

**Movement of Radio-Collared Tigers in the
Eastern Vidarbha Landscape
Maharashtra, India**



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Introduction

Tigers, co-predators and associated prey species exert a strong influence on community structure within the diverse range of habitats they occupy, so their extirpation from an ecosystem is of severe ecological concern. The presence of viable populations of tigers is an indicator of the integrity, health, and sustainability of large ecosystems. Tiger numbers have only been recently rising, with about 3,200 to 3,500 surviving today, scattered across their global distribution range.

Of the global distribution range, India harbors 57% of the world's tiger population in 7% of their historic global range. An immensely dedicated conservation effort has led to an increase in tiger numbers, however, in a country with over 1.25 billion people growing at a rate of 1.7% per year, it continues to be a challenge to conserve this large ranging species. Protected tiger habitats in India are geographically isolated and collectively hold the current tiger population under tremendous anthropogenic pressure. These protected areas are in itself not enough to sustain the growing tiger population, intensifying human-tiger conflict as dispersing individuals enter human-occupied areas in search of territories. These factors— isolation and inadequate size of the protected lands harboring tiger meta-populations, highlight the need to maintain the connectivity of tiger habitats thereby stressing the importance of corridors beyond protected lands. However, a great part of these corridors lies outside the protected area (PA) network and under different land ownership tenures.

Traditionally, management actions have been implemented in areas like protected areas (PAs), wildlife reserves or sanctuaries that have clearly demarcated boundaries. The movements of animals beyond these boundaries were often excluded from the planning process, partly because little was known about species movements. Moreover, daily movement of individuals may be outside demarcated areas and may result in it leaving the protected management areas (Minor and Lookingbill, 2010). Subsequently, once animals move outside of protected areas, it comes into conflict as it moves in a human-dominated landscape. In such a matrix of the landscape, animals have to compromise their movement while crossing barriers such as highways, villages and agricultural fields. Many high-traffic highways crisscross the few remaining forested landscapes of the country and cause an array of short- and long-term ecological impacts. The movement of tigers across these fragmented forested areas becomes critical to maintain a healthy gene flow. Over time, research has shown that even the largest PAs fail to fully protect a species (Thirgood *et al.*, 2004)

and identification and conservation of 'functional corridors' has become the new trend in tiger conservation in the recent past (Wikramanayake *et al.*, 2011; Dutta *et al.*, 2015; Mondal *et al.*, 2016).

With the advancement of technology in telemetry, there is a shift in paradigm in the conservation of wildlife species and management. Landscape connectivity is another key concept in which movement is a vital component to understand processes like dispersal and subsequent genetic diversity (Baguette and Van Dyck, 2007). This is where movement ecology can provide the knowledge needed for an understanding of species movements to begin with and help us to identify novel management actions that can improve the scale of management. This will help not only to delineate management areas but also to identify alternative management actions that increase the scale and flexibility of management.

In this backdrop, the Wildlife Institute of India in collaboration with the Maharashtra Forest Department envisaged the project titled **“Studying dispersal of tigers across the Eastern Vidarbha Landscape, Maharashtra, India”**, with a vision to understand tiger movement ecology in Protected and outside the Protected Areas. Along with this project, another long-term monitoring program of tigers and its co-predators titled **“Long-Term Monitoring of Tigers, Co-predators and Prey in Tadoba-Andhari Tiger Reserve and Adjoining Landscape, Maharashtra, India”** was being simultaneously carried out in the Eastern Vidarbha Landscape since 2013.

Objectives of the study

To understand the movement ecology of tigers in the Eastern Vidarbha Landscape, focusing on individual patterns of space use in general, utilization distribution in different areas and landscape, spatio-temporal activity and effect of environmental features on animal movement, the point-wise objectives are as follows:

1. To understand the movement of tigers that drives population connectivity on a landscape scale and effect of environmental features on dispersal.
2. To validate the modeled corridors and identify new functional corridor and habitats in a highly dynamic landscape.
3. Directly aiding effective conservation and management of tigers beyond the Protected Area (PA) system as a result of real-time data from radio-collars.

