Current Population Status, Distribution and Threats to Indian pangolin (*Manis crassicaudata*) in Terai Arc Landscape, Uttarakhand: A pilot study

Final Report

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CONTENTS

Citation

Lyngdoh, S; Goyal, S.P; Nigam, P; Kumar, V; Badola, S and Rasailly, S (2020) Current Population Status, Distribution and Threats to Indian pangolin (Manis crassicaudata) in Terai Arc Landscape, Uttarakhand: A pilot study. Pp 56. TR NO.

Correspondence
Dr. Salvador Lyngdoh, Scientist D
Animal Ecology and Conservation Biology
Wildlife Institute of India, Dehradun

Chapter 1

Introduction and Background

The pangolin is a mammalian species belongs to the order 'Pholidota' and family 'Manidae'. They are the medium-sized mammals covered with the individual, overlapping scales made of keratin (Prater, 1980), which helps pangolin for protection against predator and insect bites. There are eight species of pangolins found globally, out of which four are native to Asia (Chinese pangolin *Manis pentadactyla*, Indian pangolin *M. crassicaudata*, Sunda pangolin *M. javanica* and Philippine Pangolin *M. culionensis*) and four are native to Africa (black-bellied pangolin *Phataginus tetradactyla*, white-bellied pangolin *P. tricuspis*, giant pangolin *Smutsia gigantea* and Temminck's ground pangolin *S. temminckii*) (Emry, 1970; IUCN, 2020).

In India, there are two species of pangolin found; Indian pangolin (*Manis crassicaudata*) and Chinese pangolin (*Manis pentadactyla)* (Prater, 1980; Mohapatra *et al*., 2015). The Indian pangolin is found throughout the country except for Trans-Himalaya, Thar Desert, and some parts of north-east India, whereas the Chinese pangolin is limited to its range within north-east India (Chakraborty *et al.*, 2002). The presence of only Indian pangolin is recorded from the southern part of Uttarakhand (IUCN, 2020).

Indian pangolin is a habitat generalist species and found across many terrestrial ecosystems (Roberts, 1997). They are an obligate myrmecophagous (Redford, 1987) and fossorial species. In the ecosystem, they act as a natural pest controller by exclusively feeding on ants, termites and insects (Mahmood et al., 2013); and also act as habitat engineers as their behavior of digging a burrow for shelter helps soil to aerate and rotate mineral cycle (Hansell, 1993; Maurice et al., 2019) Due to such characteristics feature, Indian pangolin is an important species in their biological niche (Akrim et al., 2017). Living in the vicinity of forest and farmlands, they play a crucial role in an agroecosystem (Roberts, 1997). But being an ecologically important species they are threatened too. They are facing threats from habitat loss, road traffic, forest fire (Molur *et al.,* 2005) and most extensively from trafficking and poaching for meat & scales (Mahmood *et al.*, 2012; Mohapatra *et al.*, 2015).

Majorly, large scale poaching and trafficking is the main threat for the population declination of pangolins in India. According to an estimate, equivalent to 7500 pangolins were seized in 119 seizures from illegal trade between 2009 and 2018 (Tiwari et al., 2020). This massive illegal poaching of pangolin brought them into the "Endangered" category of red-list by the International Union of Conservation of Nature and Natural Resources (Baillie *et al.* 2014) and 'Appendix-I' of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2016). The published studies on the account of pangolin trading have shown that Uttarakhand state is becoming a hotspot of illegal trade in India as the percentage contribution of total country-wise seizure is increasing from 4.08% in the year 2009-14 (Mohapatra et al., 2015) and 6% in the year 2009-17 (Chaudhary et al., 2018) to 12% in the year 2009-18 (Tiwari et al., 2020).

For the conservation of any species, the exact knowledge on distribution, population status and other ecological aspects are required. Illegal trading of this ecologically important species is increasing in the state, but information regarding their status, current distribution and hotspot of trade are not sufficiently known. With this rationale, the Wildlife Institute of India, Dehradun, Uttarakhand Biodiversity Board and Uttarakhand State Forest Department undertook this pilot study to provide information on the current distribution of Indian pangolin and major poaching hotspots throughout its ranges to suggest appropriate conservation strategies and protection measures for the species.

The proposed objectives for this pilot study are the following:

a. To review the current status, distribution and threats to the Indian pangolin population in the study area.
b. To prepare a standard protocol for the survey and population estimation of Indian pangolin.
c. To formulate effective anti-poaching strategies and devise conservation measures for Indian pangolin to help Uttarakhand Forest Department.

Chapter 2

Species Introduction

2.1 Taxonomy:

The term Pangolin is derived from a Malayan phrase 'Pen Gulling' meaning 'rolling ball', while the term Pholidota came from a Greek word meaning 'scaled animals' (ZSI, 2002). The pangolin is categorized in the Manidae family in the Pholidota order. There are eight extant species of pangolins found in the world which are distributed over South Asia and Africa (Lekagul and McNeely, 1977). Pangolins were previously classified with the new world xenarthrans (anteaters, armadillos and sloths) in the Order Edentata; however, they have now been recognized as taxonomically distinct species (Murphy 2001). Taxonomic revisions have categorized all eight subspecies of pangolin in the order Pholidota.

The family 'Manidae' having three extant genera; *Manis* for Asian pangolins, *Smutsia* for the African ground pangolin and *Phataginus* for the African tree pangolin (Gaudin 2009). The Genus, *Manis* is characterized by the presence of well-developed pinnae, hair layered between scales that are retained in adults (Macdonalds 2006) and a median row of scales that continue to the end of the tail (Patterson 1978).

Taxonomic classification of Indian pangolin, *Manis crassicaudata*

Kingdom	:	Animalia
Phylum	:	Chordata
Subphylum	:	Vertebrata
Class	:	Mammalia
Order	:	Pholidota
Family	:	Manidae (Gray 1827)
Genus	:	*Manis* (Linnaeus 1758)
Species	:	*crassicaudata* (E. Geoffroy 1803)

2.2 Status and Distribution:

Indian pangolin is distributed in South Asian countries. Extent over India, Pakistan, Nepal, Bangladesh, Srilanka (Schlitter 2005, Srinivasulu & Srinivasulu 2012; Baillie et al., 2014) (Refer Figure 1.) In Pakistan, the species is distributed over Sind, Baluchistan, and spread over Pakhtunkhwa and Punjab, which includes Potohar Plateau (Roberts, 1994). In Shri Lanka, the species is distributed all over the continent, co-occurring with the range of termites (Phillips, 1981) Recently, a study suggests that in all provinces of the country the species inhabit up to 1850m elevation, with the abundant occurrence from Nuwara Eliya District (Perera et al. in prep; IUCN, 2019) the species also exist in all the coastal, shore and dry areas of the country (IUCN, 2019).

In India, Indian pangolin occurs throughout peninsular India (Israel et al.1987; Prater 1980). The species is widely distributed from the plains and lower hills south of the Himalayas to extreme southern India (Tikader 1983). The distribution range of Indian pangolin covers almost the region of India except for the Trans Himalayas, Thar Desert and North-eastern Region of the country.

In Uttarakhand, the species occurs in the Lower-Himalayan region and Terai Arc Landscape.

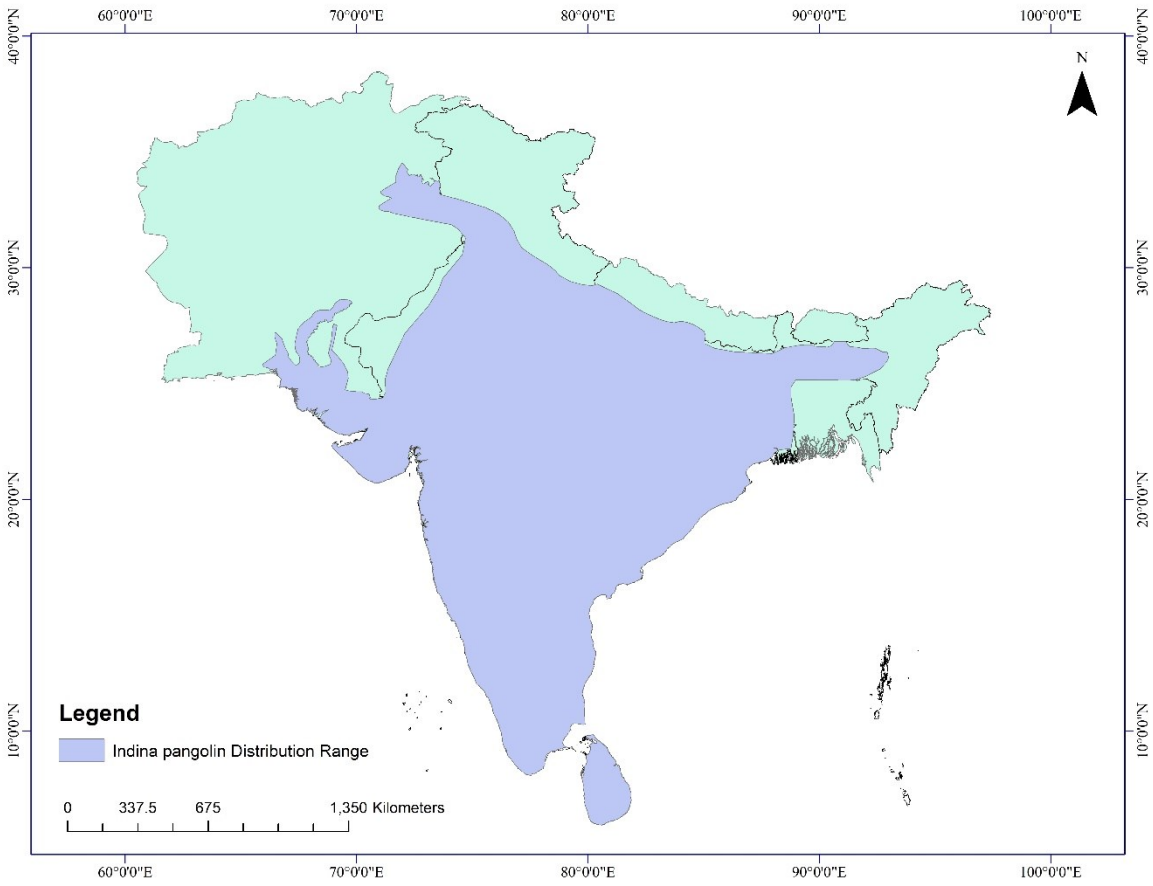


Figure 1: Distribution range of Indian pangolin (Courtesy IUCN, 2020)

2.3 Habitat Ecology:

Indian pangolin is a habitat generalist species (Roberts, 1997); their occupancy has been reported from a variety of habitat types. They need minimal habitat requirements such as annual water supply for drinking, loose earth substratum to dig burrows, abundant prey population (Mahmood et al., 2014; Pabasara et al., 2015). Hutton, 1949 had reported the occurrence of Pangolin at the elevation of 2300 m (7545 ft.) in India. They live in open and grasslands (Saxena 1986), scrub forest, rainforest, tropical forest, moist forest, dry deciduous, wet forest, semi-evergreen forest and near human settlements (ZSI 2002), they are also live in the desert zone (Roberts 1977).

The species is thought to adapt well to human-dominated landscape and modified habitats such as plantation, farmlands near the forest fringes (Prater, 1980; Saxena, 1986). Many sightings and rescue records have also shown its presence in and around urban forests (Bhandari et al., 2019). Pabasara 2015 has recorded that Indian pangolin preferred pine-dominated forest rather than natural forest.

The habitat preference of Indian pangolin is not clearly known but the species occurrence is found closely associated with the presence of plant species like *Zizyphus mauritiana*, *Acacia nilotica*, *Zizyphus nummularia*, *Prosopis cineraria* and *Lantana camara* in Potohar, Pakistan (Mahmood 2014), *Acacia modesta*, *Dalbergia sissoo*, *Pinus roxburghii* in MHNP, Pakistan (Mahmood 2015).

2.4 Foraging Ecology:

Indian pangolin is an obligate myrmecophagous species (Redford 1987), they forage on ants, termites (Prater 1980, Roberts 1977, Mahmood 2013), beetles, cockroaches, worms, grubs (Hutton 1949). They likely prefer to forage on insect eggs over adults (Prater 1980). According to an estimate, one adult pangolin can consume approximately more than 70 million insects annually (d'Aulaire and d'Aulaire 1983).

They have morphological adaptations for Myrmecophagy including the absence of teeth, absence of external ear, conical head and long-sticky tongue to lap up prey (Macdonald 2006). Their forelegs are large with long-sharp claws which helps them to dig the burrow and excavate insect's nest (Payne and Francis 1998). Indian pangolin is a nocturnal species so they primarily rely on their sense of smell to locate the nests of insect nest (Israel 1987, Mohapatra and Panda 2014b).

Indian pangolin prefers ants and termites in their diet. The Red weaver ant (*Oecophylla smaragdina*) is one of the favorite food of Indian pangolin (Heath 1995; Mahmood et al., 2013). Irshad et al., 2015 identified two species of black ants including *Camponotus confucii* and *Camponotus compressus* and one species of termite named *Odontotermis obesus* as main constituents of pangolin's diet in Pakistan. Karawita et al., 2019 found ant, termite, scorpion and lacewing in the fecal material of Indian pangolin in Srilanka, ants and termites were found majorly while scorpion and lacewing found only one event and completely undigested. Ants of genera *Monomorium*, *Camponotus, Anoplolepis* and *Oecophylla* and two termite species i.e. *Odontotermes horni* and *Odontotermes redemanni* were identified as the main prey item of Indian pangolin in Srilanka.

2.5 Threats and Conservation Status:

Indian pangolin is such a species that is facing a high risk of extinction throughout its distribution ranges due to many stressors. Habitat loss, degradation due to expansion of agriculture, alteration of habitat due to plantations, increase in human settlements, construction of dams, forest fire and pest control practices (CAMP 2005) and hunting for scales and meat (Mahmood et al., 2012; Mohapatra et al., 2015) are the major threats to this species. Indian pangolin is persecuted for bushmeat, traditional medicine, luxury goods and various superstitious concoctions for local consumption and international trade (Mahmood et al., 2012; Mohapatra et al., 2015). The Indian pangolin is amongst the world's most illegally trafficked animals due to the high demand for its scale.

Previously, Indian pangolin was classified as 'Near Threatened' by the IUCN Red List of Threatened Species throughout its range in all the countries of occurrence (IUCN 2006); but due to rapid decline in its population, later it was re-classified as 'Endangered' category (IUCN 2014). The species was listed in 'Appendix II' of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) till the year 2016 but due to an increase in international trade, the species was transferred into 'Appendix I' of CITES (CITES 2016).

In India, Indian pangolin is listed in 'Schedule I' of India's Wildlife (Protection) Act 1972 which is the highest level of protection of wildlife in the country.

Chapter 3
Study Area

Terai Arc Landscape (TAL), Uttarakhand is a stretch between the 'Yamuna' and 'Sharda' rivers in west and east respectively, comprises of Shivalik hills and adjoined by river plains. The landscape is a part of the Terai-Duar Savannah Ecoregion and is divided into two distinct physiographic regions, i.e., 'Terai' and 'Bhabar'. The term 'Terai' means 'Lowlands,' and has flat terrain with fine silt texture, while Bhabar is a local tall growing grass species (*Eulaliopsis binata*) in the south of the Shivalik hills and the terrain is composed of coarse soil and boulders. The Terai region comprises of tall grasslands and swamp forests interspersed with Sal forests while the lower Himalayas of Bhabar are predominantly reigned by Sal forests (Verma, 2011). The elevation of this landscape lies between 210 to 2000 meters. The major drainage system of the Terai Arc Landscape is formed by Yamuna, Ganga, Ramganga, Gola and Sharda rivers.

