Mammalian diversity, distribution, and potential key conservation areas in the Western Ghats: an update

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An updated list confirms the presence of 134 species of wild mammals in the Western Ghats. The superimposed distribution range of all, and threatened, species of mammals depicts the potential mammalian key diversity areas for the Western Ghats which can be prioritized for long-term conservation. These mammalian key diversity areas are confined to the central and the southern Western Ghats. The most crucial key diversity areas for
both threatened and all mammalian species occur in Pushpagiri-Talakaveri, the Nilgiri Biosphere, the Anamalai Hills, the Periyar landscape, and the Agastyamalai Hills.

**Keywords** Mammal, Conservation, Sahyadris, threatened, Western Ghats

Planning conservation and management of animal/plant species and the landscapes they inhabit requires prioritization so that the stated conservation goals are achieved efficiently. Within this perspective, Myers et al.\(^1\) prioritized different regions of the Earth for biodiversity that they considered as ‘biodiversity hotspots’. Initially, they came up with 25 hotspots, which was later expanded to 36 hotspots by Conservation International, which included four regions of India, i.e., “the Himalaya”, forests of the north-east and Andaman group of islands under “the Indo-Burma”, the Western Ghats under “the Western Ghats and Sri Lanka”, and the Nicobar Islands under “the Sundaland”.

The terrestrial area of the Earth was also prioritized for conservation of mammals by Ceballos and Ehrlich\(^2\) considering three parameters, viz., species richness, number of restricted-range species, and number of threatened species. Though the overall richness and the diversity of restricted-range species in the Western Ghats of India are less than in many other global biodiversity hotspots, the high richness of threatened species and endemic species elevates the importance of the Western Ghats as a globally important mammalian hotspot\(^2\).

Although the prioritization of the terrestrial areas of the Earth was achieved by keeping the biodiversity of mammals, the prioritization of the same within each of the hotspots is equally important to manage the hotspot efficiently. Among the global hotspots, the forests of the Western Ghats are highly threatened due to the high density of human population\(^3\) and anthropogenic activities. The prioritization of areas for conservation and development of the protected area network was attempted in the Western Ghats by considering threatened and endemic plants, vertebrate species, forest contiguity, and vegetation types\(^4\). They identified several pockets as irreplaceable and projected further expansion of protected areas to cover these areas for better protection. The Gadgil Commission\(^5\) advocated that the entire area of the Western Ghats should be declared as an Ecologically Sensitive Area (ESA) whereas the Kasturirangan\(^6\) committee reduced it to 37% to balance the economic, developmental, and
conservation priorities. Presently, there are two Biosphere Reserves, 10 National Parks, and 37 Wildlife Sanctuaries and Reserved Forests in the region. Although the checklist of mammals was prepared earlier by Nameer et al.\textsuperscript{7} based on the available knowledge and distribution provided in the IUCN Red List, identification of the important areas for mammalian conservation was not attempted for the Western Ghats. Since the forests of the entire Western Ghats fall under different states (Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, and Gujarat) and many administrative divisions, managing forests and providing protection becomes a serious concern. To prioritize the conservation efforts, here we compile the updated information on the distribution of mammals in the Western Ghats and identify the important areas using the richness of, all and threatened mammalian species.

**Analysis**

The Western Ghats, a series of hill ranges with a length of about 1600 km from north to south and with an east to west width of 30-80 km, run parallel to the western coast of southwestern India\textsuperscript{8}. The hill system has been classified as comprising ecological zones \textit{viz.}, wet evergreen forests, dry evergreen climax forests, and deciduous climax forests\textsuperscript{9}. High variation in altitude and rainfall resulted in a wide variety of forest types. In brief, the forests of the Ghats include tropical evergreen forests on the western slopes and the ridges, and deciduous and scrub forests on the rain shadow areas of the eastern slopes of the hill system that supports a wide array of species.

We updated the list of mammals for the Western Ghats, taking into consideration the recent knowledge on their distribution and taxonomy. We have provided the status of the species as per the IUCN Red List and the Indian Wildlife Protection Act-1972. We downloaded the shape file of the distribution maps (geographic range) from the International Union for Conservation of Nature and Natural Resources (IUCN Red List) for all the species that range in the Western Ghats. We further updated the range map with the recent findings from published literature and created the shape files for each species known to occur in the Western Ghats.

