# Distribution of the invasive tree *Senna spectabilis* in the Thirunelli-Kudrakote elephant corridor, Wayanad: implications for management

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# Introduction

Introduction of plant species outside their native range by humans has increased in recent decades and the exotic invasions are threatening the native biodiversity and human well-being worldwide (Callaway & Maron 2006; IPBES 2019). Invasive plants cause several threats to natural ecosystems including hybridization, transmission of diseases and species competition, harming the health of humans and domestic animals, altering nutrient cycling or changing fire and water regimes (Hiremath & Sundaram 2005; Vilà et al. 2011; IPBES 2019). Among the invasive plants, trees are long-lived and large, hence they can dominate and alter the native vegetation and seriously hamper the ecosystem processes in the invaded ranges when compare to other plant forms (van Wilgen and Richardson 2014; Dyderski & Jagodzi´nski 2020). Currently, over over 430 tree species have been documented in diverse ecosystems worldwide (Richardson and Rejma´nek 2011; Wilgen and Richardson 2014). *Senna spectabilis (DC.) H.S. Irwin & Barneby* is a medium to large tree belonging to the family Fabaceae, native to tropical America (Jothy et al. 2012*)*. Life history traits such as fast growth rate, capability to produce a large number of seeds, thick canopy cover, lack of natural enemies, and capability to propagate profusely from seeds, stems, or roots, seed dispersal by native mammals and allelopathic properties make *S. spectabilis* a potential invasive species (Ladha et al. 1993; Wakibara and Mnaya 2002; Mungatana and Ahimbisibwe 2010; Anoop et al. 2021).

*Senna spectabilis* was introduced outside its native range including in Africa, Asia, North America, and Oceania, and threatening native biodiversity (Mungatana and Ahimbisibwe 2010; Randall 2012; Royal Botanical Garden KEW 2023). In the Budongo forest reserve of Uganda, *S. spectabilis* possess a high risk to the native flora (NARO 2004; Mungatana and Ahimbisibwe 2010) and is a threat to the low-land areas of Mahale Mountain National Park in Tanzania, an important conservation area for Chimpanzees. Here, *S. spectabilis* is taking over the habitat of Chimpanzees and suppressing the growth of native tree species (Nishida 1996; Wakibara and Mnaya 2002). In Sri Lanka, *S. spectabilis* is spreading extensively in the mountain forests (Gunasekera 2015), and in Australia, although naturalized, it is considered to be a weed in the natural environment, indicating its negative

impact on the environment (Randall 2007). In Singapore and Cuba, *S. spectabilis* have become invasive (Chong et al. 2009; Oviedo-Prieto et al. 2012).

View of the Thirunelli-Kudrakote elephant corridor from the south-eastern corner of the Brahmagiri hill (Begur Range)

In India, it is presumed to have been introduced as an ornamental plant in the botanical gardens (Sathyanarayana and Gnanasekaran 2013). Currently, it is an emerging invader in the Western Ghats Biodiversity hotspot after being deliberately introduced by the state forest departments (Anoop et al. 2021). Among the 32 species of invasive plants reported from the forests of Kerala, *S. spectabilis is* categorized as a medium-risk species (Sankaran et al. 2012). It was introduced in the Wayanad Wildlife Sanctuary during the early 1980s. A study in 2021 found that a total of 78.91 $km^2$ area in the sanctuary is occupied by the species, of which the density of the species very high in17.4 $km^2$ area (Vinayan et al. 2020; Anoop et al. 2021). Currently, from Tholpetty Range, the species is spreading to other areas of the Western Ghats, notably to the Brahmagiri hill area, primarily through the Thirunelli-Kudrakote elephant corridor (See map 1).

An elephant among a dense growth of Senna trees in the Naykatti areas of Tholpetty Range (Near the Corridor). Elephant habitats are being rapidly taking over by the *Senna* in Wayanad.

The proliferation of Senna diminishes the carrying capacity of the habitat for large herbivores, adversely impact the availability of non-timber forest produces for local communities and lead to human-wildlife conflicts. The forest department has implemented multiple measures and techniques to eradicate this tree. Yet, these efforts have not yielded success in either its removal or the prevention of its expansion into new areas. In this study, we assessed the distribution and abundance of *S. spectabilis* in the Thirunelli-Kudrakote elephant corridor and suggest approaches for its management.