The Terai Arc Landscape, Uttarakhand, is drained by significant rivers like Yamuna, Ganga, Ramganga, Gola and Sharda. The study area comprises of 12 forest divisions of the Uttarakhand state i.e., Dehradun Forest Division, Rajaji Tiger Reserve, Haridwar Forest Division, Lansdowne Forest Division, Corbett Tiger Reserve, Ramnagar Forest Division, East Terai Forest Division, West Terai Forest Division, Central Terai Forest Division, Haldwani Forest Division, Kalsi Forest Division and Nainital Forest Division encompassing a total area of 13486.37 Km^2.

The landscape has a total forest cover of 6891.29 km^2 (Figure 3) which represents the Upper Gangetic Plain Biogeographic Zone with mainly tropical moist and dry deciduous vegetation. The landscape harbors forest types classified by Champion & Seth as: 3C/C2 a Moist Siwalik Sal, 3C/C2 c Moist Terai Sal, 3C/C3 a West Gangetic Moist Mixed Deciduous, 5B/C1 a Dry Siwalik Sal, 5B/C2 Northern Dry Mixed Deciduous, 5/1S2 Khair Sissoo and 12/C1 a Ban Oak forest types (Champion and Seth, 19.; Figure 4). The significant vegetation associations in the mixed deciduous forests comprise tree species such as Sal (*Shorea robusta),* Saaj *(Terminalia tomentosa),* Bahera *(Terminalia bellerica),* Dhavra *(Anogeissus latifolia),* Rohni *(Mallotus philipensis),* Kanju *(Holoptelia integrifolia),* Chamror *(Ehretia laevis),* Bael *(Aegle marmelos),* Haldu *(Haldina cordifolia),* Khair *(Acacia catechu)* and Sheesham (*Dalbergia sisso)*.

TAL has been identified as an important site for the conservation of Tiger (*Panthera tigris tigris*) and the Asian elephant (*Elephas maximus*), specifically that the populations of the two species represent the north-westernmost of their distribution range. The landscape supports a good population of other threatened mammalian species such as Swamp deer (*Rucervus duvaucelii duvaucelii*), Indian pangolin (*Manis crassicaudata*), Himalayan Goral (*Naemorhedus goral*), Indian leopard (*Panthera pardus fusca*), Sloth Bear (*Melursus ursinus*) and Himalayan Black Bear (*Ursus thibetanus*). The area also supports many ungulate species such as Sambhar (*Rusa unicolor*), Chital (*Axis axis*), Barking deer (*Muntiacus muntjak*), Nilgai (*Boselaphus tragocamelus*), Wild pig (*Sus scrofa*) and a diverse number of avifauna and reptiles.

Terai Arc Landscape, Uttarakhand is one of the most densely populated areas in the country; more than 8 million people inhabit this landscape (Census, 2011). The surge in population size is 54.2% in the last two decades (Ghosh, 2016) prompts towards increased intensive utilization of natural resources. There is a high dependency of people on natural forest resources in forest fringe regions for fuelwood, firewood and rope making grasses with mainly agrarian economy. The NTFPs like fruits, honey, medicinal plants and leaves are extensively collected by the rural people. Industrialization and urbanization have led to the overexploitation of resources and fragmentation of the habitat with the expansion of cities and increased road and rail network connectivity. These are the major conservation and management threats for the forest management authorities. Most of the people in this landscape are dependent on agriculture and they are also dependent on forests such as firewood, fodder and rope making grass. Fruits, honey, medicinal plants and leaves are some Non-timber Forest Products (NTFPs) that are collected by the rural people in this landscape. The continuous increase in population and expansion of cities & villages over the years has reduced forest cover and resources. Also, the expansion of road and rail network weakens the connectivity of forest. These issues have become major conservation and management issues for the forest management authorities.

Delayed permission and prolonged monsoon reduced our survey periods and field sessions for detailed observations. The shortened time period and funding issues further impacted the extensive research practice. Thus, 6 forest divisions were undertaken as potential sites for the conducting surveys which are: Corbett Tiger Reserve, Dehradun Forest Division, Haridwar Forest Division, Kalsi Forest Division, Lansdowne Forest Division and Rajaji Tiger Reserve.

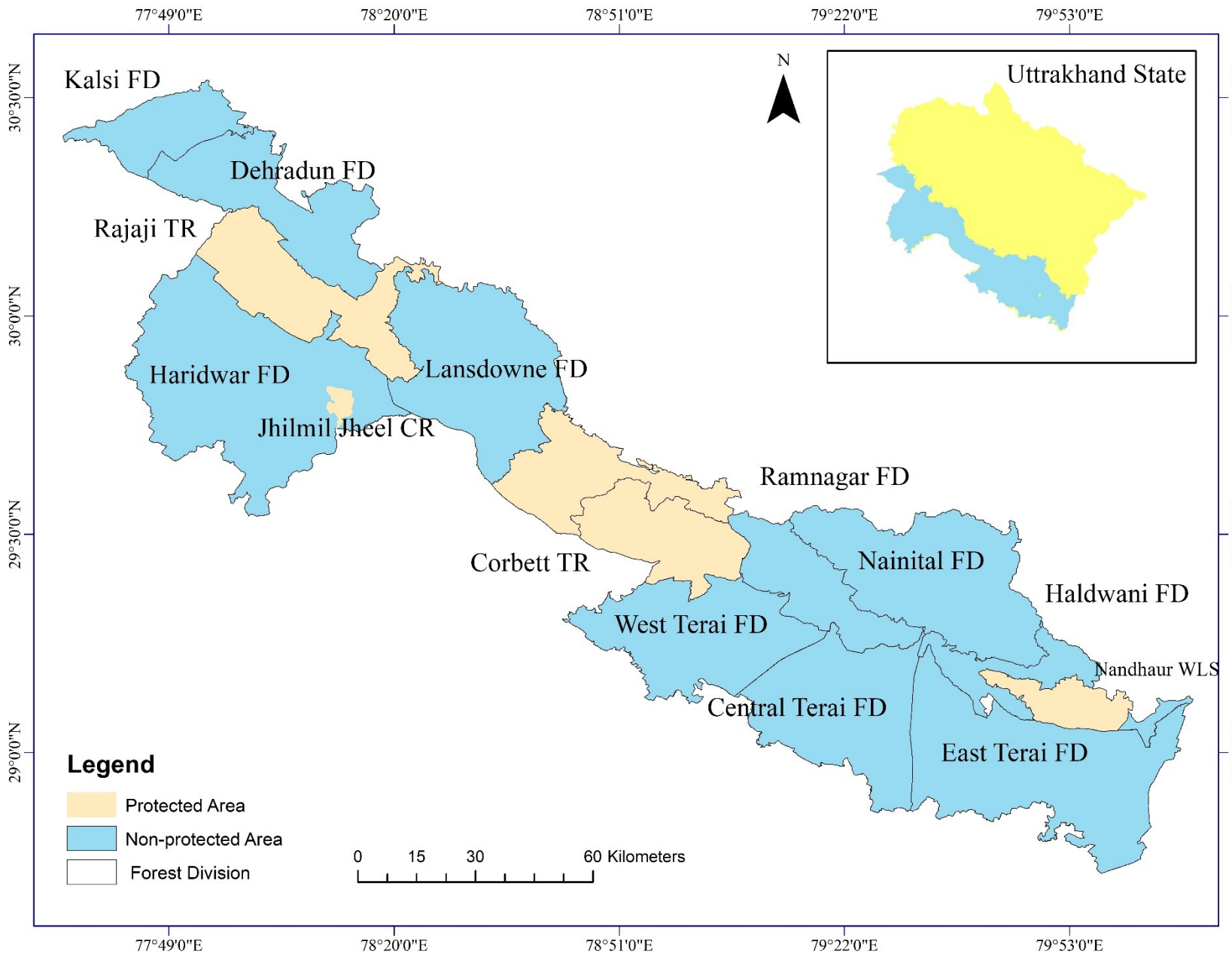


Figure 1: Protected and Non-protected area of Terai Arc Landscape, Uttarakhand

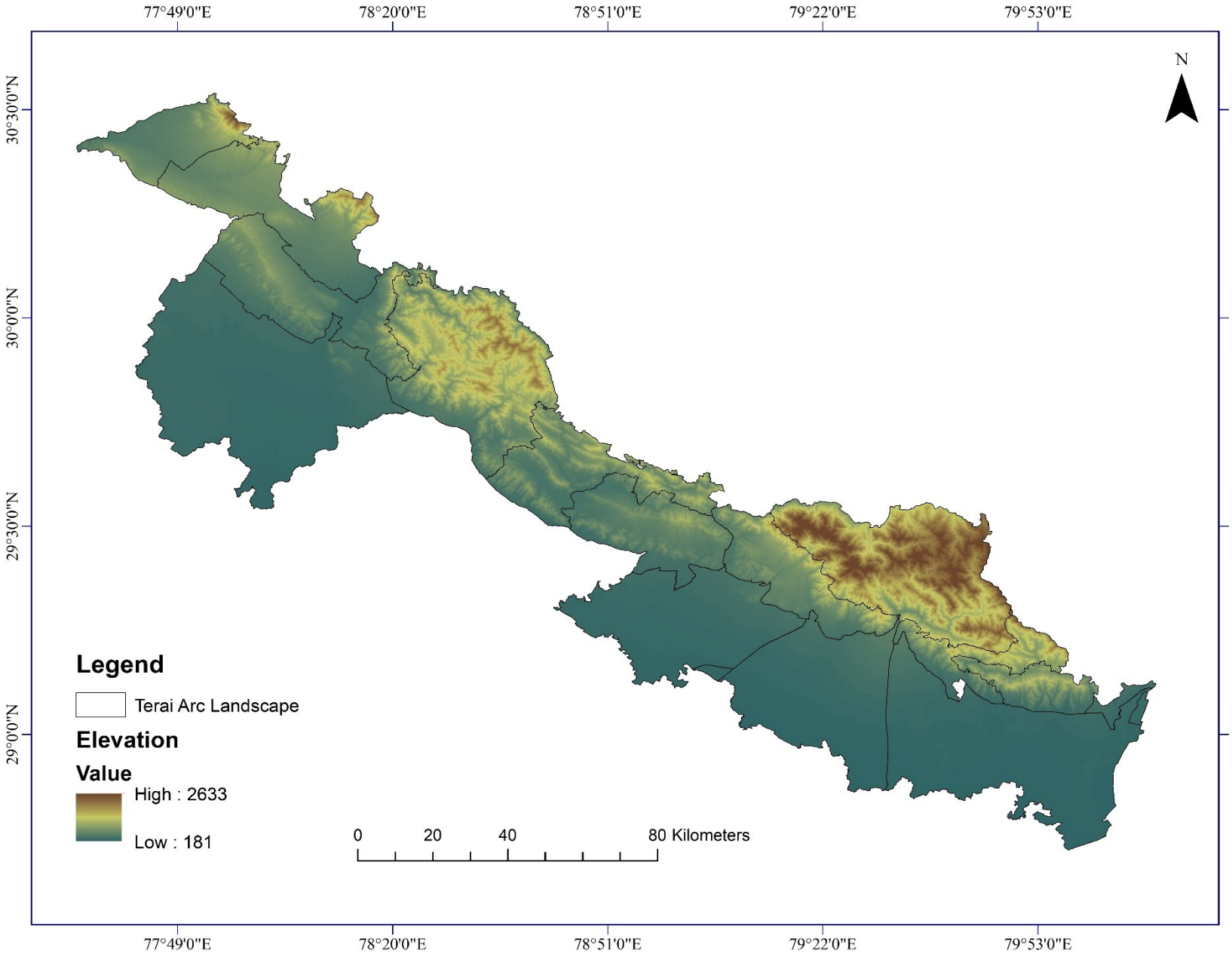


Figure 2: Altitudinal range of Terai Arc Landscape, Uttarakhand (Source: SRTM, Earthexplorer 2019)

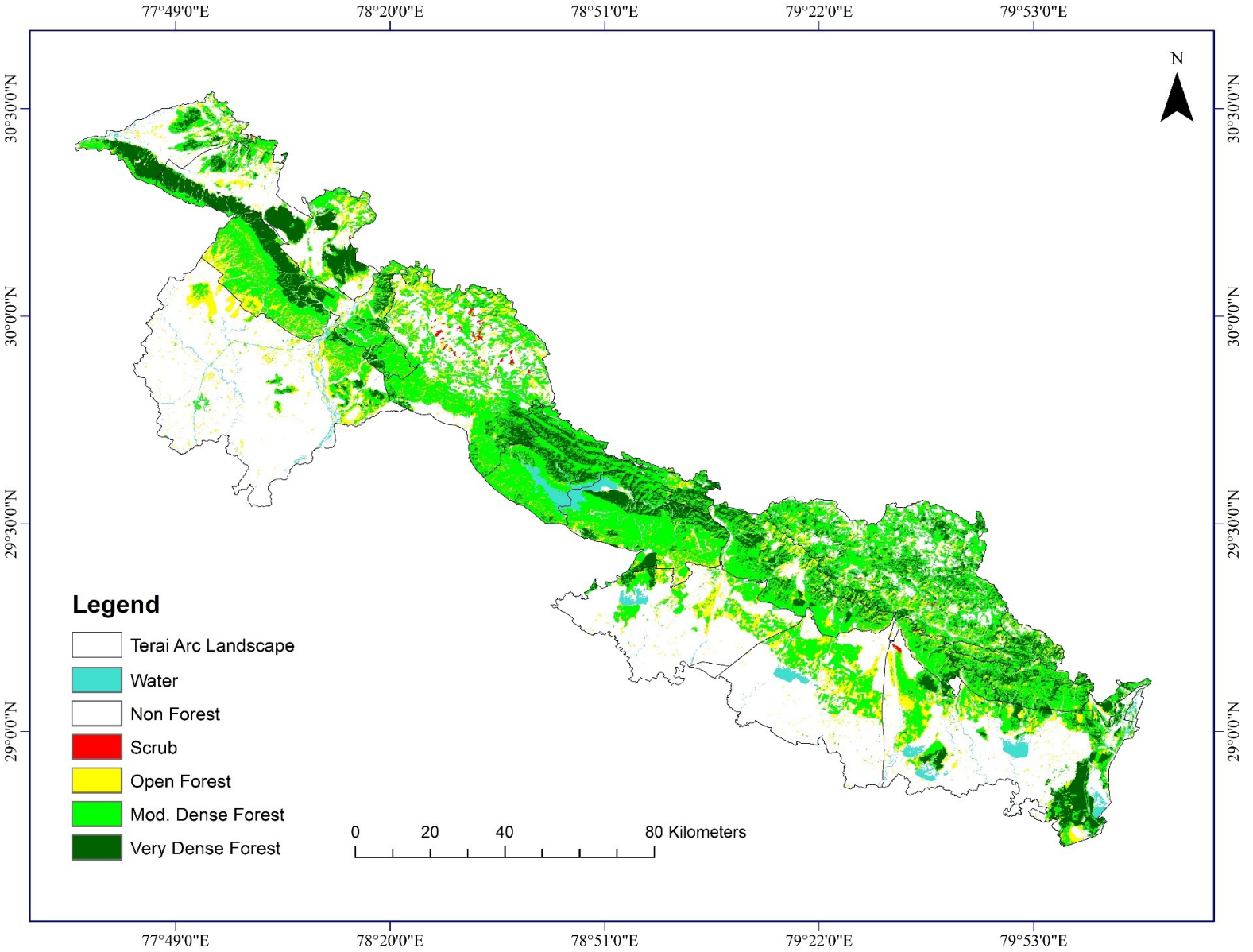


Figure 3: Forest Cover of Terai Arc Landscape, Uttarakhand (Source: Forest Survey of India, 2014)

