: 110-113.

Raman, T. R. S. 2006. Effects of habitat structure and adjacent habitats on birds in tropical rainforest fragments and shaded plantations in the Western Ghats, India. Biodiversity and Conservation 15: 1577–1607.

Ramesh, B.R., S. Menon, and K.S. Bawa. 1997. A Vegetation Based Approach to Biodiversity Gap Analysis in the Agastyamalai Region, Western Ghats, India. Ambio 26:529-536.

Rao, G (2005) Management Plan for Grizzled Squirrel Wildlife Sanctuary, Srivilliputtur (2005-2010), Tamil Nadu Forest Department.P 90.

S.S Bist, 2002, "An overview of elephant conservation in India, The Indian Forester 128, Dehradune, pp.121-136.

Sukumar, R. (1989). Ecology of the Asian elephant in southern India. I. Movement and habitat utilization patterns. Journal of Tropical Ecology 5: 1-18.

Sukumar, R. (1995). Minimum viable populations for Asian elephant conservation. In: A week with elephants.

Eds. J.C. Daniel and H. Datye, Bombay Natural History Society, Bombay and Oxford University Press, New Delhi. Pp. 279-288.

Sukumar, R. (2003). Asian elephants in zoos – A response to Rees. Oryx, 37: 23-24.

Sukumar, R., Ramakrishnan, U. and Santosh, J.A. (1998). Impact of poaching on an Asian elephant population in Periyar, southern India: a model of demography and tusk harvest. Animal Conservation 1: 281-291.

TNFD (2005) A Report on Kanniyakumari Forest Division. Tamil Nadu Forest Department

Venkataraman, A. B, Sandeep R., Baskaran, N. Mukti Roy, Madhivanan, A., and Sukumar R. 2005.Using Satellite Telemetry to mitigate elephant-human conflict: An experiment in northern West Bengal, India. Current Science 88 (11): 1827-1831.

Venuprasad, H. (2001) Management Plan for Agasthiyamalai Biosphere Reserve-Thirunelveli Division. Tamil Nadu Forest Department.

Vidya, T.N.C. and Sukumar, R. (2005). Social organization of the Asian elephant (Elephas maximus) in southern India inferred from microsatellite DNA. Journal of Ethology, 23: 205-210.

Vidya, T.N.C., Fernando, P., Melnick, D.J. and Sukumar, R. (2005). Population genetic structure and
conservation of Asian elephant (Elephas maximus) across India. Animal Conservation, 8: 377-388.

Viswanathan, M. B. (2001) Biodiversity and sociological assessment and monitoring of Eco-development initiatives in KMTR, SPK Centre for Environmental Sciences, Manonmaniam Sundaranar University,Alwarkurichi. P93

8 Annexure

8.1 Species distribution data for various forest divisions

ABP Special FD					
		Source (type of survey)			
S. No	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Macaca radiata*	yes	-	-	Least concern
2	*Elephus maximus*	yes	-	-	Endangered
3	*Macaca silenus*	-	-	yes	Endangered
4	*Ratufa indica*	-	-	yes	Least concern
5	*Tragulus meminna*	yes	-	-	Least concern
6	*Cervus unicolor*	yes	-	-	Vulnerable
7	*Funambulus palmarum*	yes	-	-	Least concern
8	*Sus scrofa*	yes	-	-	Least concern
	Overall	**6**	**0**	**2**	

Achankovil					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Macaca radiata*	yes	-	-	Least concern
2	*Funambulus sublineatus*	yes	-	-	Least concern
3	*Elephus maximus*	yes	-	-	Endangered
4	*Bos gaurus*	yes	-	-	Vulnerable
5	*Panthera pardus*	yes	-	-	Near threatened
6	*Ratufa indica*	yes	-	-	Least concern
7	*Hystrix indica*	yes	yes	-	Least concern
8	*Cervus unicolor*	yes	yes	-	Least concern
9	*Melursus ursinus*	yes	-	-	Vulnerable
10	*Viverricula indica*	-	-	yes	Least concern
11	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
12	*Funambulus palmarum*	yes	-	-	Least concern
13	*Panthera tigris*	yes	-	-	Endangered
14	*Sus scrofa*	yes	-	-	Endangered
15	*Cuon alpinus*	yes	yes	-	Least concern
	Overall	13	3	2	

Kanniyakumari WLS					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Amblonyx cinereus*	-	-	yes	Vulnerable
2	*Bos gaurus*	yes	-	-	Vulnerable
3	*Cervus unicolor*	yes	yes	-	Vulnerable
4	*Cuon alpinus*	yes	-	yes	Endangered
5	*Elephus maximus*	yes	-	yes	Endangered
6	*Felis chaus*	yes	-	-	Least concern
7	*Funambulus palmarum*	yes	-	-	Least concern
8	*Hemitragus hylocrius*	yes	-	-	Endangered
9	*Loris tardigradus*	-	-	yes	Endangered
10	*Macaca radiata*	yes	-	-	Least concern
11	*Macaca silenus*	-	-	-	Endangered
12	*Manis crassicaudata*	yes	yes	-	Least concern
13	*Melursus ursinus*	-	-	yes	Vulnerable
14	*Muntiacus muntjac*	yes	-	-	Least concern
15	*Panthera pardus*	yes	yes	-	Near threatened
16	*Panthera tigris*	yes	-	yes	Endangered
17	*Viverricula indica*	-	yes	-	Least concern
18	*Ratufa indica*	yes	-	yes	Least concern
19	*Sus scrofa*	yes	-	-	Endangered
20	*Trachypithecus johnii*	yes	-	yes	Vulnerable
21	*Tragulus meminna*	yes	yes	-	Least concern
22	*Hystrix indica*	-	yes	-	Least concern
	Overall	**16**	**6**	**8**	