We downloaded the shapefile of the Western Ghats boundary from India Biodiversity Portal-The Western Ghats (http://thewesternghats.indiabiodiversity.org). We overlaid the 10 km\textsuperscript{2} grid cells
on the Western Ghats boundary and considered each grid cell as a minimum unit of sampling. The geographical range map of all the species, and a separately assorted range map of threatened species (all species considered as ‘Endangered’, ‘Critically Endangered’, ‘Vulnerable’, and ‘Near Threatened’ by the International Union for the Conservation of Nature and Natural Resources), were superimposed on these grid cells, and the grid cells were scored as a total number of species range covering that cell, which we considered as species richness, and threatened species richness. The grid cell score was then used to identify areas of the Western Ghats that were likely to have the highest concentration of species and threatened species. For total species, the cells having more than 70% of total species were considered the priority areas. For threatened species, the cells with 8 to 17 species (25-50% of species) were considered moderately important, and with ≥ 18 species (> 50% of species) were considered high priority areas, and these were accordingly plotted on the map based on the score from the richness data of each grid cell. The creation of all shapefiles with updating with the recent findings, gridding, scoring of the grid cells, and mapping of the important areas for total species and for threatened species richness was done in QGIS.

Comments on the species occurrence and the number of species in the Western Ghats

Using the data from a status assessment made for each species during a workshop in the 1997 ‘Conservation Assessment and Management Plan (CAMP)’, Nameer et al.\(^7\) projected 135 species of mammals to occur in the Western Ghats. Nameer\(^10\) created a database for mammals in the Western Ghats in 2020, where 121 species were reported. We updated this mammal list with the current nominal distribution range depicted on the IUCN Red List website and using the recent explorations and findings which clarify the status of some mammalian species (Table 1).

Rhesus Macaque \textit{Macaca mulatta} occurs at the northern tip of the Ghats, though many groups are known to be introduced in different parts of northern Western Ghats\(^11\). The updates on the occurrence of Hanuman Langurs \textit{Semnopithecus} sp. show the occurrence of two species of Hanuman Langurs, i.e., Black-footed Gray Langur \textit{S. hypoleucus} and Gray-tufted Langur \textit{S. priam} in the Western Ghats\(^12\)-\(^14\). We added the Rhesus Macaque and two species of langurs instead of one species of Hanuman Langur to the list for Primates.

Among carnivores, the occurrence of Malabar Civet \textit{Viverra civettina} and Fishing Cat \textit{Prionailurus viverrinus} in the Western Ghats is debatable. Malabar Civet was thought to occur in
the western slopes of the Western Ghats\textsuperscript{15,16}, however, Nandini and Mudappa\textsuperscript{17} suspect the existence of the species of Malabar Civet itself. The Fishing Cat was thought to occur along the west coast. However, the lack of evidence for the occurrence of a species in several surveys raises doubt on the occurrence of the Fishing Cat anywhere in the Western Ghats\textsuperscript{18,19}. Thus, both the species have been removed from the list.

Among rodents, the occurrence of Layard’s Striped Squirrel \textit{Funambulus layardi} in the Western Ghats was based on one juvenile, and the species was described without much clarity and detail. Several further explorations have not yielded the species in the region. Thus, Molur et al.\textsuperscript{20} consider this as a misinterpretation, and the species may not be occurring in India, which however occurs in Sri Lanka\textsuperscript{20}. The Ranjinis Rat \textit{Rattus ranjiniae} has been removed from the genus \textit{Rattus}\textsuperscript{21}, and its status is debatable and uncertain. It is thus removed from the list.

The occurrence of two species of chiropterans in the Western Ghats is unclear. There are no proper sight records for Small Mouse-tailed Bat \textit{Rhinopoma muscatellum} and Schreibers Long-fingered Bat \textit{Miniopterus schreibersii} in the entire Western Ghats. \textit{Hipposideros schistaceus} is a synonym of \textit{Hipposideros lankadiva}\textsuperscript{22}. Few bat species are recently recorded from the Western Ghats i.e., \textit{Barbastella darjelingensis} and \textit{Miniopterus fuliginosus}, which are confined to the Anamalai Hills in the southern Western Ghats and their distribution in other areas is not clear\textsuperscript{23,24}.