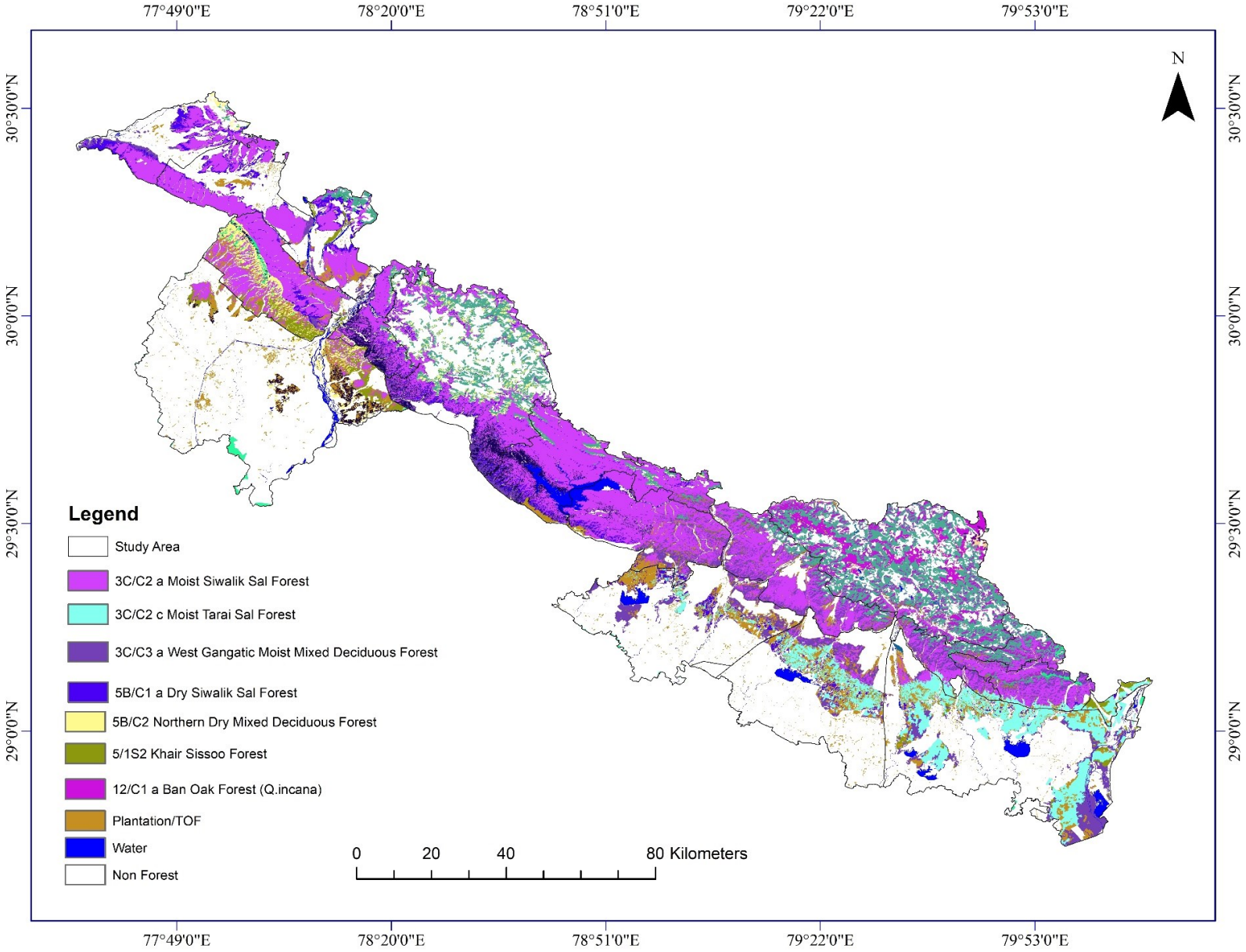


Figure 4: Forest types of Terai Arc Landscape, Uttarakhand (Source: Forest Survey of India, 2014)

Chapter 4

Current Distribution Status and Threats to Indian pangolin

4.1 Introduction:

The knowledge of distribution, current status and threats to a species, whose conservation status is under concern, is crucial to help uptake appropriate measures in conservation efforts (Mahmood et al. 2015). The Indian pangolin is such a species that is an Evolutionary Distinct and Globally Endangered (EDGE) species (Gray, 2016) as well as a species of conservation concern as it is an important species in their biological niche (Faraz et al., 2017); they act as a natural pest controller by exclusively feeding on ants, termites and other insects (Robert, 1974) and their fossorial behavior help soil to aerate (Hansell, 1997; Maurice et al., 2019). Despite being an ecologically important species, they are threatened too. Indian pangolin throughout its distribution range has become an endangered species and is facing the risk of extinction due to many un-natural threats from anthropogenic activities such as trafficking, habitat loss, forest fire, killing during 'Shikar Utsav' and road trampling (Molur et al., 2005; Mahmood et al., 2012 and Mohapatra et al., 2015).

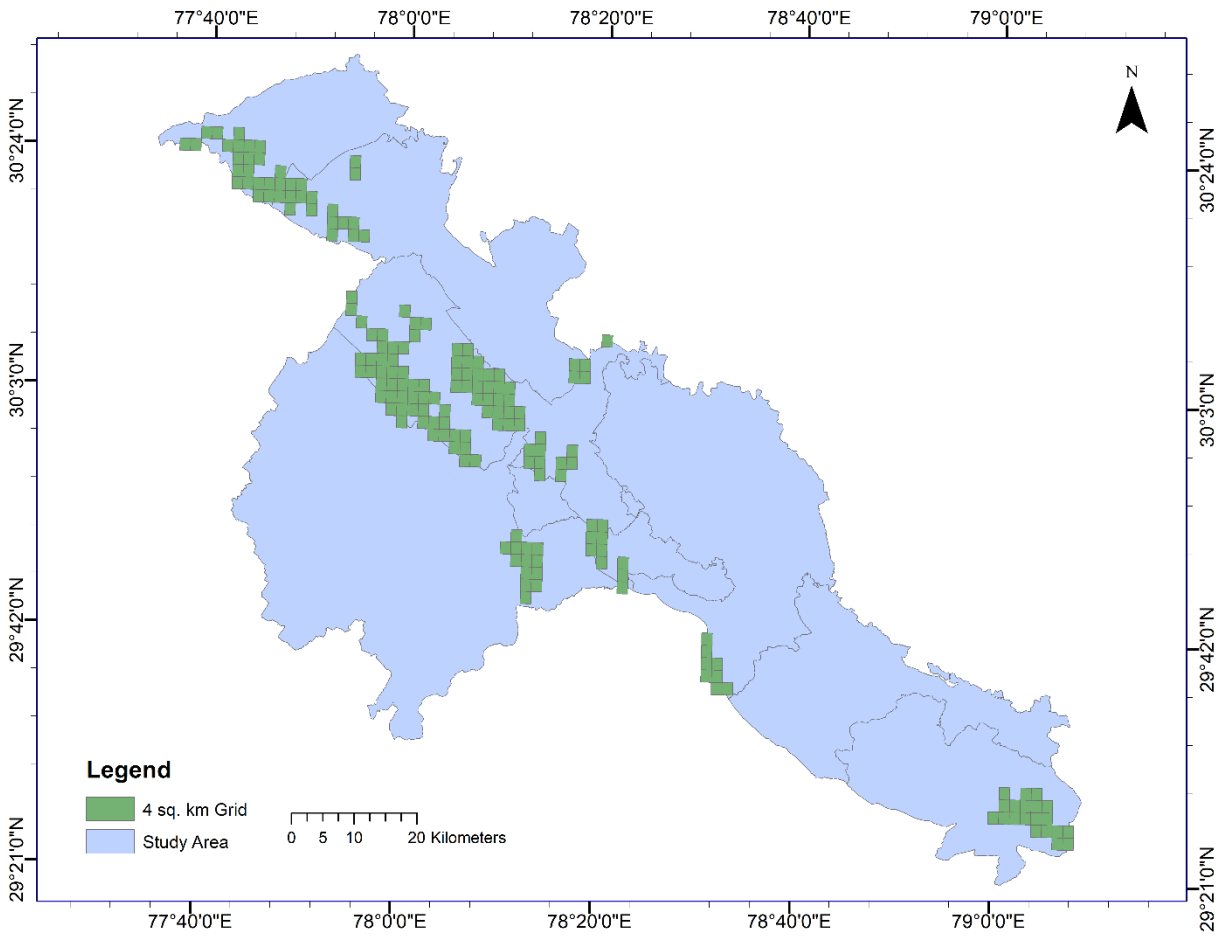
The distribution range of the Indian pangolin is known to be found in the Terai and Bhabar area, in the lower Shivalik hill in the state in the Uttarakhand (IUCN, 2020). The presence of the species in the Uttarakhand state has been recorded from Corbett Tiger Reserve (CWC, 2012), Nandhaur Wildlife Sanctuary (UKFD, 2011), Rajaji Tiger Reserve (UKFD, 2012), Motichur-Kansrao-Barkot Wildlife Corridor (Joshi et al., 2010) and Motichur-Gohri Wildlife Corridor (Joshi et al., 2010). Indian pangolin has been rescheduled from Appendix II to Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2016) as it became one of the most trafficked species throughout its distribution range. In India, this species became the most trafficked mammalian species due to mass level poaching for body scales and meat. The account of pangolin trafficking in India is recorded in three studies (Mohapatra et al., 2015, Chaudhary et al., 2018 and Tiwari et al., 2020), these studies have quantified the rate of trafficking based on the data of trade seizures. These published studies have shown that Uttarakhand state is becoming a hotspot of illegal trade of pangolin in India as the percentage contribution of trade seizure is increasing from 4.08% in the year 2009-14 (Mohapatra et al., 2015) and 6% in the year 2009-17 (Chaudhary et al., 2018) to 12% in the year 2009-18. There are two records of Indian pangolin mortality, both due to the accident from a vehicle at Motichur, RTR in 2010 (Joshi and Dixit, 2010) and Jhilmil Jheel Conservation reserve, HFD in 2017 (Badana, 2017).

Although there is some information available in the published literature regarding the presence and threats to Indian pangolin in Uttarakhand state, yet this information is not sufficient to find the conservation solution for the species. Information regarding current distribution, suitable area and other threats to pangolin in Uttarakhand is lacking. Therefore, the present chapter is aimed to find the current distribution of the species and how much potential area is available for the species in the study area as well as to identify the significant threats behind their population declination and also to find the hotspot of threats.

4.1 Method:

4.1.1 Site selection and study design:

Reconnaissance surveys were done to identify the potential area of intensive searches for Indian pangolin. The reconnaissance survey was based on the interviews of forest department employees, community people and villagers. The department employees, community people and villagers were asked about their past sighting, past camera trap capture, unnatural mortality events and rescue event related to the study species. The information gathered through the reconnaissance survey was used for the selection of the study site. The identified



area based on the reconnaissance survey was selected for the intensive search for the species and overlaid with four km² spatial grids (n=180; refer figure 1).

4.1.2 Data collection:

For the determination of the distribution of Indian pangolin in the study area, occurrence data of Indian pangolin was collected from two standard ecological methods i.e. sign survey method and secondary data information. A sign survey was done using a stripe transect method following Mahmood et al. 2015, in which a trail of variable length with a fixed width of 30-meter was walked to record pangolin occurrence through signs such as living/resting burrows (active and abandoned), feeding sign and fecal pellets. Total 139 random trails of variable length (3-5 km) and fixed-width (30-meter) were walked in the intensive study area; a total of 474.75 km effort was made during the survey to find pangolin presence signs in the study area. Also, the site of the presence of Indian pangolin was collected from secondary sources such as previous study, forest department camera trap data and past sightings. These gathered presence locations from the primary survey and secondary data information were used to map the distribution of Indian pangolin in the study area.

For the identification and quantification threats to Indian pangolin in the study area, the questionnaire survey method was used. In this, data on threats were collected using structured and close-ended questionnaires (n=150) with frontline forest staff. The main objective of the questionnaire survey was to identify significant threats faced by the species and to quantify these threats. In the questionnaire survey, we collected data on the sightings of species, illegal poaching and other unnatural deaths by vehicle, forest fire, or hunting by community peoples. Other than the questionnaire survey, information on poaching cases and other unnatural deaths were also collected from forest department officials and literature.

4.1.2 Analytical method:

The potential distribution area of Indian pangolin was estimated through presence data only maximum entropy species distribution modeling using MaxEnt software version 3.4.1 (Phillips et al. 2006). A series of environment variables such as forest type, forest cover, elevation, slope, terrain ruggedness and disturbance (nightlight) were used in this species distribution modeling. Combining features (Linear, product, quadratic, hinge and threshold) and regularization multipliers (6; 1-6) and default 'Auto' feature (with default regularization multiplier; 1), we assessed total 31 models for this study. The best fit model was opted on the lowest AIC based model selection approach (Burnham and Anderson, 2002) using the

ENM tool version 1.4.4 (Warren et al. 2011). We run a new model using an opted model based on the lowest AIC value, with 30 replicates for the final prediction of the potential distribution area of Indian pangolin in the study area. The ten percentile training presence logistic threshold was selected as the threshold value for defining the species presence. This threshold value was used to reclassify our model into 'non-potential', 'moderate potential' and 'high potential' distribution areas. Calculation of the area of these reclassified predicted distribution areas was done using threshold value using software ArcGIS 10.5 (ESRI).

Response curves derived through the model were plotted to know how each variable influences presence probability. We also used Jack-knife sensitivity analysis to estimate the actual contribution by each variable. Another analysis of data was done using Excel (Microsoft Office, 2016).

4.2 Result:

4.2.1 Distribution:

4.2.1.1 Pangolin Occurrence Survey:

A total of 15 forest ranges of six forest divisions were searched for the presence of Indian pangolin. Out of which occurrence of Indian pangolin was recorded from 13 forest ranges of the studied area i.e. Dhaulkhand, Beribada, Chillawali, Haridwar, Motichur, Chilla and Kansrao ranges (Rajaji Tiger Reserve), Rasiyabad range (Haridwar forest division), Kotdi range (Lansdowne forest division), Asarori and Malhan ranges (Dehradun Forest Division), Timli range (Kalsi Forest Division) and Bijrani range (Corbett tiger reserve).

In this intensive search of Indian pangolin in all 15 ranges, a total of 474.75 km efforts were made in which 132 locations of Indian pangolin presence (Living burrow and feeding sign) were recorded. The overall encounter rate of Indian pangolin occurrence sign is calculated 0.28 sign per km, in which the encounter rate of living burrow and feeding is calculated 0.1 (n=49) and 0.18 (n=83) sign per km, respectively. In these surveys, feeding signs (n=83) were found in higher numbers than living burrow (n=49). Also, 56 pangolin presence locations were collected from secondary data sources. All these locations are obtained from two data sources i.e. Forest department and previous studies from the same study area. In this 44 pangolin presence locations (Sighting, camera trap capture and un-natural mortality record) are collected from the forest department and 12 pangolin presence locations are obtained from a previous study 'Population genetic structure and tracking poaching cases of Indian pangolin (*Manis crassicaudata*) from Uttarakhand' conducted by Wildlife Institute of India in 2017-19 (Refer Table 1 and figure-2).