KMTR					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Elephus maximus*	yes	-	yes	Endangered
2	*Bos gaurus*	yes	-	-	Vulnerable
3	*Muntiacus muntjac*	yes	-	yes	least concern
4	*Trachypithecus johnii*	yes	-	yes	Vulnerable
5	*Mus famulus*	-	-	yes	Endangered
6	*Hystrix indica*	yes	yes	-	least concern
7	*Herpestes fuscus*	-	-	yes	Vulnerable
8	*Herpestes edwardsi*	yes	-	-	least concern
9	*Funambulus palmarum*	yes	-	-	least concern
10	*Paradoxurus jerdoni*	-	-	yes	least concern
11	*Amblonyx cinereus*	-	-	yes	Vulnerable
12	*Ratufa indica*	yes	-	yes	least concern
13	*Latidens salimali*	-	-	yes	Endangered
14	*Tragulus meminna*	yes	yes	yes	least concern
15	*Sus scrofa*	yes	yes	-	least concern
16	*Panthera tigris*	yes	-	yes	Endangered
17	*Hemitragus hylocrius*	yes	-	yes	Endangered
18	*Martes gwatkinsii*	-	-	yes	Vulnerable
19	*Semnopithecus entellus*	yes	-	yes	least concern
20	*Macaca silenus*	yes	-	yes	Endangered
21	*Hipposideros hypophyllus*	-	-	yes	Endangered
22	*Cervus unicolor*	yes	yes	-	Vulnerable
23	*Prionailurus rubiginosus*	-	-	yes	Near threatened
24	*Panthera pardus*	yes	yes	yes	Near threatened
25	*Viverricula indica*	-	yes	-	least concern
26	*Mus famulus*	-	-	yes	Vulnerable
27	*Lutra lutra*	-	-	yes	Vulnerable
28	*Lutrogale perspicillata*	-	-	yes	Vulnerable
29	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
30	*Melursus ursinus*	yes	yes	yes	Vulnerable
31	*Hemiechinus nudiventirs*	-	-	yes	Least concern
32	*Cuon alpinus*	yes	-	yes	Endangered
33	*Herpestes vitticollis*	yes	-	yes	Least concern
34	*Suncus dayi*	-	-	yes	Endangered
35	*Suncus montanus*	-	-	yes	Vulnerable
36	*Loris tardigradus*	-	-	yes	Endangered
	Overall	**19**	**7**	**29**	

Konni					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	-	-	Vulnerable
2	*Cervus unicolor*	yes	-	-	Vulnerable
3	*Cuon alpinus*	yes	-	yes	Endangered
4	*Elephus maximus*	yes	-	yes	Endangered
5	*Funambulus palmarum*	yes	-	-	least concern
6	*Panthera tigris*	-	-	yes	Endangered
7	*Paradoxurus hermaphroditus*	yes	-	-	least concern
8	*Ratufa indica*	yes	-	yes	least concern
9	*Sus scrofa*	Yes	-	-	least concern
10	*Trachypithecus johnii*	yes	-	-	Vulnerable
11	*Muntiacus muntjac*	yes	-	-	least concern
	Overall	**10**	**0**	**4**	

Kottayam					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	-	-	Vulnerable
2	*Cuon alpinus*	yes	-	-	Endangered
3	*Elephus maximus*	yes	-	-	Endangered
4	*Funambulus palmarum*	yes	-	-	least concern
5	*Ratufa indica*	yes	-	yes	least concern
6	*Sus scrofa*	yes	-	-	least concern
7	*Muntiacus muntjac*	yes	-	-	least concern
8	*Hystrix indica*	yes	-	-	least concern
	Overall	**8**	**0**	**1**	

Neyyar WLS					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	-	-	Vulnerable
2	*Cuon alpinus*	-	-	-	Least concern
3	*Elephus maximus*	yes	-	yes	Endangered
4	*Funambulus palmarum*	yes	-	-	Endangered
5	*Ratufa indica*	-	-	yes	Least concern
6	*Amblonyx cinereus*	-	-	yes	Vulnerable
7	*Macaca radiata*	yes	-	-	Least concern
8	*Panthera pardus*	yes	-	yes	Near threatened
9	*Lutra lutra*	-	-	yes	Vulnerable
10	*Lutrogale perspicillata*	-	-	yes	Vulnerable
11	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
	Overall	**5**	**0**	**7**	

Ranni					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	-	-	Vulnerable
2	*Cuon alpinus*	-	-	yes	Endangered
3	*Elephus maximus*	yes	-	yes	Endangered
4	*Ratufa indica*	yes	-	yes	Least concern
5	*Funambulus palmarum*	yes	-	-	Least concern
6	*Hystrix indica*	-	-	-	Least concern
7	*Funambulus sublineatus*	yes	-	-	Vulnerable
8	*Macaca radiata*	yes	-	-	Least concern
9	*Trachypithecus johnii*	yes	-	-	Vulnerable
10	*Melursus ursinus*	yes	-	-	Vulnerable
11	*Cervus unicolor*	yes	-	-	Vulnerable
12	*Hemitragus hylocrius*	yes	-	-	Endangered
13	*Paradoxurus hermaphroditus*	yes	-	-	Least concern
14	*Tragulus meminna*	yes	yes	-	Vulnerable
15	*Prionailurus rubiginosus*	-	-	yes	-
	Overall	**12**	**1**	**4**	

Cendurni WLS					
		Source (type of survey)			
S.no	**Scientific name**	**Ground**	**Camera-trap**	**Literature**	**IUCN Status**
1	*Cuon alpinus*	-	-	yes	Endangered
2	*Elephus maximus*	yes	-	yes	Endangered
3	*Ratufa indica*	yes	-	yes	Least concern
4	*Funambulus sublineatus*	yes	-	-	Vulnerable
5	*Macaca radiata*	yes	-	-	Least concern
6	*Trachypithecus johnii*	yes	-	yes	Vulnerable
7	*Melursus ursinus*	yes	-	-	Vulnerable
8	*Amblonyx cinereus*	-	-	yes	Vulnerable
9	*Lutra lutra*	-	-	yes	Near threatened
10	*Lutrogale perspicillata*	-	-	yes	Vulnerable
11	*Platacanthomys lasiurus*	-	-	yes	vulnerable
12	*Panthera tigris*	yes	-	yes	Endangered
13	*Petinomys fuscocapillus*	-	-	yes	Near threatened
14	*Loris tardigradus*	-	-	yes	Endangered
15	*Macaca silenus*	-	-	yes	Endangered
16	*Paradoxurus jerdoni*	yes	-	yes	Least concern
17	*Viverricula indica*	yes	-	-	Least concern
18	*Herpestes edwardsii*	-	yes	-	Least concern
	Overall	**9**	**1**	**13**	