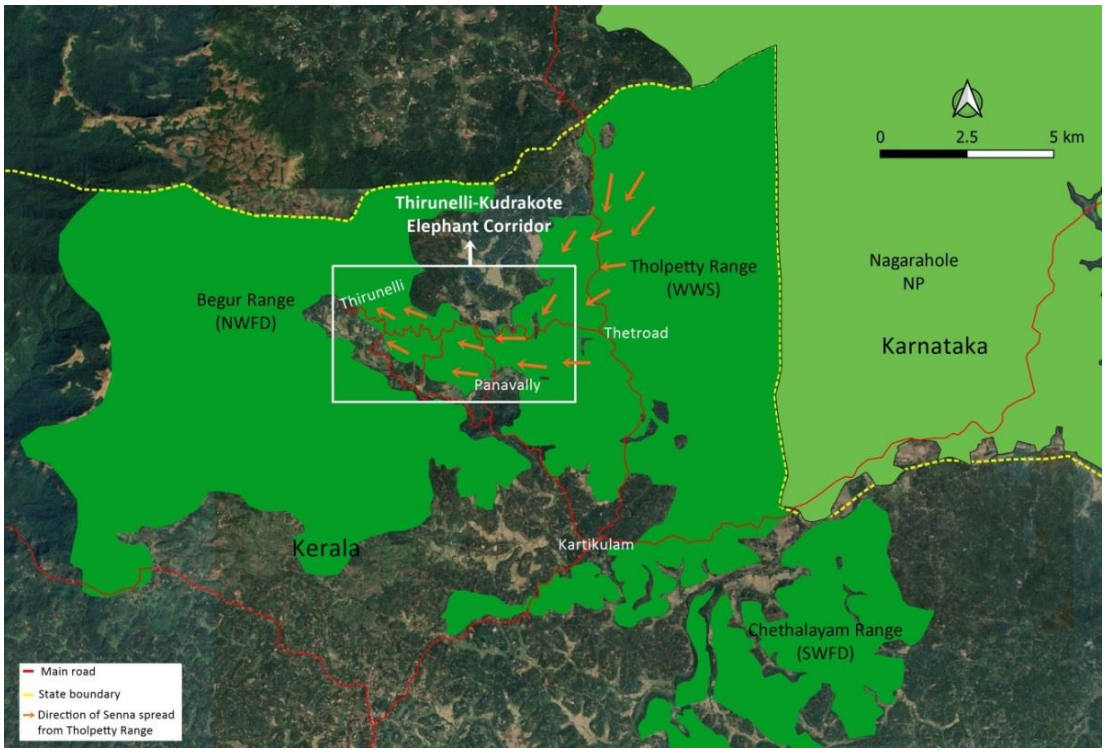
## Materials and methods

### Thirunelli-Kudrakote elephant corridor

The study was conducted in the Thirunelli-Kudrakote Elephant Corridor in the Wayanad district of Kerala state (located between 11° 53’ 9”- 11° 54’ 44” N and 76° 0’ 19”- 76° 3’ 55” E). The forest connectivity between Brahmagiri hills and Nilgiri Biosphere Reserve has been mostly disrupted in the post-colonial period due to the expansion of farmlands and human settlements. Currently, the Thirunelli and Kudrakote Reserve Forest provide a narrow forest connection (6 km long and 1–1.5 km wide) between the Brahmagiri Wildlife Sanctuary in Karnataka state and North Wayanad division in the west with the Tholpetty range of Wayanad Wildlife Sanctuary to the east. This corridor starts from Thetroad (Wayanad Wildlife Sanctuary) in the east and extends up to 6 km towards

Edayurvayal-Pothumoola villages (See map 1). It is located in the Brahmagiri-Nilgiri-Eastern Ghats elephant Landscape (Nilgiri landscape) of south India that holds the largest breeding population of Asian elephants globally (Baskaran 2013; Menon et al. 2017).

Due to its extensive utilization by elephants, this corridor is identified as one of the high-priority elephant corridors in South India (Menon et al. 2017). The primary vegetation types in the corridor comprise of moist deciduous forest, teak and eucalyptus plantations. Study are supports a diverse assemblage of large mammals, including gaur (*Bos gaurus*), chital (*Axis axis*), sambar deer (*Rusa unicolor*), tiger (*Panthera tigiris*), leopard (*Panthera pardus*), dhole (*Cuon alpinus*), and sloth bear (*Melursus ursinus*). The land use around the corridor is a heterogeneous matrix of human land use including plantations with various cash crops, open agriculture such as paddy and vegetables in the wetlands, and small towns. Coffee is a major crop in the area that is usually inter-cropped with pepper, areca nut, coconut, and banana.