Table 1: Account of Pangolin Occurrence information of Studied area.

Sr. No.	Forest Division	Range	Encounter Rate	Living Burrow	Feeding Sign	Secondary Data Information	Total
1	Corbett Tiger Reserve	Bijrani	0.11	0	6	2	8
		Pakhrau	-	-	-	1	1
		Sarpduli	-	-	-	1	1
2	Dehradun	Asharodi	0.07	0	1	3	4
		Jhajhara	0	0	0	0	0
		Malhan	0.10	0	3	1	4
3	Haridwar	Chidiyapur	-	-	-	3	3
		Rasiyabad	0.66	10	11	8	29
		Shyampur	-	-	-	2	2
4	Kalsi	Choharpur	-	-	-	1	1
		Timli	0.15	0	7	4	11
5	Lansdowne	Laldhang	0	0	0	0	0
		Kotdi	0.1	1	1	1	3
6	Rajaji Tiger Reserve	Beribada	0.99	11	20	3	34
		Chilla	0.83	8	5	4	17
		Chillawali	0.58	2	4	6	12
		Dhaulkhand	0.48	5	10	0	15
		Gohari	0	0	0	0	0
		Haridwar	0.15	3	0	3	6
		Kansrao	0.22	3	4	6	13
		Motichur	0.40	5	11	6	22
		Ramgarh	0	0	0	0	0
		Ravasan	-	-	-	1	1
Total			**0.28**	**48**	**83**	**56**	**187**

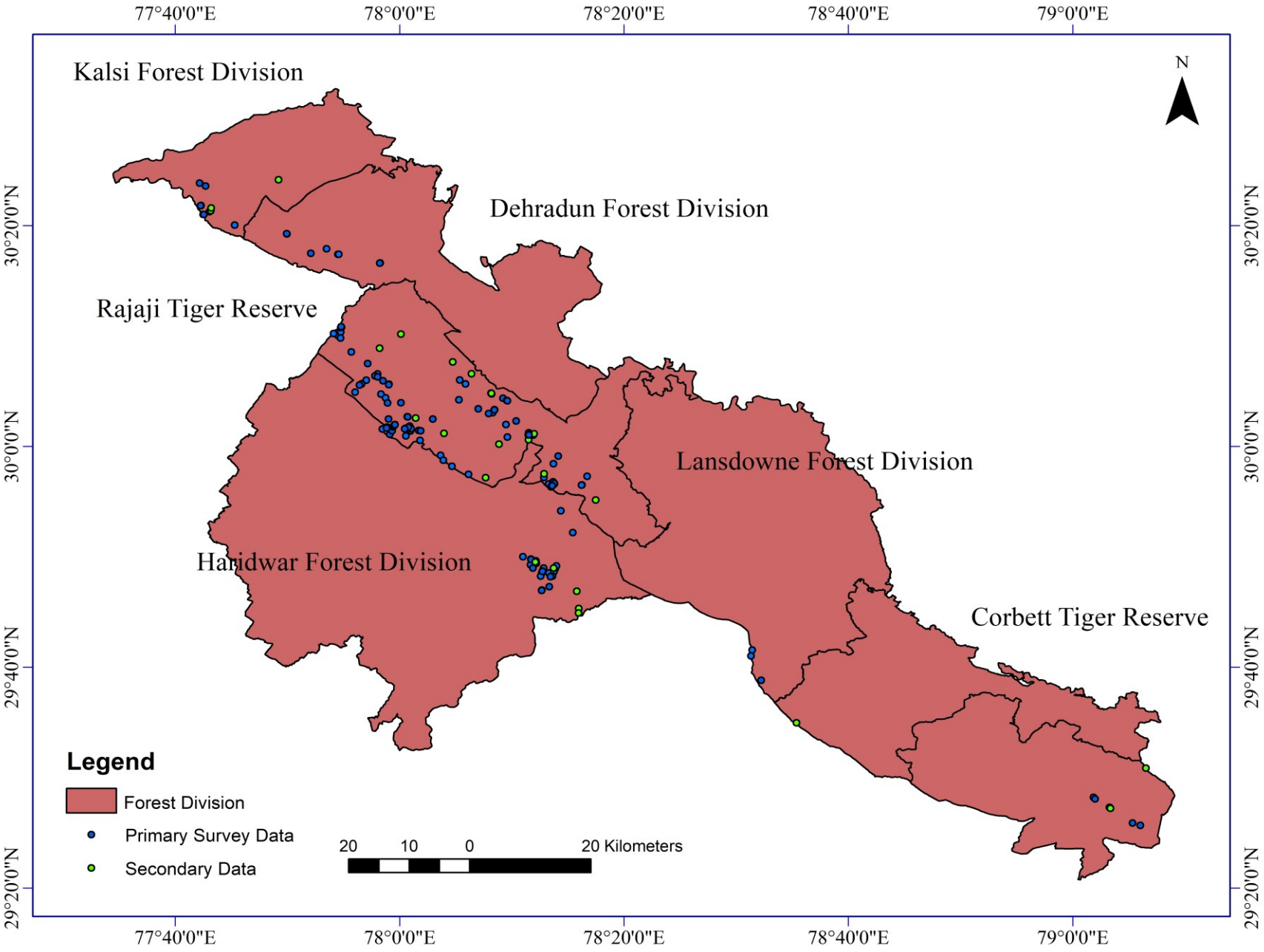


Figure-2: Locations of pangolin occurrence in study area recorded through sign survey and secondary information.

4.2.1.2 **Model Selection:**

The occurrence of Indian pangolin was recorded at 188 locations within the study area. Combining 'Feature' with 'Regularization Multiplier', a total of 31 models were run and their AIC and AICc values were calculated using 'ENM Tool' (Warren et al. 2011) 'Model selection' function. The best fit model was selected based on minimum AICc value instead of minimum value as the ratio of the sample size and the number of parameters is less than 40 (Burnham and Anderson, 2002). The model with the 'threshold' feature and 'one' regularization multiplier (AIC 4182.27 and AICc 4201.71) was opted as a best-fit model to estimate the potential distribution of the species. The ten-percentile training presence logistic threshold calculated from the model is 0.238.

4.2.1.3 **Distribution Prediction:**

Our model showed high levels of predictive performances as can be seen from the value of area under curve > 0.9 (0.971). The Maxent model suggested that there is suitable pangolin habitat within the areas chosen for the investigation of the Indian pangolin habitat (Refer Figure 3). The classified map discriminated between areas typically high potential & moderate potential for the Indian pangolin and those considered non-potential in the study area (Refer figure 4). The most potential areas of distribution identified from the model were located within forested land and overall, mainly within protected areas and areas with moderately human disturbance surrounding them. The model suggested that there was less suitable habitat in higher altitude areas with steep slopes and human habitation.

The model estimated 19.30 % (1295.37 km²) area as potential distribution area of Indian pangolin in the study area in which 3.96 % (266.13 km²) and 15.34 % (1029.24 km²) area was identified as high and moderate potential respectively (Refer figure 4) and left 76.09 % (5416.69 km²) area was identified as non-potential for Indian pangolin. According to the total forest-covered area (4023.71 km²) (excluding non-forest area and water) in the study area, the total potential area estimated for the Indian pangolin is 32.19 % in which 6.61 % and 25.58 % area are high and moderate potential respectively.

In the study area, Rajaji Tiger Reserve has high percentage of potential area (44.65 %, 382.42 km²; Refer Figure 7b) following Corbett Tiger Reserve (30.42 %, 387.63 km²; Refer Figure 5a), Kalsi Forest Division (16.27 %, 70.64 km²; Refer Figure 6b), Dehradun Forest Division (14.83 %, 126.39 km²; Refer Figure 5b), Haridwar Forest Division (13.61 %, 271.81 km²; Refer Figure 6a) and Lansdowne Forest Division (4.43 %, 57.39 km²; Refer Figure 7a). Rajaji Tiger Reserve has the most potential area according to area percentage,

while Corbett Tiger Reserve has the most potential area of Indian pangolin according to total area.

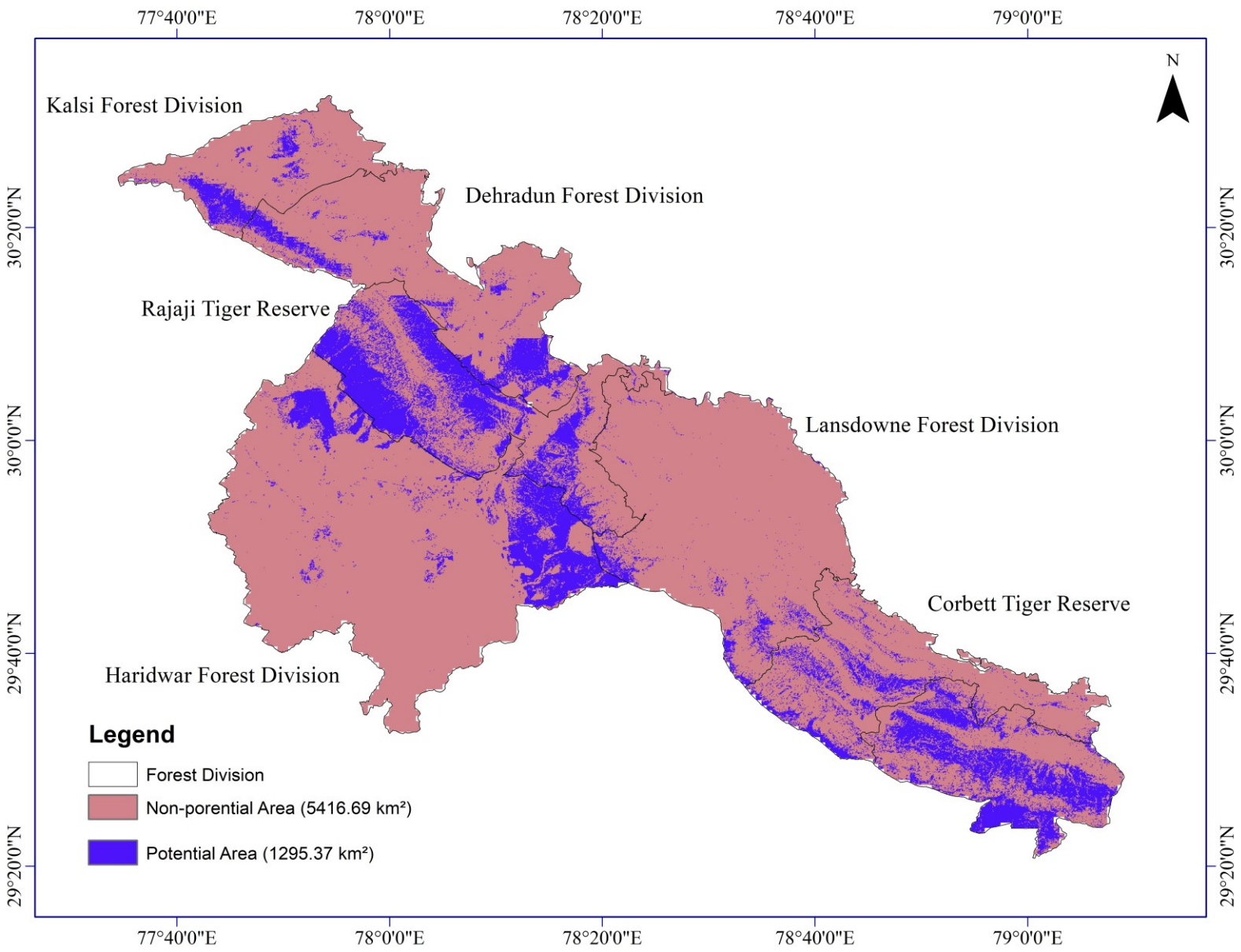


Figure 3: Predicted Potential Distribution Area of Indian pangolin in the study area.

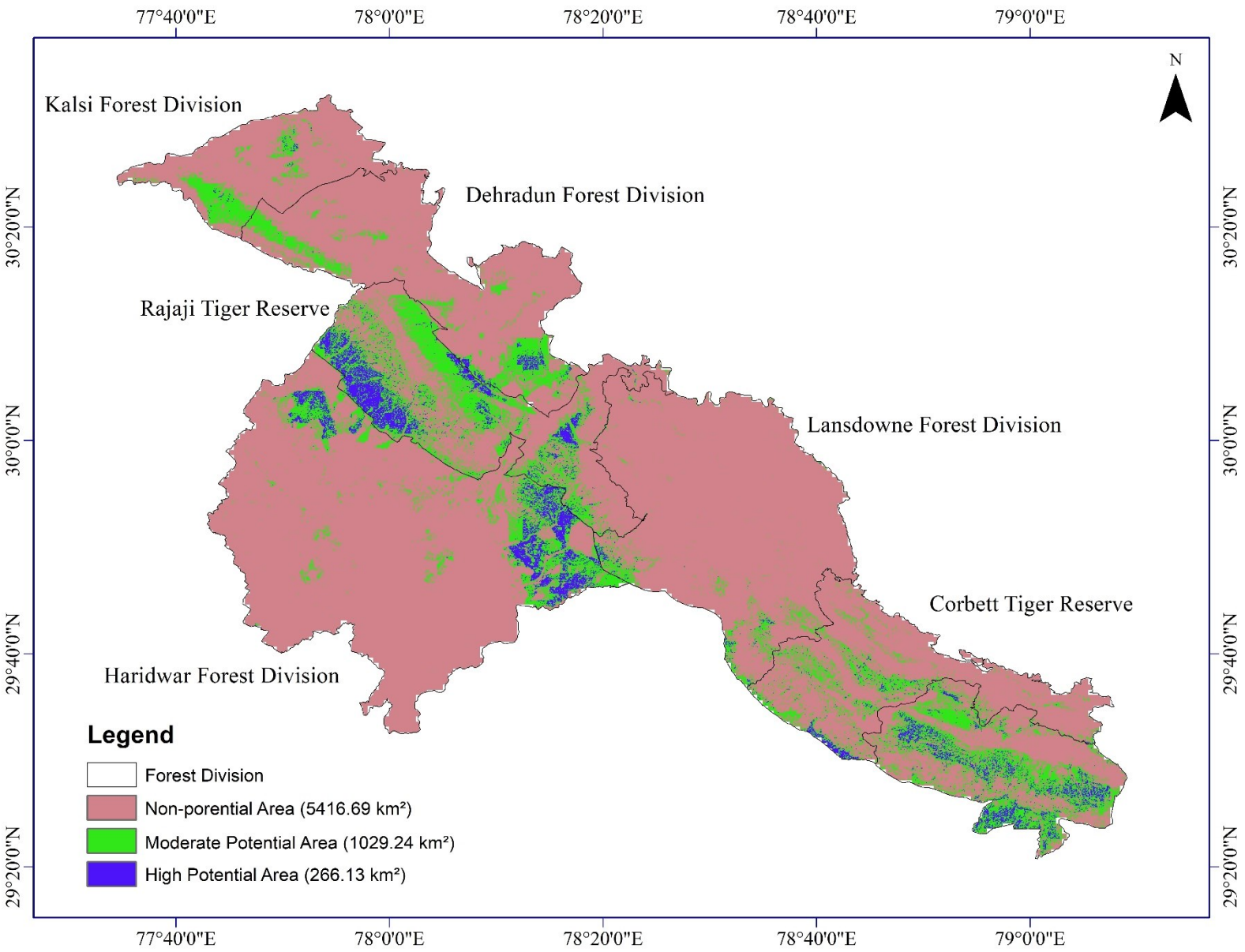


Figure 4: Predicted High and Moderately Potential Distribution Area of Indian pangolin in the study area.