Peppara WLS					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	-	-	Vulnerable
2	*Cuon alpinus*	-	-	yes	Endangered
3	*Elephus maximus*	yes	-	yes	Endangered
4	*Ratufa indica*	yes	-	yes	Least concern
5	*Amblonyx cinereus*	-	-	yes	Vulnerable
6	*Macaca radiata*	yes	-	-	Least concern
7	*Lutra lutra*	-	-	yes	Vulnerable
8	*Lutrogale perspicillata*	-	-	yes	Vulnerable
9	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
10	*Sus scrofa*	yes	-	-	Least concern
11	*Panthera tigris*	-	-	yes	Endangered
12	*Trachypithecus johnii*	-	-	yes	Vulnerable
13	*Melursus ursinus*	-	-	yes	Vulnerable
14	*Martes gwatkinsii*	-	-	yes	Vulnerable
15	*Petinomys fuscocapillus*	-	-	yes	Near threatened
16	*Loris tardigradus*	-	-	yes	Endangered
17	*Macaca silenus*	yes	-	yes	Endangered
	Overall	**6**	**0**	**14**	

Periyar TR					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Bos gaurus*	yes	yes	-	Vulnerable
2	*Cuon alpinus*	yes	yes	yes	Endangered
3	*Elephus maximus*	yes	yes	yes	Endangered
4	*Ratufa indica*	yes	-	yes	least concern
5	*Amblonyx cinereus*	-	-	yes	Vulnerable
6	*Macaca radiata*	-	-	-	least concern
7	*Lutra lutra*	yes	-	yes	Vulnerable
8	*Lutrogale perspicillata*	-	-	yes	Vulnerable
9	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
10	*Sus scrofa*	yes	-	-	least concern
11	*Panthera tigris*	yes	yes	yes	Endangered
12	*Trachypithecus johnii*	yes	-	yes	Vulnerable
13	*Melursus ursinus*	yes	-	yes	Vulnerable
14	*Martes gwatkinsii*	-	-	yes	Vulnerable
15	*Petinomys fuscocapillus*	-	-	yes	Near threatened
16	*Loris tardigradus*	-	-	-	Endangered
17	*Funambulus palmarum*	yes	-	-	least concern
18	*Panthera pardus*	yes	-	-	Near threatened
19	*Muntiacus muntjac*	yes	-	-	least concern
20	*Hystrix indica*	yes	yes	-	least concern
21	*Cervus unicolor*	yes	yes	-	Vulnerable
22	*Felis chaus*	yes	yes	-	least concern
23	*Hemitragus hylocrius*	yes	-	yes	Endangered
24	*Macaca silenus*	yes	-	yes	Endangered
25	*Herpestes edwardsii*	yes	-	-	least concern
26	*Herpestes fuscus*	-	-	yes	least concern
27	*Latidens salimali*	-	-	yes	Endangered
28	*Paradoxurus jerdoni*	-	-	yes	least concern
29	*Semnopithecus entellus*	yes	-	-	least concern
30	*Viverricula indica*	yes	-	-	least concern
31	*Funambulus sublineatus*	yes	-	-	Vulnerable
32	*Herpestes vitticollis*	yes	-	-	least concern
33	*Tragulus meminna*	-	yes	-	least concern
	Overall	**22**	**8**	**17**	

Srivilliputtur WLS					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Melursus ursinus*	yes	-	-	Least concern
2	*Sus scrofa*	yes	-	-	Least concern
3	*Bos gaurus*	yes	yes	-	Near threatened
4	*Trachypithecus johnii*	yes	-	-	Vulnerable
5	*Elephus maximus*	yes	yes	yes	Endangered
6	*Muntiacus muntjac*	yes	-	-	Vulnerable
7	*Tragulus meminna*	yes	-	-	Endangered
8	*Ratufa indica*	yes	-	-	Least concern
9	*Lutra lutra*	yes	-	-	Vulnerable
10	*Ratufa macroura*	yes	-	yes	Endangered
11	*Semnopithecus entellus*	yes	-	-	Least concern
12	*Axis axis*	yes	-	-	Vulnerable
13	*Paradoxurus hermaphroditus*	yes	-	-	Endangered
14	*Panthera tigris*	yes	-	-	Vulnerable
15	*Panthera pardus*	yes	-	-	Least concern
16	*Macaca silenus*	yes	-	-	Vulnerable
17	*Funambulus palmarum*	yes	-	-	Vulnerable
18	*Hystrix indica*	yes	-	-	Vulnerable
19	*Herpestes edwardsii*	yes	-	-	Least concern
20	*Cervus unicolor*	yes	-	-	Endangered
21	*Hemitragus hylocrius*	yes	-	yes	Near threatened
22	*Cuon alpinus*	yes	-	-	Endangered
23	Sus scrofa	yes	yes	-	Least concern
	Overall	**23**	**3**	**3**	

Theni					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Axis axis*	yes	-	-	Least concern
2	*Bos gaurus*	yes	-	-	Vulnerable
3	*Cervus unicolor*	yes	-	-	Vulnerable
4	*Cuon alpinus*	yes	-	-	Endangered
5	*Elephus maximus*	yes	yes	yes	Endangered
6	*Felis chaus*	yes	-	-	Least concern
7	*Funambulus sublineatus*	yes	-	-	Vulnerable
8	*Hemitragus hylocrius*	yes	-	-	Endangered
9	*Herpestes fuscus*	-	-	yes	Least concern
10	*Hystrix indica*	yes	-	-	Least concern
11	*Loris tardigradus*	-	-	yes	Endangered
12	*Lutrogale perspicillata*	-	-	yes	Vulnerable
13	*Macaca radiata*	-	-	-	Least concern
14	*Macaca silenus*	yes	-	yes	Endangered
15	*Martes gwatkinsii*	-	-	yes	Vulnerable
16	*Melursus ursinus*	yes	-	-	Vulnerable
17	*Muntiacus muntjac*	yes	-	-	Least concern
18	*Panthera pardus*	yes	-	-	Near threatened
19	*Panthera tigris*	yes	-	-	Endangered
20	*Paradoxurus jerdoni*	yes	-	-	Least concern
21	*Ratufa indica*	yes	-	yes	Least concern
22	*Ratufa macroura*	yes	-	-	Near threatened
23	*Semnopithecus entellus*	yes	-	-	Least concern
24	*Sus scrofa*	-	-	-	Least concern
25	*Trachypithecus johnii*	yes	-	-	Vulnerable
26	*Tragulus meminna*	yes	-	-	Least concern
27	*Viverricula indica*	-	yes	-	Least concern
	Overall	**20**	**2**	**7**	