This reveals the occurrence of 7, 23, 31, and 50 species of primates, carnivores, rodents, and chiropterans, respectively, and 23 other species for the entire Western Ghats (Figure 1A). Thus, the updated list comprises the occurrence of 134 species of mammals in the Western Ghats that includes 13 species under ‘Endangered’, 13 species under ‘Vulnerable’, five species under ‘Data Deficient’, and seven species under ‘Near Threatened’ status (Table 1; Figure 1B). Although 65 species are not assessed and listed in Indian Wildlife Protection Act, 23 species are protected under Schedule-I, while 20, 6, and 20 species are under Schedule- II, III, and IV respectively (Figure 1C).

\textit{Distribution of mammals in the Western Ghats}
Among primates, Slender Loris *Loris lydekkerianus* and Bonnet Macaques *M. radiata* are widely distributed\textsuperscript{25,26}, while Lion-tailed Macaque *M. silenus* is confined to a narrow strip of rainforests south of Aghanashini River in the central Western Ghats to the southern tip of the hill system\textsuperscript{27,28}. The northern limit of the distribution range of Nilgiri Langur *S. johnii* marks Brahmagiri hills in the central Western Ghats, where *S. hypoleucus* replaces the same niche at the north of these hills, and *S. priam* occupies the rain shadow areas, especially the eastern slopes of the Western Ghats\textsuperscript{12,14,28}.

The elephant *Elephas maximus* is the large-bodied herbivore that occurs in southern and central Western Ghats; nevertheless, few herds of elephants occur or often visit the southern part of northern Western Ghats\textsuperscript{29-31}. Although elephants have disappeared from some parts of the northern Western Ghats\textsuperscript{32}, they are widely distributed and occur in high density in some parts of the southern and central Western Ghats. Other species include Gaur *Bos gaurus*, Sambar *Rusa unicolor*, Chital *Axis axis*, Indian Chevrotain *Moschiola indica*, Muntjac *Muntiacus muntjak*, and Wild Boar *Sus scrofa* are widely distributed in the entire Western Ghats, while Nilgiri Tahr *Nilgiritragus hylocrius* is confined to high-altitude montane forests of the southern Western Ghats\textsuperscript{33}. Conversely, all antelopes occur only in the eastern foothills of the Western Ghats.

Of the 23 carnivore species, 16 of them are small carnivores, one is a meso-carnivore and the other six are large carnivores. Indian Gray Wolf *Canis lupus* is confined to the eastern border of the northern Western Ghats\textsuperscript{34,35}, where Golden Jackal *Canis aureus* shows the patchy distribution further, and is not recorded in the wet forests of southern Western Ghats, though occasionally seen in the central and the northern Western Ghats. The Striped Hyena *Hyaena hyaena* is known only from the eastern foothills with drier forests of the Nilgiri Biosphere (Mudumalai Tiger Reserve, Bandipur Tiger reserve, and Sathyamangalam Tiger Reserve). Tiger *Panthera tigris*, Leopard *Panthera pardus*, and Dhole *Cuon alpinus* have a wide range of distribution in the entire Western Ghats, however, their sizable population occurs in a few pockets largely in the Nilgiri Biosphere\textsuperscript{36}. Brown Mongoose *Herpestes fuscus*, Nilgiri Marten *Martes gwatkinsii* \textsuperscript{37} and Brown Palm Civet *Paradoxurus jerdoni* \textsuperscript{38,39} are confined to wet forests of the southern and central Western Ghats, while Common Palm Civet *Paradoxurus hermaphroditus*, Small Indian Civet *Viverricula indica*, Stripe-necked Mongoose *Herpestes vitticollis*, and Gray Mongoose *Herpestes edwardsii* are widely distributed in the Western Ghats, where Ruddy Mongoose
*Herpestes smithii* is confined to the drier forests on the eastern slopes\(^{18,38,40-43}\). The sight records of Jungle Cat *Felis chaus*, Leopard Cat *Prionailurus bengalensis*, and Rusty Spotted Cat *Prionailurus rubiginosus* are available from large parts of the Ghats. Honey Badger *Mellivora capensis* is known only from a few locations in the drier forests of Bandipur TR and Sathyamangalam forests of the southern Western Ghats.