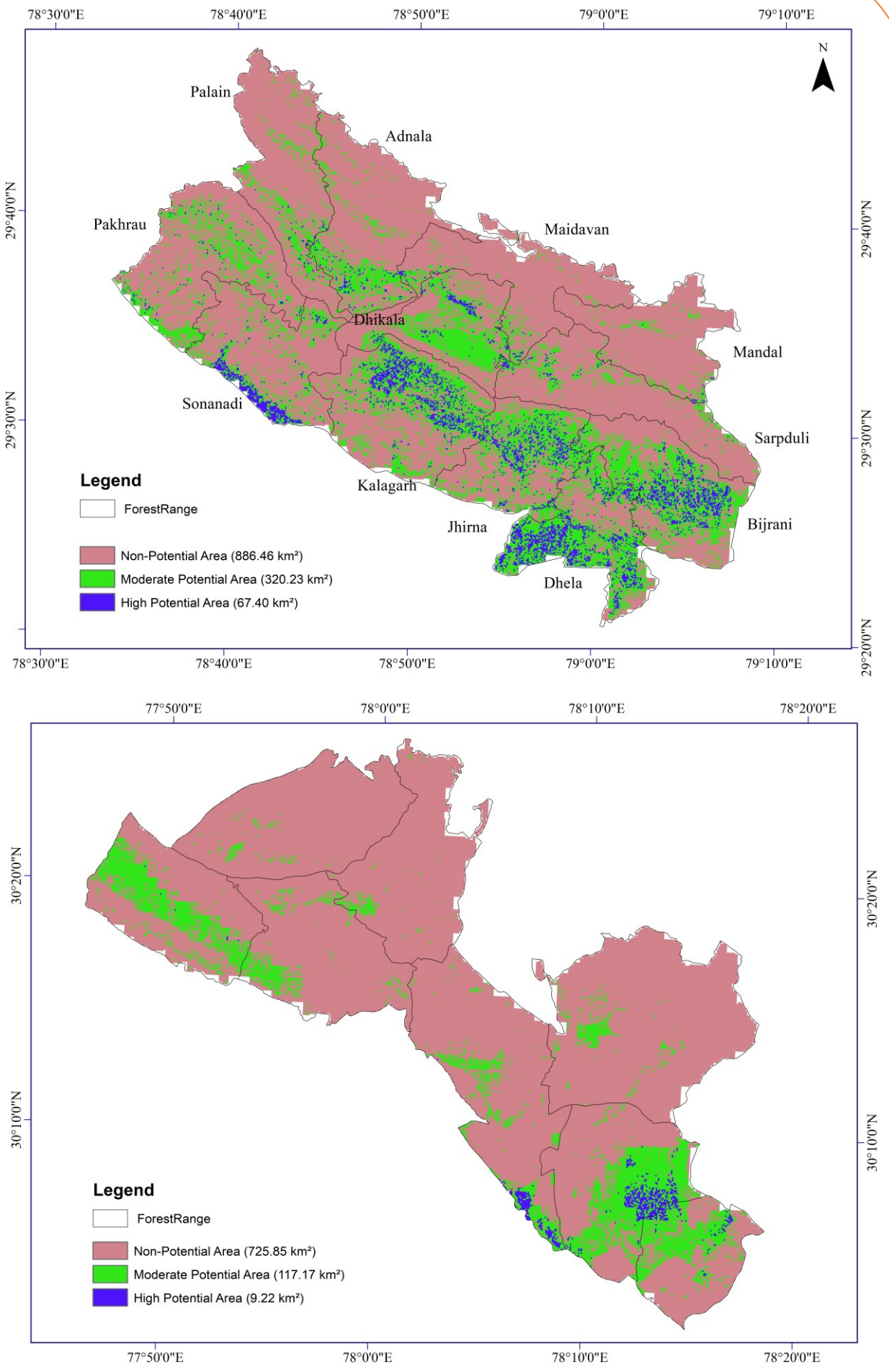
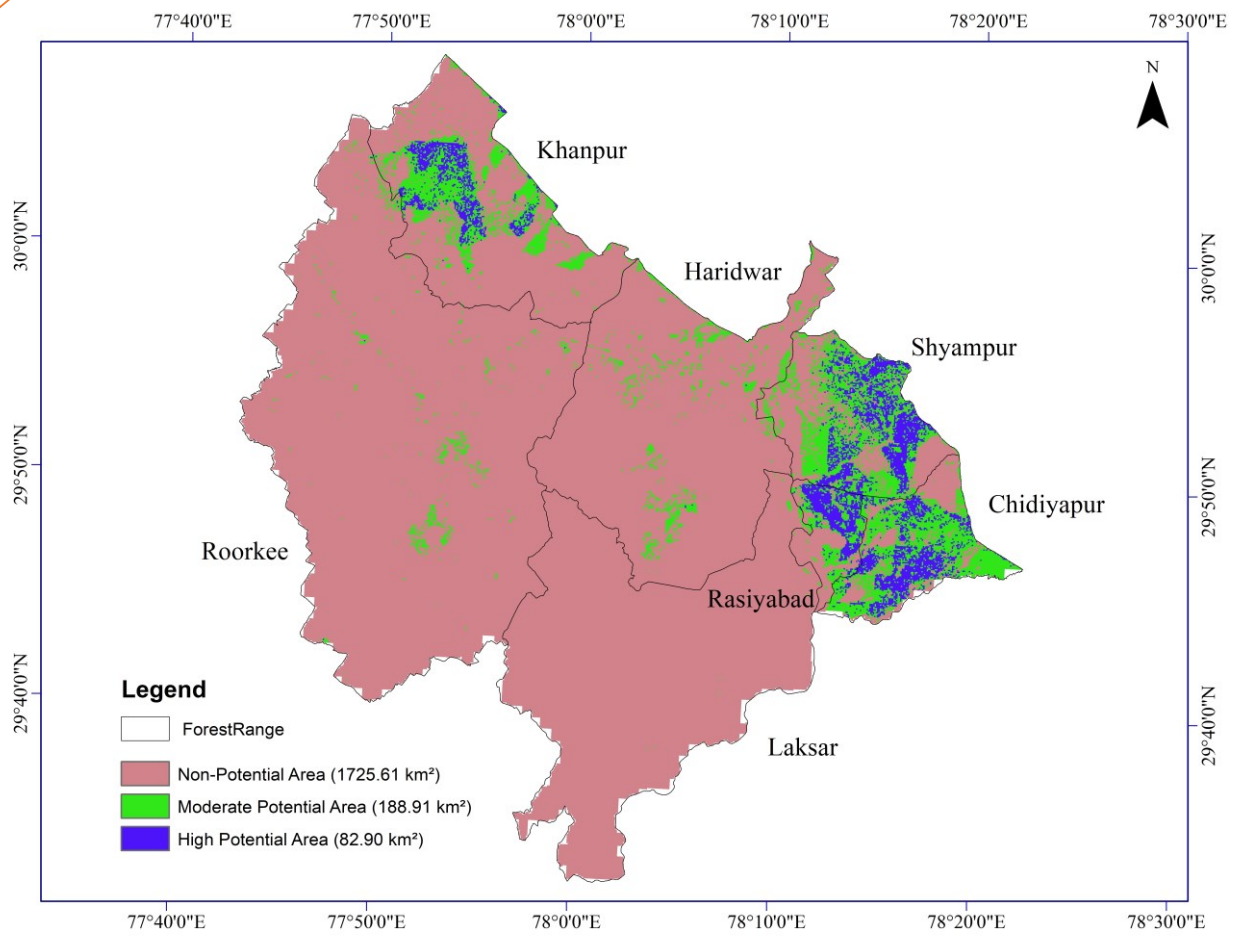


Figure 5: Predicted Potential Distribution Area of Indian pangolin in a) Corbett Tiger Reserve b) Dehradun Forest Division



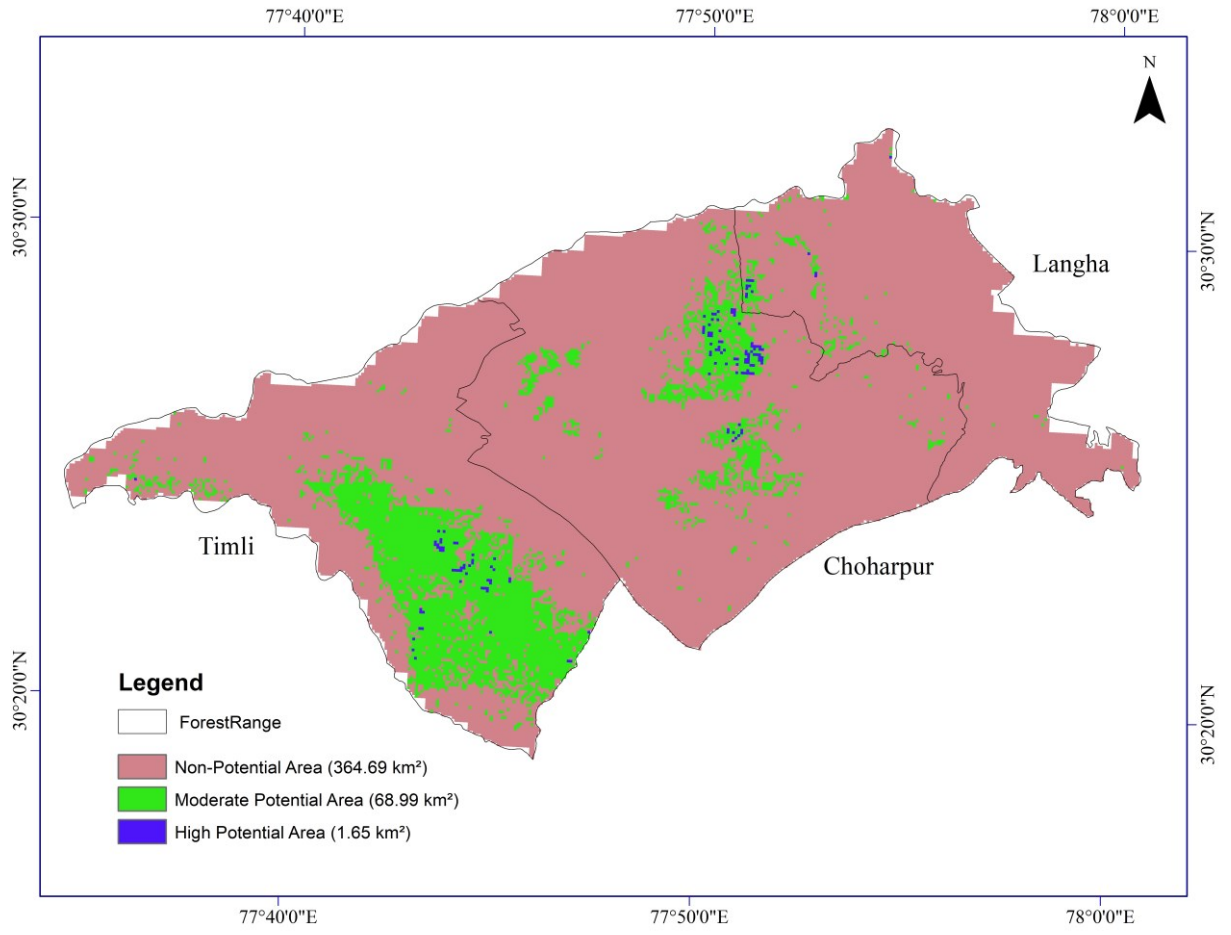
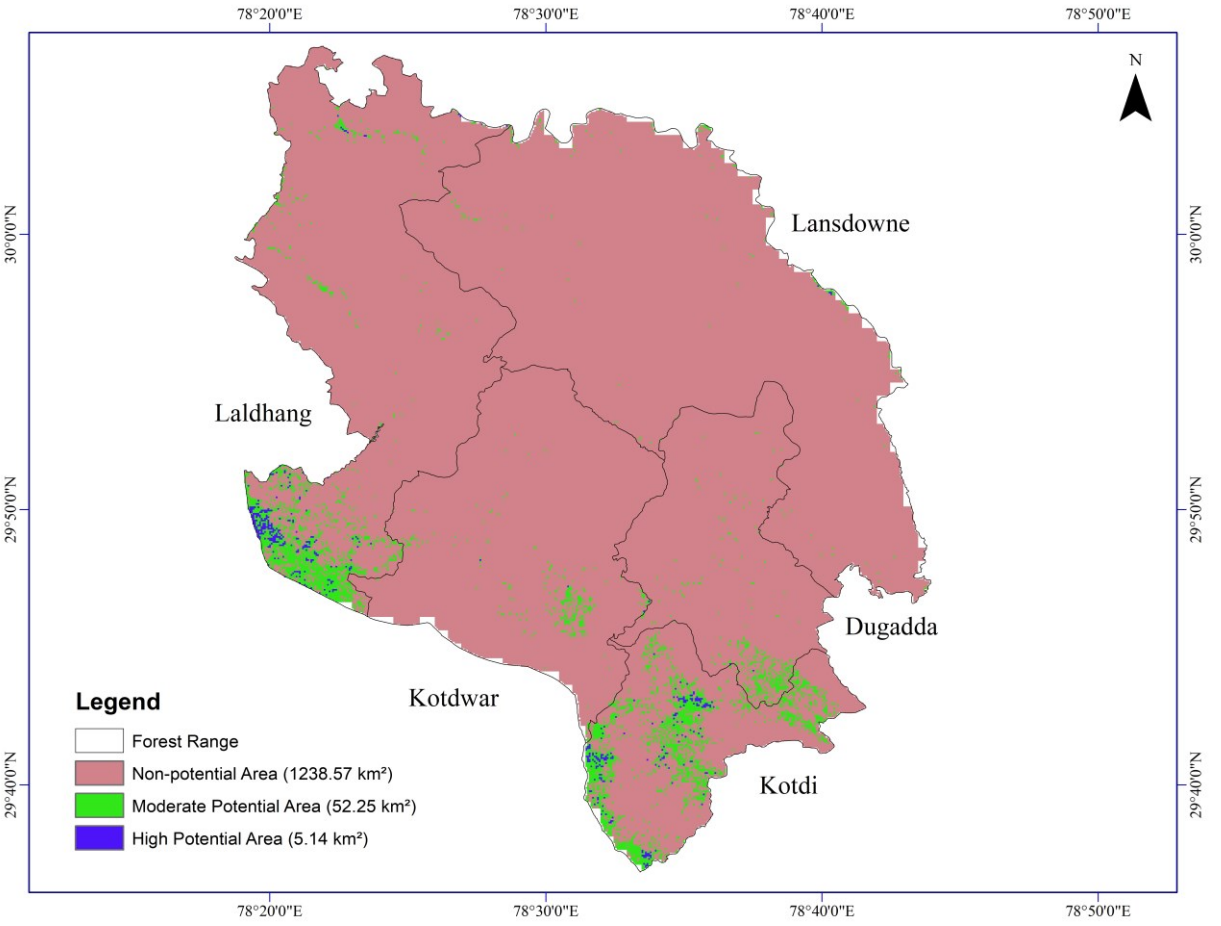