Thenmalai					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Cuon alpinus*	yes	-	yes	Endangered
2	*Elephus maximus*	yes	-	yes	Endangered
3	*Funambulus sublineatus*	yes	-	-	Vulnerable
4	*Herpestes edwardsii*	yes	-	-	Least concern
5	*Hystrix indica*	yes	-	-	Least concern
6	*Macaca silenus*	-	-	yes	Endangered
7	*Panthera tigris*	-	-	yes	Endangered
8	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
9	*Ratufa indica*	yes	-	yes	Least concern
10	*Sus scrofa*	yes	-	-	Least concern
11	*Viverricula indica*	yes	-	-	Least concern
12	*Cervus unicolor*	-	yes	-	Vulnerable
	Overall	**8**	**1**	**6**	

Tirunelveli					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Amblonyx cinereus*	-	-	yes	Vulnerable
2	*Antelope cervicapra*	-	-	yes	Endangered
3	*Axis axis*	yes	-	-	Least concern
4	*Bos gaurus*	yes	-	-	Vulnerable
5	*Cervus unicolor*	yes	-	-	Vulnerable
6	*Cuon alpinus*	yes	yes	-	Endangered
7	*Elephus maximus*	yes	yes	yes	Endangered
8	*Hemitragus hylocrius*	yes	-	yes	Endangered
9	*Herpestes fuscus*	-	-	yes	Least concern
10	*Hipposideros hypophyllus*	-	-	yes	Endangered
11	*Latidens salimali*	-	-	yes	Endangered
12	*Loris tardigradus*	-	-	yes	Endangered
13	*Lutrogale perspicillata*	-	-	yes	Vulnerable
14	*Macaca silenus*	-	-	yes	Endangered
15	*Martes gwatkinsii*	-	-	yes	Vulnerable
16	*Melursus ursinus*	yes	-	yes	Vulnerable
17	*Panthera tigris*	-	-	yes	Endangered
18	*Paradoxurus jerdoni*	-	-	yes	Least concern
19	*Platacanthomys lasiurus*	-	-	yes	Vulnerable
20	*Prionailurus rubiginosus*	-	-	yes	Vulnerable
21	*Ratufa indica*	yes	-	yes	Least concern
22	*Sus scrofa*	yes	-	-	Least concern
23	*Tetracerus quadricornis*	-	-	yes	Vulnerable
24	*Trachypithecus johnii*	-	-	yes	Vulnerable
25	*Viverra civettina*	-	-	yes	Critically endangered
26	*Viverricula indica*	yes	yes	-	Least concern
	Overall	**10**	**3**	**20**	

Thiruvananthapuram T					
		Source (type of survey)			
S.no	Scientific name	Ground	Camera-trap	Literature	IUCN Status
1	*Cuon alpinus*	yes	yes	yes	Endangered
2	*Elephus maximus*	yes	-	yes	Endangered
3	*Hemitragus hylocrius*	yes	-	yes	Endangered
4	*Hystrix indica*	yes	-	-	Least concern
5	*Macaca silenus*	-	-	yes	Endangered
6	*Martes gwatkinsii*	-	-	yes	Vulnerable
7	*Melursus ursinus*	-	-	yes	Vulnerable
8	*Panthera tigris*	-	-	yes	Endangered
9	*Ratufa indica*	yes	-	yes	Least concern
10	*Trachypithecus johnii*	-	-	yes	Vulnerable
11	*Cervus unicolor*	-	yes	-	Vulnerable
12	*Sus scrofa*	-	yes	-	Least concern
	Overall	**5**	**3**	**9**	

8.2 Check list of mammals in P-A landscape, along with Order, Family and endemism status.

S. No	Common name	Scientific name	IUCN status	Endemic status
Order: Eulipotyphla				
	Family: Erinaceidae			
1	Madras hedgehog	*Hemiechinus nudiventirs*	Least concern	WG
	Family: Soricidae			
2	Day's shrew	*Suncus dayi*	Endangered	WG
3	Hill shrew	*Suncus montanus*	Vulnerable	WGSL
4	House Shrew	*Suncus murinus*	Least concern	-
5	Pygmy White-toothed Shrew	*Suncus etruscus*	Least concern	-
Order: Chiroptera				
	Family: Pteropodidae			
6	Salim Ali's fruit bat	*Latidens salimali*	Endangered	-
7	Fulvous fruit bat	*Rousettus leschenaulti*	Least concern	-
8	Indian flying fox	*Pteropus giganteus*	Least concern	-
9	Lesser dog-faced fruit bat	*Cynopterus brachyotis*	Least concern	-

10	Short-nosed fruit bat	*Cynopterus sphinx*	Least concern	-
	Family: Rhinopomatidae			
11	Lesser mouse-tailed bat	*Rhinopoma hardwickii*	Least concern	-
	Emballonuridae			
12	Black-bearded tomb bat	*Taphozous melanopogon*	Least concern	-
13	Bare-rumped Sheathtail-bat	*Saccolaimus saccolaimus*	Least concern	-
	Family: Megadermatidae			
14	Greater false vampire	*Megaderma lyra*	Least concern	-
15	Lesser false vampire	*Megaderma spasma*	Least concern	-
	Family: Rhinolophidae			
16	Rufous horseshoe bat	*Rhinolophus rouxii*	Least concern	-
17	Blyth's horseshoe bat	*Rhinolophus lepidus*	Least concern	-
18	Lesser woolly horseshoe bat	*Rhinolophus beddomei*	Least concern	-
	Family: Hipposideridae			
19	Leafleted leaf-nosed bat	*Hipposideros hypophyllus*	Endangered	WG
20	Dusky leaf-nosed bat	*Hipposideros ater*	Least concern	-
21	Fulvous leaf-nosed bat	*Hipposideros fulvus*	Least concern	-
22	Schneider's leaf-nosed bat	*Hipposideros speoris*	Least concern	-
	Family: Vespertilionidae			
23	Least Pipistrelle	*Pipistrellus tenuis*	Least concern	-
24	Painted bat	*Kerivoula picta*	Least concern	-
Order: Primates				
	Family: Lorisidae			
25	Red Slender Loris	*Loris tardigradus*	Endangered	-
	Family: Cercopithecidae			
26	Bonnet Macaque	*Macaca radiata*	Least concern	-
27	Line tial macaque	*Macaca silenus*	Endangered	WG
28	Northern Plains Gray Langur	*Semnopithecus entellus*	Least concern	-
29	Nilgiri langur	*Trachypithecus johnii*	Vulnerable	WG
Order: Carnivora				
	Family: Canidae			
30	Wild dog	*Cuon alpinus*	Endangered	-
31	Golden Jackal	*Canis aureus*	Least concern	-
32	Bengal fox	*Vulpes bengalensis*	Least concern	-
	Family: Ursidae			
33	Sloth bear	*Melursus ursinus*	Vulnerable	-
	Family: Mustelidae			
34	Eurasian Otter	*Lutra lutra*	Near threatened	-
35	Small-clawed otter	*Amblonyx cinereus*	Vulnerable	-