Radio telemetry and movement ecology: A new approach

The revolution of radio telemetry started in early 1960 (Cochran and Lord, 1963) and since then it has been widely used in understanding animal ecology from animal movement, home range, habitat use, survival, productivity to population estimation (Samuel and Fuller, 1994). This technique is a useful tool for studying the mechanics of wildlife populations, habitat use, and resource selection. Movement provides information on how animals use the environment, migration patterns, dispersal of individual and activity patterns. Home range estimates quantify the area used by an animal and habitat use studies provides information on habitat preferences and need for various habitat types.

Recent advances in the field of movement ecology are enabling the tracking of individuals and relating those movement tracks to environmental data. The most widely used method is radio telemetry by using radio-collars which yield a number of insights into animal movement and space use. With the advancement of technology, traditionally used very high frequency (VHF) radio transmitters have been replaced by more advanced GPS transmitters revolutionizing animal tracking studies (Cagnacci *et al.*, 2010; Kays *et al.*, 2015). A major advantage of GPS telemetry is that the animal's location can be collected with different scales of a time interval or fixes depending upon the study with high temporal resolution and accuracy.

Movement ecology emerged as a new field to understand animal movement, patterns, and processes giving us a better perspective of the animal's ecology and habitat requirements (Nathan *et al.*, 2008). Extrinsic factors such as habitat quality, resource availability and access, as well as anthropogenic features on the landscape influencing animal movement, could be better studied using real-time telemetry data.

Another most fundamental concept in movement ecology is the home range, conventionally defined as "the area traversed by the individual in its normal activities of food gathering, mating, and caring for young. Ecologists can now quantitatively characterize home ranges and space use patterns over time. Often, the purpose of applying such quantification methods to movement paths is a comparison of space use among individuals or species in order to examine such processes as niche partitioning optimal foraging, social aggregation or even decision-making (Dougherty, 2017). Movement,

therefore, forms the primary link between home range size and habitat/resource selection. Habitat selection affects the home range size at different spatial scales and results in a dynamic process in different landscapes, population or individuals. Individuals within a species may exhibit different movement patterns depending on their sex, age or life-history stage, and reproductive status (Nathan *et al.*, 2008; Martin *et al.*, 2013). Studying animal movement or space use with the GPS collars gives us insights into structural and functional habitat patches. Data obtained from such studies can be used to predict population movements, and to identify potential wildlife habitat beyond PAs in a more informed way. Data from the collared animals also help us to identify crucial gaps that may impede our understanding of connectivity and its integration into successful conservation strategies.



Study Area

The Eastern Vidarbha Landscape (EVL) which is a part of the Central Indian Tiger Landscape, is a highly biodiverse region. It lies between N18°11'20.69" to N21°43'15.79" and E78°03'37.09" to E80°54'09.42" and encompasses an area of about 50,000 km² covering the six districts of Bhandara, Chandrapur, Gadchiroli, Gondia, Nagpur and Wardha (figure 1). It houses a human population of 1,17,54,434 people, and at the same time has a forest cover of about 20,000 km². This patch of forest is very important as it harbors a population of about 150-200 tigers and forms the connecting link between the central and southern Indian tiger populations. It plays a pivotal role in the exchange of individuals and thereby facilitates gene flow between these two populations increasing the viability of tiger populations in India. There are 8 protected areas or wildlife divisions where these tigers live, but these refuges are scattered like islands in a sea of human-dominated landscape and face tremendous human pressure.