Figure 6: Predicted Potential Distribution Area of Indian pangolin in a) Haridwar Forest Division b) Kalsi Forest Division



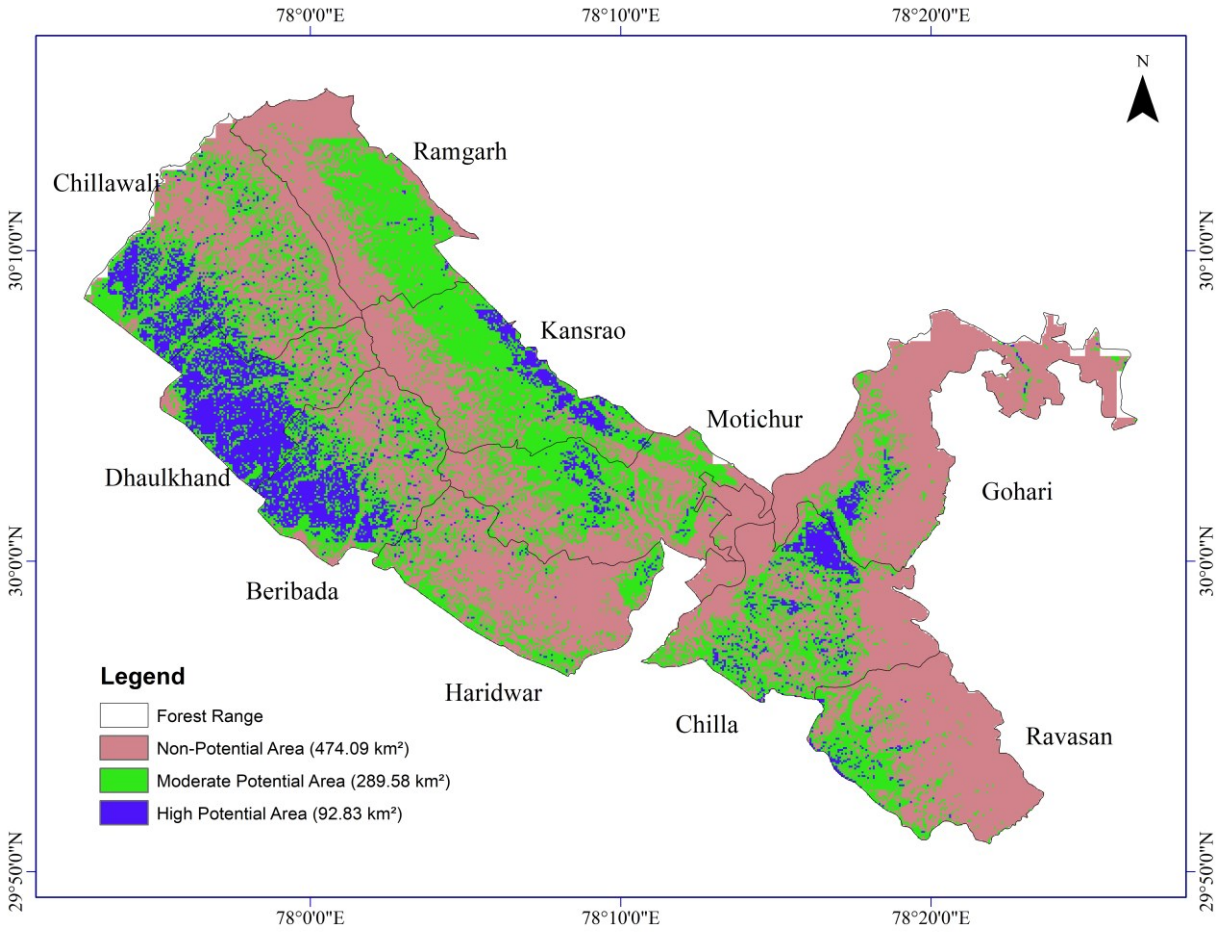
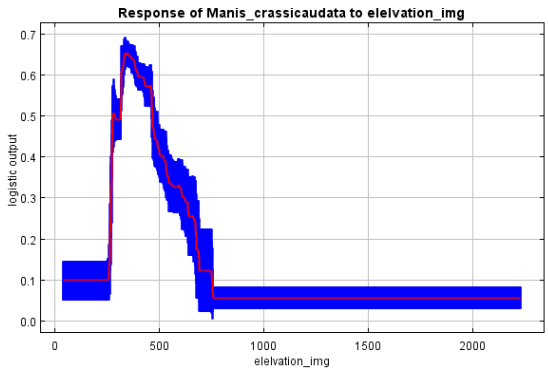


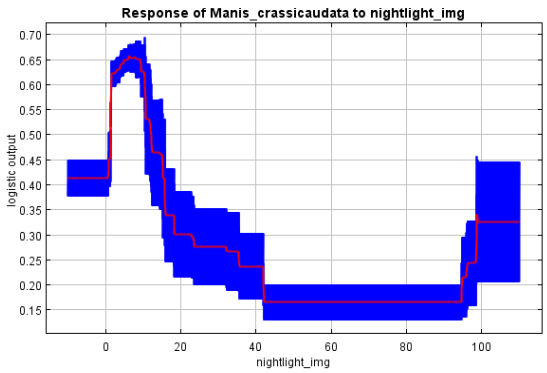
Figure 7: Predicted Potential Distribution Area of Indian pangolin in a) Lansdowne Forest Division b) Rajaji Tiger Reserve

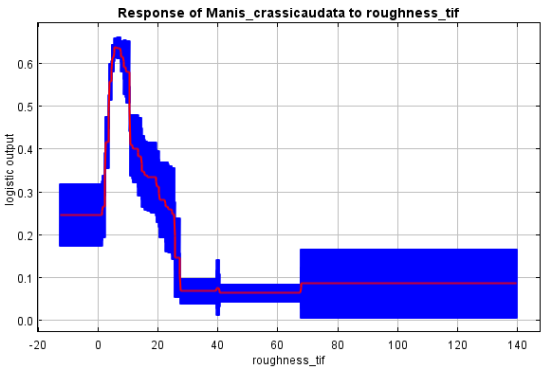
4.2.1.4 Response Curve:

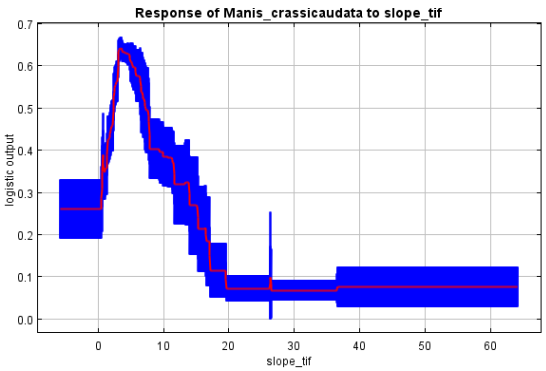
Response curves showed how the predicted probability of presence changes as each environmental variable is varied, keeping all other environmental variables at their average sample value. The thresholds of all environmental variables were obtained from the model (refer Figure 8 a-f). The elevation ranged between 222 m to 750 m (Figure 8a), the slope ranged between 0° to 20° (Figure 8f), The terrain ruggedness ranged between 0 to 27 (Figure 8c), the nightlight ranged between 0 to 42 and 95 to 100 light per unit area (Figure 8b), the forest cover ranged in Open Forest, Moderately dense Forest and Very dense Forest (Figure 8f) and the forest type ranged West Gangatic Moist Mixed Deciduous Forest, Dry Plains Sal Forest, Khair Sissoo Forest and Plantation/TOF (Figure 8e).

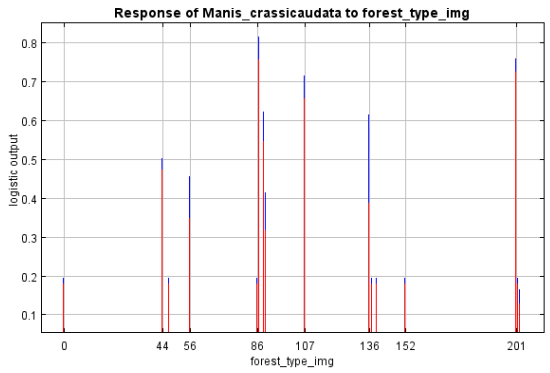
In the study area, the pangolin distribution range was likely to lie between the altitudinal range of 250-750 meters, gentle slopes less than 27° (maximum in areas with slope <20°), and low anthropogenic disturbance. Distribution was widely found in Dry Plains Sal Forest, Khair-sissoo and plantations forest types and open and moderately dense forest.











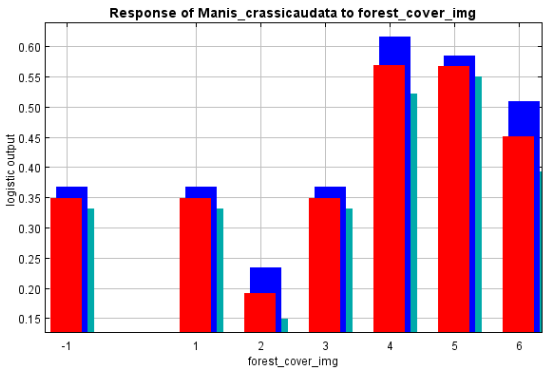


Figure 8: Response curve of the six ecological variables a) elevation b) nightlight c) terrain ruggedness d) slope e) forest type and f) forest cover

4.2.1.5 Variable Contribution:

The importance of environmental variables to the potential distribution of Indian pangolin was evaluated by the jack-knife procedure using MaxEnt. The AUC results on the test data are shown in figure 9. Forest Type (24.8%), Elevation (19.4%), Terrain roughness (19%) and Nightlight (16.2%) contributed the maximum to the distribution prediction model while Slope (12.4%) and Forest Cover (8.3%) contributed relatively little.

The Elevation is the most important environmental variable affecting the potential distribution of Indian pangolin, with an AUC value above 0.77 followed by Terrain roughness (AUC 0.76), Forest Type (AUC 0.75), Slope (AUC 0.74), nightlight (AUC 0.71) and Forest Cover (AUC 0.69). Therefore, Elevation, Terrain roughness, Forest Type and Slope are the four most important variables for predicting the potential distribution of Indian pangolin in the study area.

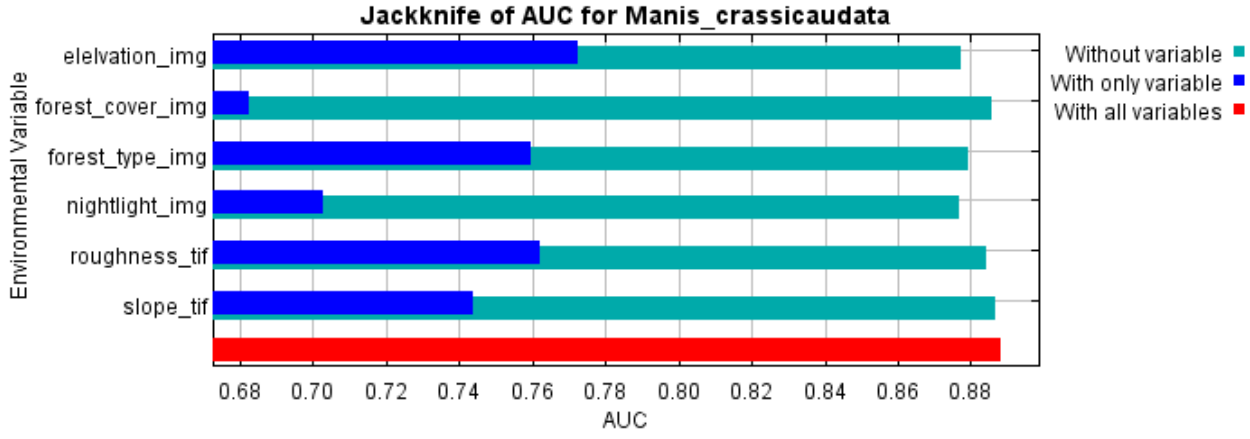


Figure 9: The results of the jack-knife procedure on AUC for Manis crassicaudata in the study area

4.2.2 Threats to Indian pangolin:

The information collected through the questionnaire survey and secondary data from the forest department was compiled and analyzed to identify and quantify the threats to the Indian pangolin in the study area. Based on the information collected, three causes of un-natural mortality of the species have been recorded i.e. trafficking, road trampling and forest fire. In this, a total of 28 trafficking and un-natural mortality events having been recorded since 2008 in which poaching (n=18) events were maximum followed by road trampling (n=9) and forest fire (n=1). In total, 18 trafficking events 68.15 kg of scales, three whole dead pangolins, and three live pangolins have been recovered, which is equal to the sum of 74 pangolins (considering 1kg scales = one pangolin based on Chaudhary *et al.* 2018). Also, individual mortality of pangolin has been recorded by road trampling (9) and forest fire (1) events. In context to both mortality event and number, trafficking (64.29 % and 88.10 %) has been identified as a significant threat to Indian pangolin in the study area following road trampling (32.14 % and 10.71 %) and forest fire (3.57 % and 1.19%).

In the study area, the maximum no. of trafficking and un-natural mortality events have been recorded from Rajaji Tiger Reserve (n=15; 53.57 %) followed by Central Terai Forest Division (n=4; 14.29 %), Kalsi Forest Division (n=4; 14.29 %), Dehradun Forest Division (n=2; 7.1 %), Haridwar Forest Division (n=2; 7.1%) and Corbett Tiger Reserve (n=1; 3.57 %) (Refer figure 10 and 11).

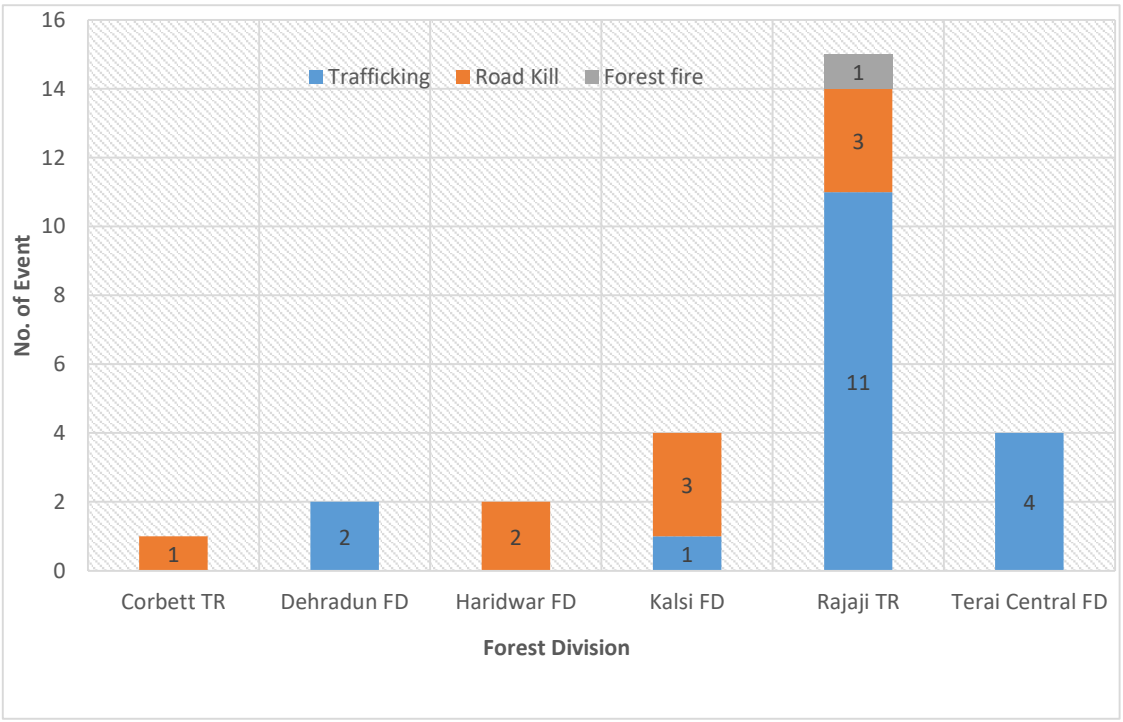


Figure 10: Trafficking and un-natural mortality events of Indian pangolin since 2009.