Madras Hedgehog *Paraechinus nudiventris* is confined to the eastern plains of the southern Western Ghats\(^44\). Pygmy Shrew *Suncus etruscus*, South Indian Tree Shrew *Anathana ellioti*, House Shrew *Suncus murinus*, and Horsfield’s Shrew *Crocidura horsfieldii* are confined to a few isolated patches in the Ghats. Most of the rodent species are widely distributed, where the Travancore Flying Squirrel *Petinomys fuscocapillus* is confined to the wet forests from the southern tip of the ghats to the south of Goa\(^45\), while the Grizzled Giant Squirrel *Ratufa macroura* is confined to a few isolated riverine forests on the eastern slopes of the southern Western Ghats\(^46\). Kondana Rat *Millardia kondana* is known from a single location in Sinagharh plateau near Pune in the northern Western Ghats\(^20\), whereas the Malabar Spiny-backed Tree Mouse *Platacanthomys lasiurus* is known from the wet forests of the southern and the central Western Ghats\(^20,47-49\), and Bonhot’s Mouse *Mus famulus* is known from few locations in the southern Western Ghats\(^20\). The Etruscan Shrew *Suncus etruscus* is known from Kodagu in the central Western Ghats\(^49\). *Rattus norvegicus* was probably an introduced species\(^50\), however, it is reported from many parts of the Western Ghats and it is listed in many checklists related to the Western Ghats e.g., Nameer\(^50\), thus the species is included in the current list. Although *Funambulus pennantii* is known from northern India, its distribution range in IUCN Red List encompasses the northern Western Ghats, which requires proper exploration. Molur and Singh\(^49\) reported *Suncus niger* from Kodagu district which is a recognized species and it is not under *S. montanus*, which is restricted to Sri Lanka.

Among 50 species of bats, 24 species are widely distributed while other species are confined to one or few locations in the Ghats\(^51\). The highly threatened Sálim Ali Fruit Bat *Latidens salimalii* is recorded from a few locations in the southern Western Ghats. Wroughton’s Free-tailed Bat *Otomops wroughtoni* is known from Barapade caves in the central Western Ghats in Karnataka.

**Mammalian key diversity areas in the Western Ghats**
All species: Of the 12,798 grid cells, 26.31% of cells had more than 70% of species of mammals, and these cells were considered as mammalian key diversity areas. The minimum number of species in any of the grid cells was 46 species of mammals. The mammalian key diversity areas are largely confined to the Nilgiris and the southern Western Ghats, while three mammalian key diversity areas are in the central Ghats: (a) area between Anshi NP, Netravali WLS and Kali River Basin Forests; (b) area between Sharavathi Valley WLS and Shettihalli WLS; (c) area between Bandipur TR, Nagarahole TR, Bramhagiri WLS, Talakaveri WLS and Pushpagiri WLS (Figure 2a).

Threatened species: Except for 11 grids, all other cells had at least one threatened species. Of the total cells, 77.34% of the cells had 8 to 17 species, while only 17.10% of the cells had ≥ 18 species that we considered as mammalian key diversity areas for threatened species. These were confined to the Nilgiris and the southern Western Ghats except for Pushpagiri WLS, Talakaveri WLS, and adjoining reserved forests in the central Western Ghats (Table 2; Figure 2b). Although, a large part of the mammalian key diversity area has about 23 protected areas, about 55% of the area is under reserved forest and some under private plantations.

Relatively detailed data on distribution range is available for large mammals than small mammals. The local extinction and colonization of a species have become a natural phenomenon due to various natural and anthropogenic reasons. Thus, the periodic updating of such information at a smaller geographic range will help in providing a higher resolution map and prioritizing the smaller unit of area for conservation and management of at least biodiversity-rich areas. This article provides updated information on mammals, their current distribution range, and their mammalian key diversity areas that would help in planning the conservation and management initiatives in the Western Ghats.


43. Kalle, R., Ramesh, T., Qureshi, Q. and Sankar, K., Predicting the Distribution Pattern of Small Carnivores in Response to Environmental Factors in the Western Ghats. *PloS one*, 2013, 8, 79295.