Map 1. Map showing the location of Thirunelly-Kudrakote elephant corridor, forest connectivity and expansion of *S. spectabilis* from the Wayanad Wildlife Sanctuary to the Brahmagiri hills.

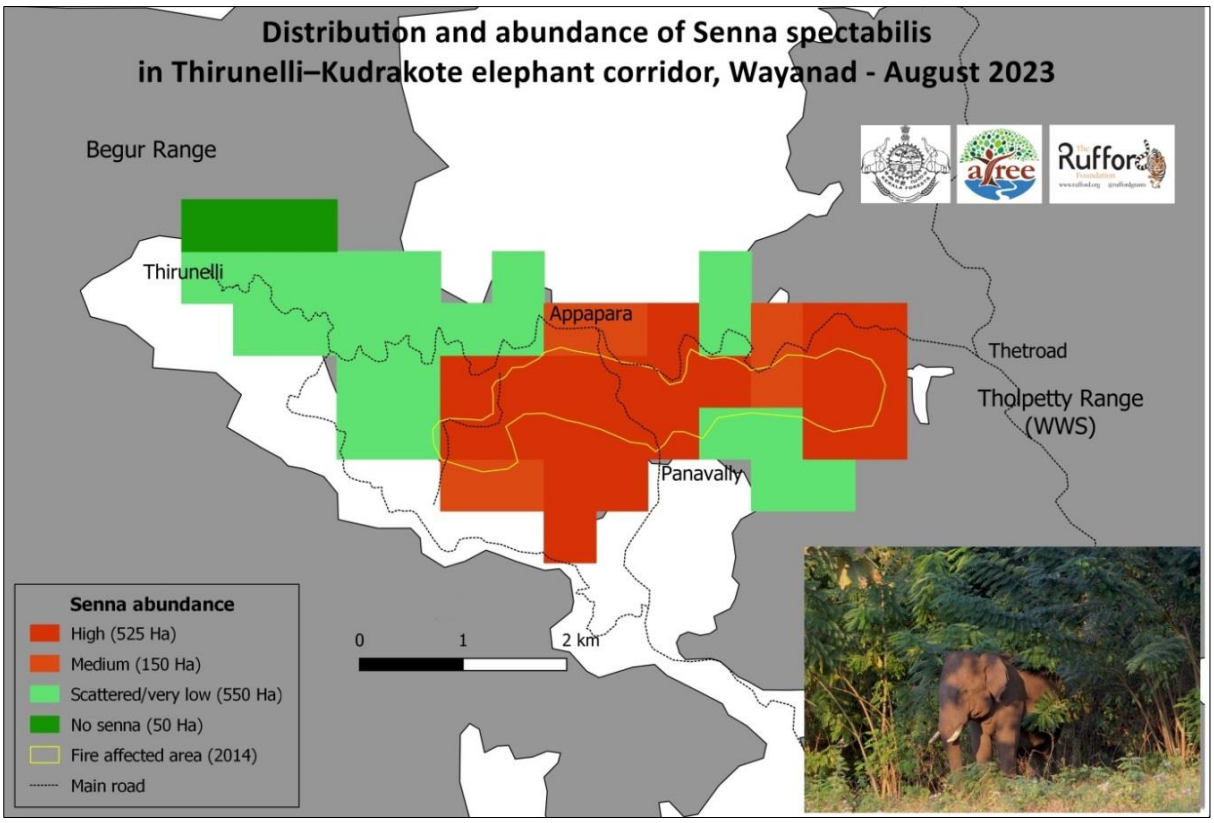
An elephant herd in Thirulkunnu swamp in the corridor