The trafficking events/cases of Indian pangolin in the study area are recorded from Rajaji Tiger Reserve (n=11), Kalsi Forest Division (n=1), Dehradun Forest Division (n=2) and Central Terai Forest Division (n=4). In this, equal to 74 individual pangolins have trafficked between the year 2012 to 2020. The maximum number of trafficked pangolins is recorded from Rajaji Tiger Reserve (55; 74.32 %) following Dehradun Forest Division (11; 14.86 %), Central Terai Forest Division (6; 8.11 %) and Kalsi Forest Division (2; 2.70 %). Also, a total of nine Indian pangolins have died in road trampling between the years 2008 to 2017, of which maximum occurred in Rajaji Tiger Reserve (n=3) and Kalsi Forest Division (n=3) followed by Haridwar Forest Division (2) and Corbett Tiger Reserve (n=1).

In Context to both trafficking and road trampling, Rajaji Tiger Reserve has been found as a hotspot of the threat to Indian pangolin in the study area following Dehradun Forest Division & Central Terai (Trafficking) and Kalsi Forest Division & Haridwar Forest Division (Road Trampling).

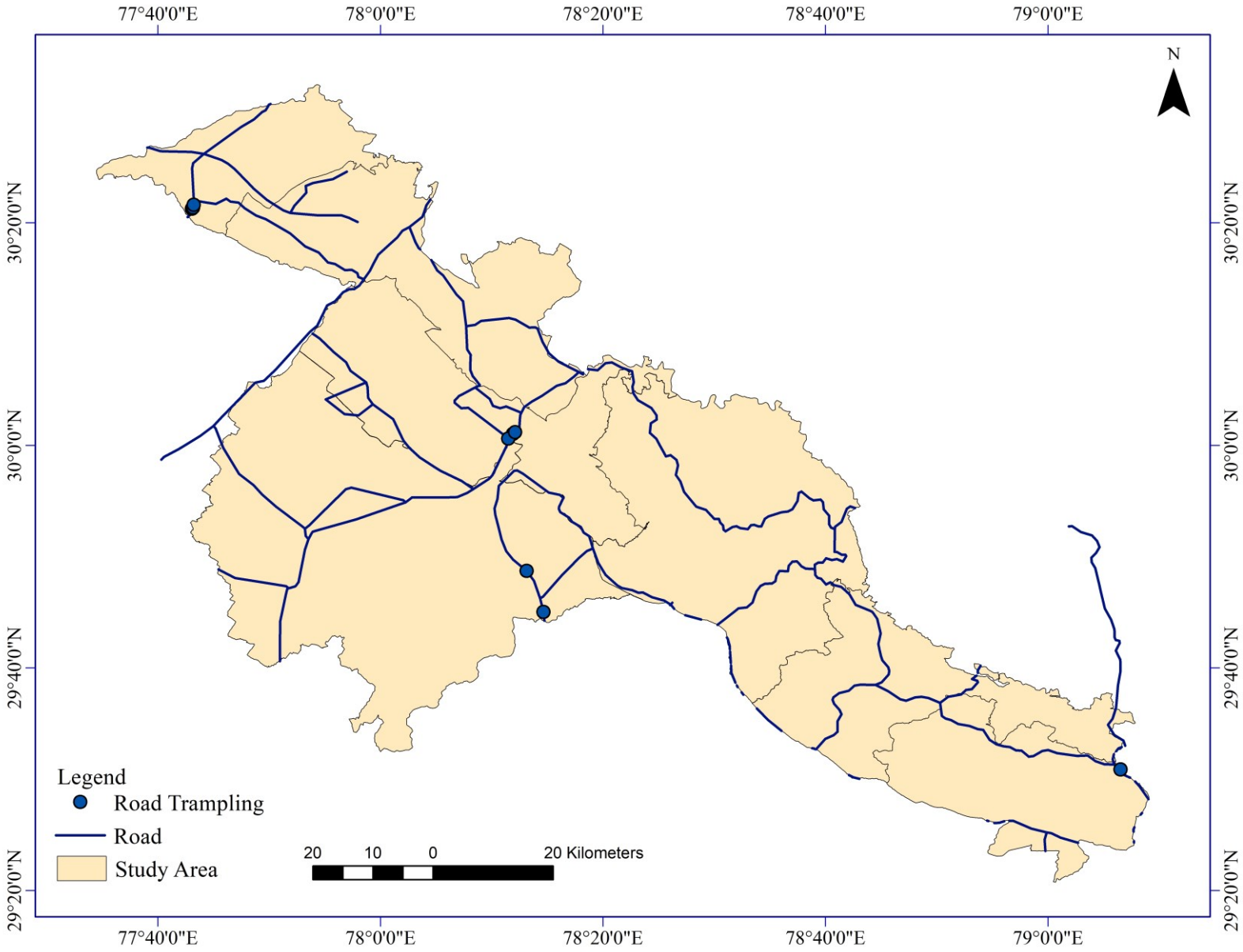


Figure 11: Location of road trampled Indian pangolin in the Study area since 2008

Discussion:

Indian pangolin is a habitat generalist species; they are found across many terrestrial habitats (Saxena, 1986; Roberts, 1997; Chakraborty et al., 2002). This study represents the first large scale assessment of Indian pangolin distribution in Uttarakhand state as well as in India. According to the occurrence data obtained from field survey and secondary data information, we obtained the potential distribution area of Indian pangolin in the study area based on the MaxEnt model and other GIS tools. We have found the presence of pangolin up to an elevation of 679-meter in the different habitats of the study area, including dense sal forests, Khair-sissoo forest, open grasslands, hill-top and mid of sloppy Shivalik ridge.

Our model found that 19.30 % of the total study area and 32.19 % of the whole forest-covered area (i.e. forest-covered area is 59.94 % of the total study area) is the potential site for Indian pangolin distribution in the study area. The model also found that most of the potential areas for species are located in the moderately elevated forest areas where human disturbance is minimal or null. Maximum high potential areas are found in Rajaji Tiger Reserve, Haridwar Forest Division and Corbett Tiger Reserve. These areas are well protected and have large forest areas with a mix of plain and undulating terrain. The Indian pangolin prefers to live in plain-undulating habitat and they need minimal requirements such as annual water supply, abundant prey and loose earth substratum (Mahmood et al., 2014; Pabasara et al., 2015), these habitat characteristics and requisites were noticed in these high potential areas.

The relationship between the species and environment was a significant factor for studying the spatial distribution of the ecological needs of the species (Yi et al., 2018; Yan et al., 2016a, 2016b). The results showed that elevation and Terrain ruggedness were the primary variables affecting the distribution of Indian pangolin in the study area. Our model predicted the presence of Indian pangolin up to the elevation of 750 meters while the sightings have been reported up to 2300 meters (Hutton, 1949). Other environmental variables such as Nightlight and Forest cover were among the variables that affected least to the distribution of Indian pangolin in the study area. In the study area, Indian pangolin also prefers specific forest types, especially West Gangetic Moist Mixed Deciduous Forest, Dry Plains Sal Forest, Khair Sissoo Forest types. Although, Indian pangolin is not a vegetation dweller species unlike to some pangolin species (White-bellied, Black-bellied and Philippine pangolin) but plant species like tree and shrubs form essential components of its habitat (Mahmood et., 2014). The presence in specific forest types might be due to that these forests are less dense and allow pangolin to move easily. Also, the micro-climatic environment present in these forest types is favorable for their prey and to make burrows. This species tolerates low to high anthropogenic disturbance and can be found near the human

settlement (Saxena 1986), our model predicted the same that the species is found in low to high nightlight zone which shows that the species is not affected by anthropogenic activities.

Our results showed that trading of live pangolin and its body parts is a major threat to Indian pangolin in the study area. Despite legal protection, trafficking and trade of body parts continue to occur in the Uttarakhand state, which leads to mass level population declination in the state. In total, equal to 74 Indian pangolins (based on seizures) were killed and captured live between the year 2008 to 2020. The pangolins were killed and captured for international pangolin scale trade, local meat consumption and superstitious believes. During the study, it was found that pangolin meat was consumed by a local community named '*kanjar*' and local people also use rings made of pangolin scale to cure piles. There are some records of consumption of pangolin parts such as scales, meat and bile for medicinal use by local tribes in India (Dixit et al., 2010; Kulkarni and Deshpande, 2011; Chinlampianga et al., 2013; Bagde and Jain, 2013).

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Chapter 5

Survey method for monitoring of Indian pangolin

5.1 Introduction and Background:

Indian pangolin (*Manis crassicaudata*) is a highly trafficked mammalian species in India (Chaudhary *et al.*, 2018) and whose current status is unknown. Indian Pangolin is listed under the 'Endangered' category of the IUCN Red List of Threatened Species (IUCN, 2019). The species is majorly threatened due to overexploitation for the illegal international trade for scales & other body parts and regionally for superstitious believes (Bhandari *et al.,* 2019). In Asia, more than 95% of the total population of pangolins is severely affected by overexploitation and illegal trade (Duckworth *et al.*, 1999). Similarly, in the last decade (2009-2018) equivalent to more than 7500 pangolins have been poached in India (Tiwari *et al.*, 2020) for illegal body part and live trade.

Detailed and reliable information about the status and spatial distribution of species provides important information for species conservation management, especially when a species is rare and of conservation interest (Qin *et al.*, 2017). To determine the species status and changes in population, survey methods play an important role but still standardized survey methods to monitor populations of many species including Indian pangolin (*Manis crassicaudata*) are not available and not reliable (Thompson, 2004; Ingram *et al.,* 2019). Many studies mentioned the use of various methods to survey Indian pangolin's population status or to assess its habitat association such as *Vehicle Survey* to search burrows (Mahmood *et al.*, 2015), *Burrow Count* using trail or transect (Mahmood *et al.*, 2014; Mahmood *et al.*, 2015; Irshad *et al.*, 2015; Pabasara *et al.*, 2015; Akrim *et al.*, 2017; Karawita *et al.*, 2018) and Opportunistic camera trap survey (Karawita *et al.*, 2018).

There are several challenges in perceiving and monitoring the species. Including detectability due to fossorial and nocturnal behavior (Willcox *et al.*, 2019), and also pangolin does not use specific or identifiable forest trails (Khwaja *et al.*, 2019) which make them difficult to detect using non-targeted survey methods. There is also an issue faced during the pangolin survey i.e. accurate identification of pangolin indirect signs and distinguishing them with sympatric species share the same habitat (Karawita *et al.*, 2018). Difficulties in monitoring pangolin lead to produce non-confident or biased information and assessment which will directly affect the management of species for its long-term conservation. For the management

of pangolin, it is important to acquire vital information about the species in its natural habitat. To achieve this goal, there is immense need to develop a protocol and set of methods which provide the guidance to assess the vital information, current status and identify potential conservation areas of the species which may help in to prepare conservation interventions for the long term survival of the species in its natural habitat.

The current chapter aimed to prepare a standardized protocol of the survey methods to monitor the Indian pangolin's status in the study area. To standardized the survey methods, a literature review-based approach was used to identify all suitable methods for the status survey. Published literature available on all eight pangolin species monitoring methods was reviewed such as '*Method for monitoring populations of pangolins (IUCN SSC Pangolin Specialist Group, 2018)*', '*Pangolin monitoring guideline for Nepal (DNPWC, 2019)*', '*Evaluating methods for detecting and monitoring pangolin populations (Willcox et al., 2019)*' and '*Evaluation of the application of methods to detect and monitor selected mammalian taxa to pangolin monitoring (Ingram et al, 2019)*'. The most appropriate methods to determine the status and monitoring of Indian pangolin were selected based on the followings i.e. feasible to perform by forest staff, precise result and also cost-efficient.

5.2. Identification of Indirect Signs of Indian pangolin:

The Indian Pangolin is an insectivore animal and feeds upon ants and termites, usually spends most of its time searching for food and digging earth's surface, mounds and logs using its long claws. Digging and feeding sings are illustrious in pangolin abundant area. Their living burrows and feeding signs have specific identifiable characteristics. The pangolin's burrow is smooth surfaced, circular (almost) in shape and 20-32 cm wide (Bhandari, 2017; Present study). They have a single entrance and a heap of soil is found at the entrance also some identifiable signs are present at the entrance of the burrows which confirms the species' burrow i.e. Claw marks, footprint, guano and scale print. Feeding sings are found in the ant's nest and termites hill,

Figure A & B: Living burrows of Indian pangolin

these feeding signs are wide-deep hole and circular. Feeding sings are found in the ant's nest and termites hill, these feeding signs are wide-deep hole and circular. Feeding sing is found in the ant's nest and termites hill, these feeding signs are wide-deep hole and nearly circular.

Figure A & B: Feeding signs of Indian pangolin

Other sympatric fossorial species i.e. Indian crested porcupine (*Hystrix indica*) share the same habitat with the Indian pangolin. There are many similarities in the appearance of burrows of both species but they can distinguish by some characteristics and sign present at advent. Indian pangolin's burrow is more smooth and surfaces are circular while porcupine's burrow is not well rounded and irregular in shape. They can be easily distinguished by the footprint, scale print, quills presence and pellets presence at the advent of burrows. One more noticeable difference is that porcupine's burrow is wider and has multiple openings.

Indian pangolin and Sloth bear (*Melursus ursinus*) both are myrmecophagy species and also share the same habitat. They both have the same foraging habit to predate upon ants and termite's nest and mounds. Both the species have their feeding signs distinguished and unique in physical properties such as shape and optimal foraging. Pangolin's feeding signs are narrow (compared to sloth bears)- deep hole and circular while sloth bear's feeding signs are much wider, large and irregularly dug.

Figure A & B: Living burrow of Indian Crested Porcupine and Feeding signs of Sloth Bear

5.3 Survey Methods:

To collect the data for presence/absence for determining the status and monitoring of the population of Indian pangolin two types of survey methods are used i.e. field-based survey and questionnaire-based survey.

5.3.1 Field-Based Survey Method:

5.3.1.1 Sign Survey:

The sign survey methods are very useful to collect the occurrence data of rare and elusive animal species efficiently (Willcox *et al.*, 2019; IUCN Pangolin SG, 2019). Sign survey is logistically easy and also not dependent on the direct detection of the species. This method is widely used to investigate the presence of pangolins across the globe (Mahmood *et al.*, 2015; Akrim *et al.*, 2017; Karawita *et al.*, 2018; Maurice et al., 2019) as pangolins are nocturnal species and elusive.