36	Smooth coated otter	*Lutrogale perspicillata*	Vulnerable	-
37	Nilgiri marten	*Martes gwatkinsii*	Vulnerable	WG
	Family: Viverridae			
38	Common Palm Civet	*Paradoxurus hermaphroditus*	Least concern	-
39	Brown palm civet	*Paradoxurus jerdoni*	Least concern	WG
40	Malabar civet	*Viverra civettina*	Critically endangered	WG
41	Small Indian civet	*Viverricula indica*	Least concern	-
	Family: Herpestidae			
42	Common mongoose	*Herpestes edwardsii*	Least concern	-
43	Indian Brown Mongoose	*Herpestes fuscus*	Vulnerable	-
44	Stripe necked mongoose	*Herpestes vitticollis*	Least concern	-
45	Ruddy mongoose	*Herpestes smithii*	Least concern	-
	Family: Felidae			
46	Leopard	*Panthera pardus*	Near threatened	-
47	Tiger	*Panthera tigris*	Endangered	-
48	Rusty spotted cat	*Prionailurus rubiginosus*	Vulnerable	-
49	Leopard cat	*Prionailurus bengalensis*	Least concern	-
50	Jungle cat	*Felis chaus*	Least concern	-
Order: Proboscidea				
	Family: Elephantidae			
51	Elephant	*Elephus maximus*	Endangered	-
	Order: Cetartiodactyla			
	Family: Suidae			
52	Wild boar	*Sus scrofa*	Least concern	-
	Family: Tragulidae			
53	Indian Mouse Deer	*Moschiola meminna*	Least concern	-
	Family: Cervidae			
54	Spotted deer	*Axis axis*	Least concern	-
55	Sambar deer	*Cervus unicolor*	Vulnerable	-
56	Southern Red Muntjac	*Muntiacus muntjak*	Least concern	-
	Family: Bovidae			
57	Black buck	*Antelope cervicapra*	Endangered	-
58	Indian gaur	*Bos gaurus*	Vulnerable	-
59	Nilgiri tahr	*Hemitragus hylocrius*	Endangered	WG
60	Four horn antelope	*Tetracerus quadricornis*	Vulnerable	-
Order: Pholidota				
	Family: Manidae			
61	Indian pangolin	*Manis crassicaudata*	Least concern	-
Order: Rodentia				

	Family: Sciuridae			
62	Three striped palm squirrel	*Funambulus palmarum*	Least concern	-
63	Dusty stripped squirrel	*Funambulus sublineatus*	Vulnerable	-
64	Travancore flying squirrel	*Petinomys fuscocapillus*	Near threatened	WGSL
65	Indian Giant Squirrel	*Ratufa indica*	Least concern	WG
66	Grizzled giant squirrel	*Ratufa macroura*	Near threatened	WGSL
67	Jungle striped squirrel	*Funambulus tristriatus*	Least concern	-
68	Indian giant flying squirrel	*Petaurista philippensis*	Least concern	-
	Family: Muridae			
69	Servant mouse	*Mus famulus*	Endangered	WG
70	Pale Field Rat	*Rattus tunneyi*	Least concern	-
71	Indian gerbil	*Tatera indica*	Least concern	-
72	Indian gerbil	*Tatera indica*	Least concern	-
73	White-bellied wood rat	*Rattus rattus*	Least concern	-
74	Indian bush rat	*Golunda ellioti*	Least concern	-
75	Soft-furred field rat	*Millardia meltada*	Least concern	-
76	White-tailed wood rat	*Cremnomys blanfordi*	Least concern	-
77	Indian field mouse	*Mus booduga*	Least concern	-
78	Spiny field mouse	*Mus platythrix*	Least concern	-
79	Asiatic Long-tailed Climbing Mouse	*Vandeleuria oleracea*	Least concern	-
80	Lesser bandicoot rat	*Bandicota bengalensis*	Least concern	-
81	Large bandicoot rat	*Bandicota indica*	Least concern	-
82	Malabar Spiny Dormouse	*Platacanthomys lasiurus*	Vulnerable	-
	Family: Hystricidae			
83	Indian Crested Porcupine	*Hystrix indica*	Least concern	-
Order: Lagomorpha				
	Family: Leporidae			
84	Black-naped Hare	*Lepus nigricollis*	Least concern	

8.3 Grizzled giant squirrel population density estimates to the forest and non - forest area

Parameter	Density/km^2	Percent CV	95% Percent CV		Overall density
			LCL	UCL	
Reserve forest direct sighting					
DS	32.9 ± 5.18	15.74	23.68	45.82	340
E(S)	1.18 ± 0.10	8.6	1	1.42	-
D	39.05 ± 7.00	17.94	27.09	56.29	403
Plantation forest direct sighting					
DS	22.5 ± 2.17	9.69	18.47	27.35	299
E(S)	1.1 ± 0.02	2.7	1	1.11	-
D	23.8 ± 2.39	10.06	19.43	29.15	316
Reserve forest nest sighting					
DS	118.6 ± 9.21	7.76	101.71	138.41	409*
E(S)	1.4 ± 0.06	4.11	1.26	1.49	-
D	162.7 ± 14.29	8.78	136.76	193.44	560*
Plantation forest nest sighting					
DS	85.9 ± 4.79	5.58	76.97	95.94	571*
E(S)	1.1 ± 0.02	2.11	1.09	1.19	-
D	98.2 ± 5.85	5.96	87.27	110.4	652*

DS.Group density, E(S). Group size, D. Individual density, * Nest density convert to Squrriel density