**Method**

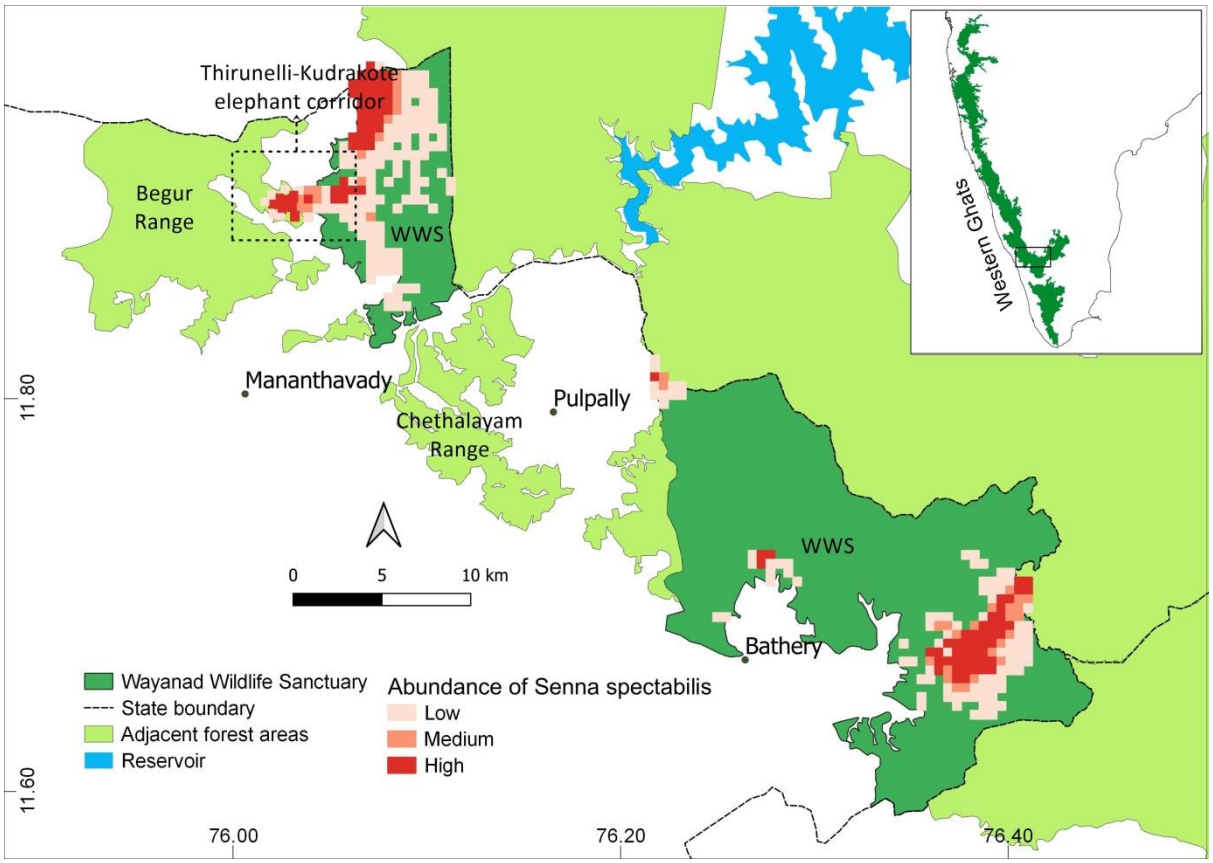
We used a grid-based sampling design to collect data on Senna distribution and abundance in August 2023. The size of each spatial sampling unit was 500×500 m. The abundance of Senna in each grid was categorized into different classes ranging from high to absent (Vinayan et al. 2020; Anoop et al. 2021). For this purpose, two trained observers walked along the available roads and forest trails in each grid and categorized different abundance classes of *S. spectabilis* based on visual estimation of abundance. The grids with no *S. spectabilis* was classified as 'absent', 'low' (≤10% of the total stems), 'medium' (10–40%), and grids with a high abundance of *S. spectabilis* was categorized as 'high' (≥40% of all the stems. A map of different abundance classes of *S. spectabilis* in the study area was prepared based on the survey (map 2).

## Findings and management recommendations

Out of the 52 grids sampled, Senna was found in 49 grids. Our findings revealed varying degrees of Senna invasion across these grids, with 525 hectares experiencing a high level of invasion, 150 hectares exhibiting medium invasion, 550 hectares showing low levels of invasion, and 50 hectares remaining entirely free of Senna (map 2). A previous study that followed the same protocol reported that high-density areas could support approximately 1300 trees per hectare, while medium-density areas sustained around 400 trees per hectare, and low-density regions contained approximately 150 trees per hectare (Vinayan et al. 2020, See Map 3). High abundance of Senna was found in the eastern side of the corridor. This concentration can be attributed to the species' initial introduction within the Tholpetty range, with subsequent spread towards the Thirunelli (west) side. The corridor area experienced a major fire incident in 2014. Currently, the burnt area and eucalyptus plantations are heavily invaded by the species (See Map 2).