5.3.1.1.1 Data collection using sign survey method:

Information on indirect signs of any species can be accumulated using the sign survey method. In this method, 3 spatial replicated transect of 8-10 km are laid in the 'Beat' (basic unit of a forest division) and searched for the indirect signs of the study animal. While walking on transects all indirect evidence of Indian pangolins such as living burrow, feeding sign, scale

print, faecal material and footprint should be recorded. Indian pangolin does not optimally use the forest trails for a transition like other animals such as felids and canids hence the random transect should be preferred for the pangolin indirect sign information areas as well as along trails. All other related information on animal signs such as GPS location, type of sign, age of sign and measurement is shall be recorded accordingly and the need for the study objective (Datasheet: I). The suitable time for sign survey for pangolins is November to June when grass and herb density is low.

5.3.1.2 Camera Trapping:

Camera trapping is a powerful and now widely used tool in scientific research on wildlife ecology and management (Rovero and Zimmermann, 2016). It provides a unique opportunity for investigating the presence of animals and monitor species over space and time. Camera trapping demonstrated as one of the successful methods to effectively study for most pangolin species (Khwaja *et al.*, 2019) and can be a successful tool to monitor Indian pangolin in their natural habitat.

5.3.1.2.1 Data collection using camera trapping method:

The camera traps should be deployed at the fixed 1-1.5-foot height from the ground and the camera trap occasion shall be 30 to 40 days to acquire the high detection probability. A minimum of two to three motion sensor-radio triggered Infra-red camera traps is suggested to deploy in a single beat or 10 Km^2 areas. For a higher probability of detection, camera traps should be placed at targeted and potential capture sites near a burrow or feeding sign.

5.3.1.3 Spotlight Survey:

Spotlight survey is a successful technique that has been widely used for the detection of nocturnal species of cats (Sliwa 1993, 2004; Olbricht & Sliwa 1997). Due to the nocturnal behaviour of the Indian pangolin, a nocturnal survey using a spotlight can be done to determine its status.

5.3.1.3.1 Data collection using a spotlight survey method:

Spotlight survey should be done by foot or using a motor vehicle at a speed of not more than 20 km/h. A minimum of two to three spotlight surveys should be done randomly or targeted near to potential sites. Survey near the potential area has higher chances of detection. Observation of pangolin sighted during the spotlight survey such as GPS location, time of the

sighting, no. of individuals and other details of the survey is recorded as prescribed in the datasheet (II).

5.3.2 Questionnaire Based Survey Method:

The Communities residing inside and along the periphery of the forest area have vigorous knowledge of species present there as they are actively dependent on forests for their livelihood. The questionnaire survey method seeking to acquire traditional ecological knowledge of community people, that has been used to generate information to make inferences on the status of species (Nash *et al.*, 2016; IUCN, 2018).

5.3.2.1 Data collection using Questionnaire-based survey method:

A questionnaire survey using a close-ended semi-structured questionnaire should be used to interview community people or older forest staff to determine the occurrence of Indian pangolin in the area. Questions must be asked related to the sighting of Indian pangolin and other related information such as the number of individuals, place, time, season and activity. The collected information should be recorded according to the datasheet (III).

Datasheet (I) for Sign Survey

Date: **Division:** **Range:** **Beat:**

Start Coordinate: **End Coordinate:** **Total Distance Covered:**

S. No.	Type of Sign (Live/dead sighting/ Burrow/ Feeding Sign/ Foot print/ Faecal Material)	Age of Sign (Very fresh/ Fresh/Old/ Very old)	GPS Coordinate	Habitat type (Forest/Shrub/ Grassland/ Barren land)	Terrain type (Flat/ Undulating/ Sloppy)	Soil type and texture (Loamy/ black/laterite ;Sandy/ semi-sandy/ clay)	Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							

Datasheet (II) for Spotlight Survey

Date: **Division:** **Range:** **Beat:**

Start Coordinate: **End Coordinate:** **Total Distance Covered:**

S. No.	Time	Activity (Walking/ feeding)	GPS Coordinate	Habitat type (Forest/ Shrub/ Grassland/Barren land)	Terrain type (Flat/ Undulating/ Sloppy)	Remarks
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Datasheet (III) for Questionnaire Survey

Date: **Division:** **Range:** **Village:**

Village Coordinate:

S. No.	Name of Respondent	Age of Respondent	Occupation of Respondent	Sighted pangolin (Yes/No; Live/Dead)	If sighted pangolin, then				Remark
					Year	Season	Time	Activity	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

5.4 Analytical Methods:

After collecting the species occurrence data through prescribed survey methods, the assessment of status and distribution of pangolin a variety of prediction analyses can be done such as Species Distribution Modelling and Occupancy Modelling.

5.4.1 Species Distribution Modelling:

Species Distribution Modelling (SDM) is a tool that is commonly used to predict the distribution of a species across geographic space using species occurrence data and environment variables (which have the potential predictive capability). Nowadays SDM tool is increasingly important for investigating the distribution and potential area for the species (Guisan and thuiller, 2005; Smeraldo *et al.*, 2017). In all the SDM algorithms, the Maximum Entropy (MaxEnt) approach has proved powerful when modelling rare species (e.g. pangolin) with narrow ranges and available presence-only data (Phillips *et al.*, 2006; Qin *et al.*, 2017).

Software required: MaxEnt tool *ver* 3.4.1

(available at https://biodiversityinformatics.amnh.org/open_source/maxent/)

Data required: Presence-only occurrence data file (.csv) and Environmental variables (.ascii)

Variables required: Vegetation (Forest Type, Forest Cover, Normalized Differentiated Vegetation Index), Digital Elevation map (Altitude, Slope, Terrain Ruggedness), Anthropogenic pressure (Human Impact Index, Human Footprint, Nightlight, Distance from Human Settlement), Distance from Water source and Soil types.

5.4.2 Occupancy Modelling:

Occupancy modelling (Mackenzie *et al.* 2002) is a general set of techniques that can be used to assess the status of species in an area, determine the probability of the true presence or absence of a species at a site and how that changes over time. Occupancy modelling is one of the few analytical methods to survey the status of Indian pangolin as it relies on both direct and indirect data. Single-season single-species occupancy, multi-season single-species occupancy and dynamic occupancy models (IUCN SSC Pangolin Specialist Group, 2018) can be used to analyse the data to get occupancy estimation of Indian pangolin.

Software Required: PRESENCE *ver.* 13.5

(available at https://www.mbr-pwrc.usgs.gov/software/presence.html)

Data Required: Presence-absence occurrence data file in binomial form (.csv) and Environmental variables (.ascii)

Variable Required: Vegetation (Forest Type, Forest Cover, Normalized Differentiated Vegetation Index), Digital Elevation map (Altitude, Slope, Terrain Ruggedness), Anthropogenic pressure (Human Impact Index, Human Footprint, Nightlight, Distance from Human Settlement), Distance from Water source and Soil types.

5.5 Conclusion:

For the conservation management of an ecologically important species such as the Indian pangolin, reliable information of its status and distribution is required. This information is determined using standardized survey methods. Such standardized survey methods are not available for the Indian pangolin as this species is very less studied in the wild throughout its ranges. It is very hard to detect the species due to various factors such as they are nocturnal, does not likely prefer trails for movement and their indirect evidences are also not easily identifiable. Bearing in mind about all the challenges in studying pangolin, some methods can be used to determine status and monitor Indian pangolin in an area that is suggested in this chapter. These methods are Sign survey, Camera trapping, Spotlight survey and Questionnaire survey. As the study species is habitat and temporally specific, effort must be made at targeted sites for a high probability of detection. For the precise determination of the status and distribution of the species in an area, the author recommends a mix of all suggested survey methods in a proper way. Firstly, secondary information regarding the occurrence of Indian pangolin can be collected through a questionnaire survey method to identify potential targeted sites for field-based survey methods then carry out sign surveys at the identified potential area to determine the distribution of Indian pangolin. Later deployment of camera traps and spotlight surveys can be carried out in the determined pangolin distributed area for precise and confident estimation of Indian pangolin status in an area. The data collected through survey methods should be analyzed using the recommended MaxEnt and PRESENCE software or related software for the prediction of the potential area and true occupancy.

Chapter 6

Anti-poaching strategies for conservation of Indian pangolin

1. Introduction:

Indian pangolin is an Evolutionary Distinct and Globally Endangered (EDGE) species (Gray, 2016). The species is considered as an apex predator amongst myrmecophagous animals; an adult pangolin consumes about 70 million insects per year (d'Aulaire and d'Aulaire, 1964). Due to its myrmecophagy behaviour the species plays a vital role as natural pest controller in our natural ecosystem (Redfort, 1987; Roberts, 1997; Mahmood et al., 2013). Indian pangolin is threatened due to multiple stressors from habitat degradation (Molur *et al.,* 2005), prey decline (Chakraborthy *et al.,* 2002), and most extensively due to poaching (Mahmood *et al.*, 2012; Mohapatra *et al.*, 2015). Due to such present level of poaching and trafficking for live trade and scales for both local and international demand; the population of the species is declining rapidly Although, the species is well protected at national and international level under 'Schedule-I' of Wildlife (Protection) Act, 1972 of India (highest level of protection by the act) and in 'Appendix-1' of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), in 2016. The distribution range of the Indian pangolin is known to be in the Terai and Bhabar area, in the lower Shivalik hill in Uttarakhand state (IUCN, 2020). As per the Uttarakhand forest department findings, the three major causes of un-natural mortality of Indian pangolin are identified as poaching and live trafficking, road trampling and forest fire. In total, 28 un-natural mortality incidents have been recorded since 2008 which includes 18 cases in trafficking, nine in road trampling (n=9) and one in forest fire. Cases of Indian pangolin trafficking are increasing day by day, recently published studies have shown that Uttarakhand is becoming a hotspot of illegal trade of pangolin in India as the percentage contribution of trade seizure is increased by twice (6% to 12%) in the interval of four years (2015-2018).

Indian pangolin is being poached from centuries for scale and meat by various communities and tribes of India (Mohapatra et al., 2015). Scales of pangolin is used as ingredient in Traditional Chinese Medicine and also used by traditional healers (Hakim) to cure several diseases (Mahmood et al., 2014) however there is no scientific evidence available regarding the medicinal properties in pangolin scale. While pangolin meat is considered as delicacy food amongst many tribes and communities of India (Mohapatra et al., 2015). There are two major types of poaching patterns have seen in the Uttarakhand: or scales and meat and live pangolin. The community people living near the vicinity of forest area such as 'Kanjar', 'Nepali' people and 'Bengali' people kill pangolins for

bushmeat and sell scales to illegal wildlife traders. Now, live pangolin is also being used in superstitious (Tantric) things which causes a high spike in live pangolin trade in Uttarakhand state.

Since 2008, 74 pangolins have been reported in poaching and illegal trafficking. Indian pangolin is very important species for the healthy forest ecosystem hence it is an urgent need for the wildlife managers to take action for combating illegal trafficking and poaching of the species. The current chapter is aimed to prepare the anti-poaching strategies to control the poaching and illegal trafficking incidents in the state. These anti-poaching strategies will help wildlife managers to make decision and management strategies to control the poaching and protect the species.

2. Identification of illegally traded pangolin body part:

The main constituents found in pangolin trade seizures are scales, scale derivative, and meat. The pangolin body parts have unique identifiable characteristics which help to precise identification from others.

Pangolin Scale and its derivative: scale are very hard, triangular in shape and yellowish brown in colour. They are very similar to date palm tree 'Khajoor' bark in appearance. People from different communities make rings and lockets from these pangolin scales. These rings and lockets are triangularly shaped with a big hole at centre.

Meat: Meat of the pangolin is bloody-reddish colour and looks similar to the meat of other mammalian species. The only distinguished characteristics to identify pangolin's meat is that it has diamond structure like imprinting

Picture (a) Ring made of pangolin scale and Picture (b) pangolin scales confiscated from illegal trade.

3. Anti-poaching strategies for controlling the poaching incidents:

3.1 Capacity Building of Forest Department Personals:

a. The staff functionaries should be provided specific training in dealing with crime, besides providing complete knowledge about the laws prevailing on the ground and to make strong cases in case of any crime detected.

b. Regular monitoring of pangolin status in an area is very important to make suitable management and conservation strategies. Hence, it is important to provide proper population monitoring trainings with appropriate instruments used in the monitoring.

3.2 Strengthen of Forest Department Enforcement and Intelligence Network:

a. It is essential that strict compliance of provision of section 34(1) (2) (3) of Wildlife (Protection) Act, 1972 be ensured to deal with pangolin poaching or crime cases.

b. Many a times villages as well as the city dwellers move in the sanctuaries without entry permission. Such movements are done either to reaching the village/city by shortest route or by people involved in legal trades and also during fair and festival times such activities are seen more. This kind of entry should be monitored and checked since this creates an opportunity to commit offence in the sanctuaries.

c. Trained Hunting Dogs are used by the poachers to detect the pangolin occupied burrow in the forest. Hence during patrolling in forest area if such dogs are encountered, immediately capture or kill the dog and further investigate to search the owner.

d. A secret information system should be developed by the department in villages nearest in and around the sanctuaries, forest area and other vulnerable locations.

e. The staff involved in protection should be vigilant about the movement of the people living on periphery and nearby villages.

f. The staff personals should be provided with adequate transiting to deal with poaching incidences and modern way of patrolling using camera traps.

3.3 Establishment of Central Anti-Poaching Management Command Centre and Rapid Response Unit:

Sometimes, poaching incidents of Indian pangolin and other species may happen even after the dedicated anti-poaching efforts of forest department. Many times it becomes hard for local forest staff to handle the incident by their own. Therefore, it is necessary to establish a Central Anti-Poaching Management Command Centre at division level and Rapid Response Unit at range level. The Members of these Special Cells will be trained to deal with poaching incidences and investigation of illegal trade link associated with poaching incidences.

After getting information about the poaching incident or entering of suspected people inside forest area through local beat in-charge or informer, the Central Anti-Poaching Command Centre and Rapid Response Unit will perform following duties:

I. Nearest chouki or patrolling camp will be informed to send 2-3 staffs at incident site as soon as possible.
II. Members of Rapid Response Unit will reach at incident site and examine the situation.
III. Information and Update about poaching incident, seizure and arrested criminals will be given to Deputy Conservator of Forest and Central Poaching Management Command Centre.
IV. Rapid Response Unit will further investigate the case to prepare charge-sheet of wildlife crime and will also rehabilitate the pangolin if found alive.
V. After collecting information of primary crime investigation, the members of Central Anti-Poaching Management Command Centre will start further investigation to get information about the roots of illegal pangolin trade organisations and people associated.

Conclusion:

Indian pangolin is an important species for the natural ecosystem as they play many vital roles by their myrmecophagy and fossorial habits. Being an ecologically important species, the species is facing extinction threats from large level poaching and illegal trafficking. Due to such mass level poaching, the population of pangolin is declining rapidly in the ecosystem. Therefore, it has become a priority duty of wildlife managers to protect the species from poaching and illegal trafficking so that this species can be saved from extinction. The current chapter suggests the three main anti-poaching strategies which could be helpful to protect the species from poaching i.e. capacity building for monitoring of status and trade, strengthening of enforcement & intelligence network and establishment of special cell to deal with crime, rehabilitation and investigation. To protect the species, proper training should be provided to frontline forest staff for the monitoring of threat and status and also to make stronger cases regarding the crime. There is also need of strengthening of enforcement by the wildlife managers by regular patrolling, identification and removal of hunting dogs, developing intelligence network and checking of human movement inside forest area during festivals and fairs. The forest departments also need specialized cells to deal with crime and investigations so that frequency of poaching can be decreased.

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