8.4 Grizzled giant squirrel damaged by plantation trees in srivilliputtur division

	Types of plantation		
Parameter	**Coconut**	**Mango**	**Tamarind**
Sample area (ha)	15.38	24.14	3.64
Total no of tree /ha (n)	55.8±44.2	18.9±5.6	10.3±3.2
Total no of fruits/ha	125.0±45.9	54.5±18.1	46.6±11.5
No. of damage fruits/tree	5.2 ± 0.89	11.2 ± 1.58	72.5 ± 18.98
Mean weight of fruits /unit	1	0.4	0.07
Cost of fruits/unit	5±0.4	9±0.5	14±1.8
Total damage fruits /ha (kg)	145.6	106.4	62.2
Total economic loss /ha	728	957.6	871

8.5 Tree species compositions for grizzled giant squirrel distribution and Non-distribution areas

Parameters	Distribution	Non-distribution
Sample size(n)	160	90
# stems	2013	1286
Tree species density /plot	315 ± 11.78	357 ± 13.17
Tree species GBH / stem	113 ± 8.3	60 ± 1.3
Tree species diversity/ plot	1.1388 ± 0.04	1.3599 ± 0.05
Tree species richness	101	77

8.6 Tree species character for grizzled giant squirrel distribution and Non-distribution areas

Tree character	Distribution	Non-distribution
Sample (n)	117	136
Richness Sp.	44	46
Tree species GBH (Mean ± SE)	175.6 ± 11.42	112.9 ± 6.42
Tree species height (Mean ± SE)	30.5 ± 1.32	17.2 ± 0.82
Tree species number of branches (Mean ± SE)	3.7 ± 0.18	5.1 ± 0.25
Tree species canopy height (Mean ± SE)	23.1 ± 1.34	14.0 ± 0.90
Tree species canopy shape circular (%)	53.8	59.09
Tree species canopy shape irregular (%)	30.8	34.09
Tree species canopy shape oval (%)	15.4	6.82
Canopy continuity (%) in all direction (Mean ± SE)	77.4 ± 2.37	51.7 ± 2.7
Canopy continuity 10m (%) in all direction (Mean ± SE)	70.7 ± 2.67	33.2 ± 3.26

8.7 Grizzled giant squirrel nesting and nesting tree characters in distribution area.

Parameters (n=204)	**Mean ± SE**
Nesting tree height(m)	38.7 ± 0.60
Nesting tree GBH (cm)	322.8 ± 8.88
Nesting tree canopy volume height (m)	33.4 ± 0.65
Nesting height(m)	31.6 ± 0.59
Nesting length(cm)	54.5 ±2.98
Nesting width (cm)	21.7 ± 0.91
Type of primary nesting	20 ± 2.5
Type of secondary nesting	10 ± 0.9
No. of branches involved nest consecutions	3.6 ± 0.12
No. of branches distance to main stem (m)	6.6± 0.31
Nearest nest branch distance	1.9 ± 0.10
Nest consecution for primary branch	15.2 ± 1.54
Nest consecution for secondary branch	4.6 ± 0.52
Nest consecution for territory branch	21.5 ± 2.13
Canopy volume length (m)	28.6 ± 0.61
Canopy volume width (m)	19.7 ± 0.37
Canopy contiguity all directions (%)	68.5 ± 1.81
Canopy contiguity (10 m) all directions (%)	66.9 ± 1.91
Canopy shape circular (%)	25.5
Canopy shape oval (%)	38.7
Canopy shape irregular (%)	35.8
Anthropogenic pressure (%)	18.1

8.8 Disseminnation of Data

We have made arrangements to disseminate the data obtained from the current project to various stakeholders in the Western Ghats. Below are two initiatives taken by us in this direction.

Introduction: The Western Ghats (WG) is one of the 34 global hotspots of biodiversity, simultaneously it is the hotspot with the highest human densities. The forests of the WG, are some of the best representatives of non equatorial tropical evergreen forests in the world. Nearly 63% of India's arborescent evergreen taxa are endemic to the WG. Apart from plants, taxonomic groups such as reptiles, mollusks, and amphibians exhibit high levels of endemism, > 50% of species in these taxa are endemic to the WG. With the identification of the Western Ghats as a hotspot of biodiversity there has been an explosion of studies to assess the past and present status of species and ecosystems. However, despite the opportunities provided by these studies there still remains a concern about the present status of biodiversity in the Western Ghats, and the ability to predict the response of biodiversity to local and global environmental change.

One of the major challenges to conservation has been the lack of spatial data on species, environmental information, socio-economic data that could be freely available to various stakeholders in the WG. Further, there is considerable variability in the methods employed, and the temporal and spatial scale at which they are executed. The data, information, and knowledge generated by these studies essential for assessing and prioritizing biodiversity conservation needs in the Western Ghats is not publicly available. From the data gathered by ANCF (Baskaran et al. 2012), we have compiled spatial data on mammalian species distribution in the Periyar-Agasthyamalai landscape. Below is the summary and metadata associated with the creation of this spatial database.

Summary: This is a database on the distribution of mammal species in the Periyar-Agasthyamalai landscape in the southern Western Ghats as assessed by a survey conducted in the year 2010-2011.

Method: To document the mammalian species a rapid survey was conducted supplemented by camera traps. The rapid survey method took into account both direct sighting of mammal species and their indirect evidences. The indirect evidences such as droppings, pug/hoof/pad marks and feeding signs were mainly used to identify presence or absence of mammal species. The forest ranges were treated as sampling units for rapid survey. In each range, an average of four man days of sampling was carried out and in case of larger ranges (>100 km^2) sampling effort increased for two additional man days. At every direct sighting (includes camera traps) or indirect evidences of mammal species, the subject was first photographed (when possible), and the species name recorded. Also recorded were number of individuals, the sighting location (latitude and longitude) and land use/landcover parameters were collected. This data was then populated into 2 km x 2 km grids for the entire landscape.

This data has been published in ArcGIS online portal at below given URL http://www.arcgis.com/home/item.html?id=0bf39b5029e34de68aa00e8c829b4210

This has been submitted to The Western Ghats portal also.