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Table 1. List of mammals, their IUCN Red list status and distribution in Western Ghats, India

<table>
<thead>
<tr>
<th>No.</th>
<th>Order</th>
<th>Family</th>
<th>Scientific name</th>
<th>Common name</th>
<th>IUCN Red List status</th>
<th>IWPA status</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artiodactyla</td>
<td>Bovidae</td>
<td>Antilope cervicapra</td>
<td>Blackbuck</td>
<td>LC</td>
<td>I</td>
<td>Fragmented Population, eastern slopes or plains along the WG</td>
</tr>
<tr>
<td>2</td>
<td>Bovidae</td>
<td>Bovidae</td>
<td>Bos gaurus</td>
<td>Gaur</td>
<td>VU</td>
<td>I</td>
<td>Entire WG</td>
</tr>
<tr>
<td>3</td>
<td>Bovidae</td>
<td>Bovidae</td>
<td>Boselaphus tragocamelus</td>
<td>Nilgai</td>
<td>LC</td>
<td>III</td>
<td>Eastern plains of WG in Maharashtra and further north</td>
</tr>
<tr>
<td>4</td>
<td>Bovidae</td>
<td>Bovidae</td>
<td>Gazella bennettii</td>
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<td>LC</td>
<td>I</td>
<td>Exist at the eastern plains of WG in Maharashtra and further north</td>
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<tr>
<td>5</td>
<td>Bovidae</td>
<td>Bovidae</td>
<td>Nilgiritragus hylocrius</td>
<td>Nilgiri Tahr</td>
<td>EN</td>
<td>I</td>
<td>Fragmented population in southern and central WG</td>
</tr>
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<td>Bovidae</td>
<td>Bovidae</td>
<td>Tetracerus quadricornis</td>
<td>Four-horned Antelope</td>
<td>VU</td>
<td>I</td>
<td>Central WG</td>
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<td>Cervidae</td>
<td>Cervidae</td>
<td>Axis axis</td>
<td>Spotted Deer, Chital</td>
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<td>III</td>
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<td>Rusa unicolor</td>
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<td>VU</td>
<td>III</td>
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<td>Cervidae</td>
<td>Muntiacus muntjak</td>
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<td>III</td>
<td>Entire WG</td>
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<td>Suidae</td>
<td>Sus scrofa</td>
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<td>Tragulidae</td>
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<td>Moschiola indica</td>
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<td>Canis lupus</td>
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<td>Canidae</td>
<td>Cuon alpinus</td>
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<td>II</td>
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<td>Canidae</td>
<td>Vulpes bengalensis</td>
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<td>II</td>
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<td>I</td>
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<td>Prionailurus rubiginosus</td>
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<td>Herpestidae</td>
<td>Herpestes</td>
<td>Herpestes vitticollis</td>
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<td>Southern WG from North Kanara</td>
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<td>II</td>
<td>Southern WG and Sri Lanka</td>
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<td>Hyaenidae</td>
<td>Hyaena</td>
<td>Hyaena hyaena</td>
<td>Striped Hyena</td>
<td>NT</td>
<td>III</td>
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<td>Mustelidae</td>
<td>Aonyx</td>
<td>Aonyx cinereus</td>
<td>Oriental (Asian) Small-clawed (Clawless) Otter</td>
<td>VU</td>
<td>I</td>
<td>Hills of southern WG</td>
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<td>Mustelidae</td>
<td>Lutra</td>
<td>Lutra lutra</td>
<td>Common (Eurasian) Otter</td>
<td>NT</td>
<td>II</td>
<td>Hills of southern WG</td>
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<td>Mustelidae</td>
<td>Lutrogale</td>
<td>Lutrogale perspicillata</td>
<td>Smooth-coated Otter</td>
<td>VU</td>
<td>II</td>
<td>Entire WG</td>
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<td>29</td>
<td>Mustelidae</td>
<td>Martes</td>
<td>Martes gwatkinsii</td>
<td>Nilgiri Marten</td>
<td>VU</td>
<td>II</td>
<td>Fragmented distribution in Southern and also may be 29 in central WG</td>
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<tr>
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<td>Mellivora</td>
<td>Mellivora capensis</td>
<td>Ratel, Honey Badger</td>
<td>LC</td>
<td>I</td>
<td>Known from Bandipur TR, and Sathyamangalam forests</td>
</tr>
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<td>Southern and Central WG</td>
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<tr>
<td>109</td>
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<td>110</td>
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<td>Millardia meltada</td>
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<td>I</td>
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<td>132</td>
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<td>Ratufa indica</td>
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Table 2. Details of the threatened mammal rich areas in the Western Ghats