Map 2. Distribution and abundance of *Senna spectabilis* in the Thirunelli-Kudrakote elephant corridor in August 2023.




Map 3. Distribution of *S. spectabilis* in Wayanad forests in 2020 (See Vinayan et al. 2020, Anoop et al. 2021).

**Management of Senna from the corridor**

The complete eradication of *Senna* requires careful considerations. Girdling and felling of trees in combination with removal of seedlings and sprouts was found to be an effective way to control *S. spectabilis* in Mahale Mountains National Park in Western Tanzania (Lukosi, 1997; Wakibara & Mnaya, 2002). Furthermore, the second author, who actively participated in the Senna management project within the Wayanad sanctuary, advocates for the regular uprooting of trees and saplings and eco-restoration as the optimal method for Senna management in Wayanad. We recommend the following strategies for eradicating the species from the corridor.

A heavily Senna infested area near Appapara (north of the Appapara-Panavalli road). This area experienced high intensity forest fire in 2014. The fire affected areas in the corridor are now dominated by Senna (See the map 2).

(I) *Senna spectabilis* is spreading from the Tholpetty Range to the Brahmagiri hills. In regions where these plants initially took hold during the early stages of invasion, such as the Thetroad to Appapara area, the density is notably high. Conversely, areas with lower plant density, like the Thirunelli area, have more recently succumbed to invasion, and the plants there are relatively young. To effectively curb the expansion of this species and prevent it from encroaching upon new landscapes, it is crucial to prioritize eradication efforts from low-density areas to high density areas (Thirunelli to Tholpetty, See map 2).

An adult tree can produce thousands of seed in a season. Image from the Kotayur-Karamad area in the corridor.

(II) The most effective method for the removal of Senna involves uprooting the trees and saplings. To deplete the soil seed reserve, a consistent effort to manually pull out seedlings is necessary. We suggest removing the saplings during the monsoon season when the soil is moist, allowing the complete removal of their root system.

Once established, Senna replace native vegetation and other invasive plants such as *Lantana camara* and *Chromolaena odorata*

For removing the mature trees, top soil should be removed using spades followed by cutting and removing the main roots. In cases where the soil is damp, three to four individuals together can easily pull out the tree after eliminating the secondary roots. To prevent Senna from regenerating through remaining root fragments in the soil under favourable conditions, root removal should continue for a minimum of three years.

It's important to note that the removal of Senna will alter local environmental conditions, primarily by creating open spaces that may become susceptible to infestations by invasive species such as *Lantana camara*, *Chromolaena odorata* and even Senna itself. To mitigate this issue, we propose implementing eco-restoration efforts in the managed areas, utilizing native plant species.

(III) Constant removal of adult trees and pruning of branches will lower flowering and fruiting that reduces the dispersal of seeds to new areas by the dispersers. Also, it is important to understand the interactions of *S. spectabilis* and its native dispersers for better management.


Forest First NGO successfully removing large Senna trees in Tholpetty Range of Wayanad Wildlife Sanctuary.

Forest department used four-wheelers to remove Senna from the corridor

Seeds of Senna in elephant dung reported from Thirulkunnu swamp in the Corridor. Elephant and spotted deer are the main dispersers of Senna seeds in the Western Ghats.

(IV) Debarking of adult trees (debarked all around the stem about one meter above the soil and ensure reasonable destruction of phloem tissues) during summer needs to be continued in the area. However, it's worth noting that in cases of ring barking, there have been observed instances of coppice growth.

Multiple branches growing from the debarked tree in Wayanad Sanctuary

**Eco-restoration in the corridor**

As part of our eco-restoration initiative, ATREE and the Rufford Foundation, in collaboration with the Kerala Forests and Wildlife Department, Ferns Naturalist Society, and Pazhassiraja Smaraka Grandhalayam, have planted around 3500 saplings and seeds of various native plants in the corridor between 2022 and 2023.

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