*Metadata_Layer

layer_name :Mammalian distribution in the Periyar-Agasthyamalai Landscape

layer_tablename :: Mammalian_distribution.dbf

layer_description : Map of themammal distribution in the Periyar-Agasthyamalai Landscape

status : 1

created_by :Dr.Avinash K G, Asian Nature Conservation Foundation

created_date : 2011

min_scale :1:10,000

max_scale :1:1,250,000 (can be seen beyond this scale, but with compromise on quality)

aggregation :Dr N. Baskaran et.al/ ANCF, 2012

attribution :ANCF/ Dr N. Baskaran,

license : (by) Asian Nature Conservation Foundation

lineage :

tags : Western Ghats, Periyar-Agasthyamalai, mammals

comments :

access : 0

layer_type : POLYGON

summary_columns :NI (number of individuals in the grid)

editable_columns :none

is_filterable : 0

filter_columns :

search_columns : all

color_by :Any column

AREA: Area (sq.km): 4 sqkm (grid size)

Total number of grids: 4914

Number of grids with animal sightings: 216

theme_id :species_t

attributes :

species_i: string

species_ids: string

species_tot: integer

geo_id : Western Ghats

geographical_extent:

upper latitude: 9.847171 dd

lower_latitude: 8.196173 dd

left_longitude: 76.833150 dd

right_longitude: 77.825620 dd

projection: WGS_84

Representation in table: Species code_d/ids/tot*

Example: ae_d(ant eater direct sighting).

Species	Species code	Endemic	Order	Family	IUCN
Ant Eater	ae		Pholidota	Manidae	Near Threatened
Barking Deer	bd		Artiodactyla	Cervidae	Least Concern
Brown Palm Civet	bpc	Endemic	Carnivora	Viverridae	Least Concern
Common Langur	cl		Primates	Cercopithecidae	Least Concern
Common Otter	co		Carnivora	Mustelidae	Near Threatened
Dusky Striped Squirrel	dss		Rodentia	Sciuridae	Vulnerable
Elephant	ele		Proboscidea	Elephantidae	Endangered
Grizzled Giant Squirrel	ggs	Endemic	Rodentia	Sciuridae	Near Threatened
Indian Gaur	ig		Artiodactyla	Bovidae	Vulnerable
Indian Grey Mongoose	igm		Carnivora	Herpestidae	Least Concern
Indian Palm Civet	ip		Carnivora	Viverridae	Least Concern
Jungle Cat	jc		Carnivora	Felidae	Least Concern
Leopard	lp		Carnivora	Felidae	Near Threatened
Lion Tailed Macaque	ltm	Endemic	Primates	Cercopithecidae	Endangered
Malabar Giant Squirrel	mgs	Endemic	Rodentia	Sciuridae	Least Concern
Mouse Deer	md		Artiodactyla	Tragulidae	Least Concern
NilgiriLangur	nl	Endemic	Primates	Cercopithecidae	Least Concern
NilgiriTahr	nt	Endemic	Artiodactyla	Bovidae	Endangered
Porcupine	pp		Rodentia	Hystricidae	Least Concern

Rusty Spotted Cat	rsc	Endemic	Carnivora	Felidae	Vulnerable
Sambar	sam		Artiodactyla	Cervidae	Vulnerable
Sloth Bear	sb		Carnivora	Ursidae	Vulnerable
Small Indian Civet	sic		Carnivora	Viverridae	Least Concern
Spotted Deer	sd		Artiodactyla	Cervidae	Least Concern
Stripe Necked Mongoose	snm		Carnivora	Herpestidae	Least Concern
Three Striped Palm Squirrel	tsps		Rodentia	Sciuridae	Least Concern
Tiger	t		Carnivora	Felidae	Endangered
Wild Boar	wb		Artiodactyla	Suidae	Least Concern
Wild Dog	wd		Carnivora	Canidae	Endangered

NI	Number of individuals in the grid
lulc	Landuse/landcover

Suffix *	
d	direct sighting
id	indirect sighting
t	total individuals

8.9 Photo gallery

The following photographs were taken during the project period in the P-A landscape and provides the reader with glimpses on different forest types, species, and threats to biodiversity in the landscape.

Landscape of PA

Croplands adjoining mixed deciduous forest

Scrub along with mixed deciduous forests

Grasslands with mixed deciduous forests

Grasslands

Grassland overlooking human habitation in the plains

Mixed deciduous and evergreen forests

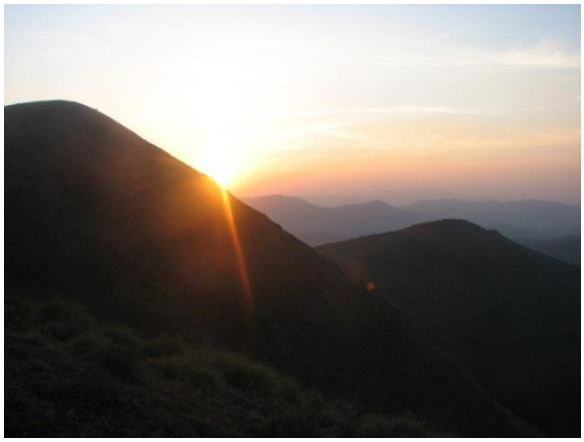
Mixed deciduous and evergreen forests

Shola Grassland

Shola grasslands

Shola grasslands

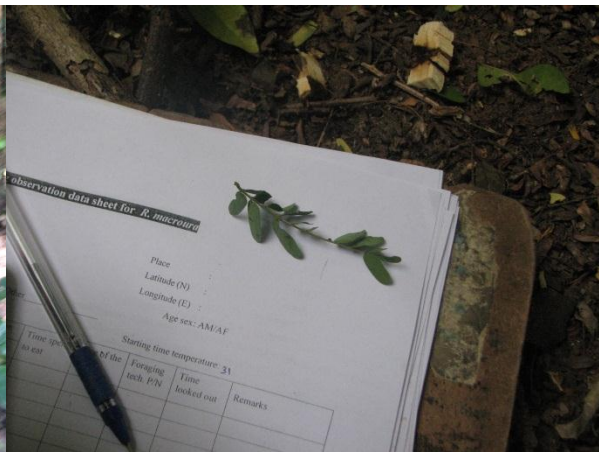
Panoramic view of the vegetation of the landscape.



Panoramic view.