<table>
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<tr>
<th>Sl No</th>
<th>Mammalian key diversity areas</th>
<th>Sites</th>
<th>State</th>
<th>Forest status</th>
<th>~Area (km²)</th>
<th>Elevation gradient (min - max) (m)</th>
<th>Vegetation</th>
</tr>
</thead>
</table>
| 1     | Pushpagiri - Talakaveri       | Madikeri Division and Mangaluru Forest Division (Subramanya sub division) | Karnataka | Pushpagiri WLS, Talakaveri WLS, Reserved Forest | 890 | 60 - 1700 | • Medium Altitude Forest Type with Mesua ferrea–Palaquium ellipticum  
• Low Altitude Rainforest Type with Persea macrantha–Diospyros spp.–Holigarna spp.  
• Coffee and cardamom plantations  
• Wet evergreen forests  
• Grassland |
| 2     | Aralam-Kottiyoor-Malabar      | Kottiyoor RF covers the area between Aralam WLS and Malabar WLS. The area also falls inside the Anamudi ER. | Kerala | Part of Aralam WLS, Malabar WLS, Reserved Forest | 320 | 600 - 1200 | • West Coast tropical evergreen forest  
• West coast semi-evergreen forests  
• South Indian moist deciduous forest  
• Southern hilltop evergreen forest  
• Plantations |
| 3     | Wayanad                      | The maximum area of the district | Kerala | Human-dominated landscape | 650 | 700 - 2100 | • Evergreen rain forests  
• Dry mixed deciduous forest  
• Moist mixed deciduous forest  
• Plantations of teak, eucalyptus, and silver oak  
• Marshy lands, locally called “vayals” |
| 4     | Vavul Mala                   | Areas around the Vavul Mala Hill | Kerala | Reserved Forest | 170 | 600 - 2339 | • West Coast tropical evergreen forest  
• West coast semi-evergreen forests  
• South Indian moist deciduous forest  
• Southern hilltop evergreen forest  
• Plantations |
| 5     | Nilgiri Biosphere Reserve    | Silent Valley NP | Kerala | National Park |  | | |
|       |                               | Wayanad WLS | Kerala | Wildlife Sanctuary |  | | |
|       |                               | New Amarambalam WLS | Kerala | Wildlife Sanctuary |  | | |
|       |                               | Karimpuzha WLS | Kerala | Wildlife Sanctuary |  | | |
|       |                               | Attappadi Reserved Forest | Kerala | Reserved Forest |  | | |
|       |                               | Mudumalai TR | Tamil | Tiger Reserve |  | | |

- **Silent Valley NP**: 5000-7000 km², 80 - 2600 m
- **Wayanad WLS**: 320 km²
- **New Amarambalam WLS**: 650 km²
- **Karimpuzha WLS**: 170 km²
- **Attappadi Reserved Forest**: 650 km²
- **Mudumalai TR**: 170 km²
<p>| | | | |</p>
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<td>Pudussery East</td>
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<td>• Southern wet tropical evergreen</td>
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<td>Bodhi Hill North Forest</td>
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<td>Manjampatti - Kudiraiaar - Kookal</td>
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<td>Reserved Forest</td>
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<td>• Evergreen rain forests • Montane forests • Dry mixed deciduous forest • Moist mixed deciduous forest • Grasslands • Thorn forests • Monoculture plantations</td>
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| Kalakad-Mundanthurai TR | Tamil Nadu | Tiger Reserve | Dry Savannah Forests  
| | | | Thorn Scrub Forests  
| | | | Wet bamboo brakes  
| | | | Inland wetlands and marshes  
| | | | Riparian fringing forest |
Figure Legend

Figure 1. Number of mammal species under (A) different order, (B) IUCN status, and (C) Indian Wildlife Protection Act-1972 status.
Figure 2. Mammalian key diversity areas of all the mammal species and threatened mammal species richness in the Western Ghats. 1a shows all species, and 1b shows threatened species.