Field

A camera trap



Model of Data sheet used

Pugmark

Pugmark

Pugmark

Pellets

Mammals sighted during rapid survey

Grizzled Squirrel

Three – Striped Palm Squirrel

Nilgiri Langur

Wild Boar

Nilgiri Thar

Muntjac or Barking Deer

Spotted Deer

Sambar

Gaur (Male)

Gaur (Females)

Asian Elephant

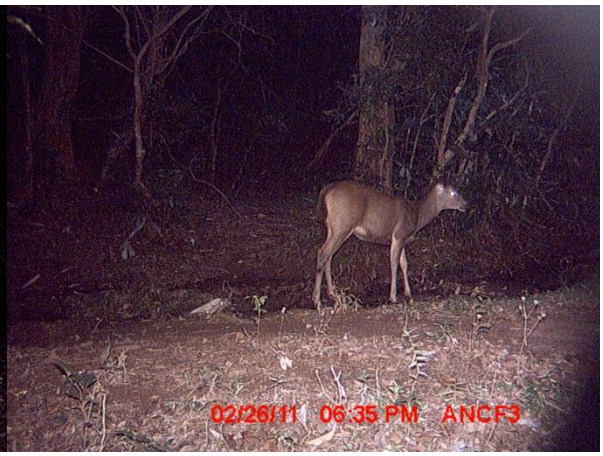
Asian Elephant

Camera trap captures

Asian Elephant

Gaur

Sambar (Male)



Sambar (Female)

Wild Boar

Indian Porcupine

Indian Pangolin.

Civet

Black Naped Hare

Sloth Bear

Wild Dog (Dhole)

Leopard

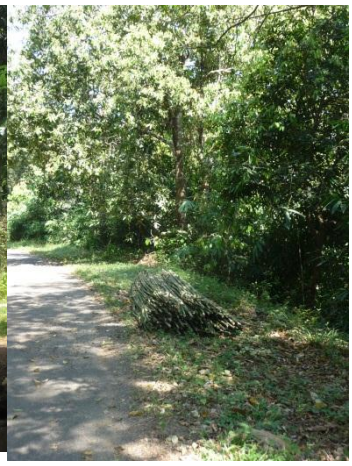
Tiger

Field

Data collection in the field

Exploring the landscape through vehicle

Human pressures on the landscape



NTFP collection

Human modifications and barriers

Tea Estate

Tea Estate

Railway Line , bridges and road

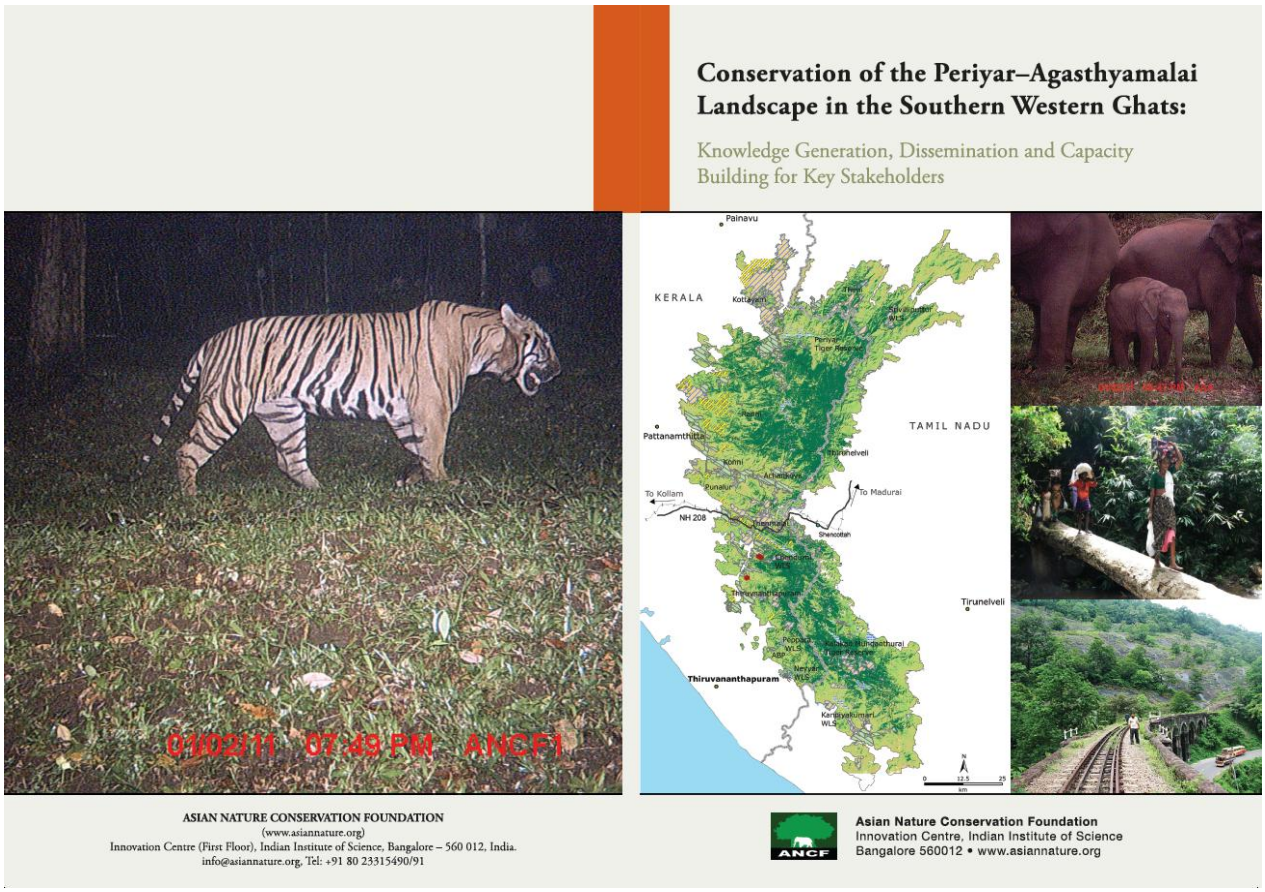
Road

Road

8.10 Other resource materials

This manual for schools has been produced as part of the same project. It is intended to help children, teachers and others to explore the wild, green and fascinating Periyar Agasthyamalai Landscape of the Western Ghats. It is a mixture of information, fun and learning, encouraging children to ask questions and to look for answers themselves through observation and shared stories.

Contact ANCF for more details


Conservation of the Periyar–Agasthyamalai Landscape in the Southern Western Ghats:
Knowledge Generation, Dissemination and Capacity Building for Key Stakeholders
01/02/11 07:49 PM ANCF1
KERALA
TAMIL NADU
Palnavu
Pattanamthitta
To Kollam
NH 208
To Madurai
Tirunelveli
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