Pench Tiger Reserve
Bor Tiger Reserve
Umred-Karhandla Wildlife Sanctuary
Navegaon-Nagzira Tiger Reserve
Tadoba-Andhari tiger Reserve
Tippeshwar Tiger Reserve
Brahmapuri Forest Division

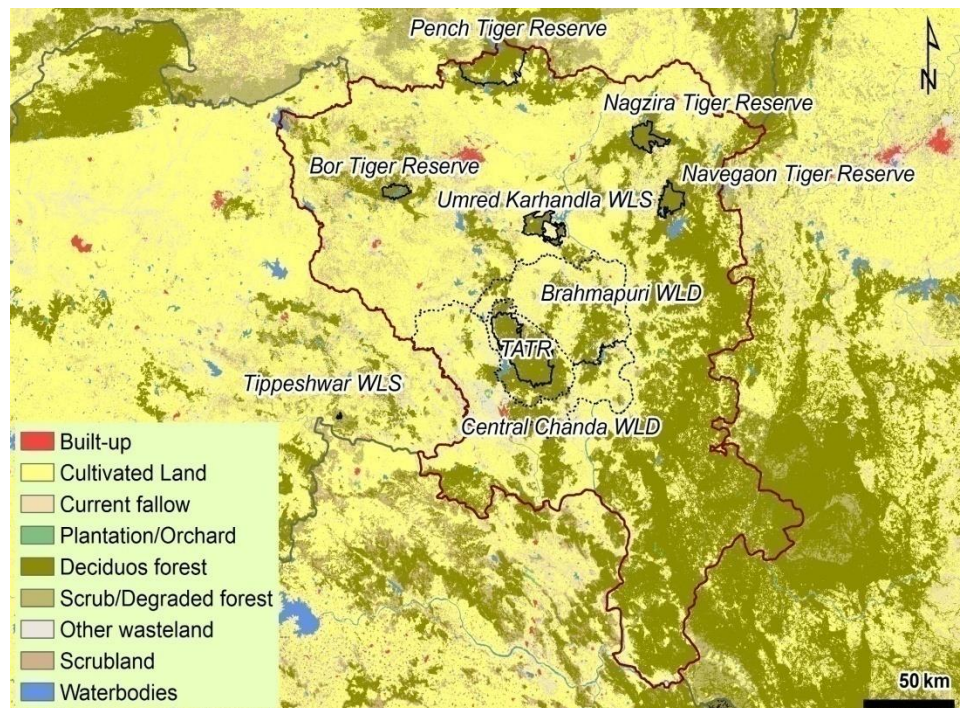


Figure 1: Eastern Vidarbha Landscape, Maharashtra, India-Protected Areas and Territorial Forest



Functionality of collars in the Eastern Vidarbha Landscape (EVL)

Under the two ongoing research project in the state of Maharashtra titled “**Long-Term Monitoring of Tigers, Co-predators and Prey in Tadoba-Andhari Tiger Reserve and Adjoining Landscape, Maharashtra, India**” and “**Studying the dispersal of tigers across the Eastern Vidarbha Landscape, Maharashtra, India**”, the radio-collaring exercise was carried out between 2016-2017 at different Protected Areas and Territorial forest to understand the dispersal and movements of tigers across the landscape. Following table summarizes the details of the functionality of collars in EVL.

Table 1: Functionality of GPS collars on different individuals in the Eastern Vidarbha Landscape (EVL), Maharashtra

Tiger ID	Collar ID	Collaring date	Collared removed/stopped	Active number of days	Number of fixes
T7 (Tara)	14616	17.10.2014	20.03.2016	520	1871
T42 (Gabbar)	14617	19.10.2014	02.04.2015	166	1301
T1 (Jai)	18855	15. 09.2015	25.10.2015	42	922
	19867	18.03.2016	19.04.2016	33	175
T09 Bittu	19864	17.03.2016	13.01.2017	303	2887
	21596	13.01.2017	03.03.2018	393	3882
T10 Srini	19865	17.03.2016	29.10.2016	227	1812
	21595	05.12.2016	19.04.2017	135	1385
Brahmapuri Female	21593	03.06.2016	04.11.2016	155	833
Brahmapuri Male	21594	04.06.2016	09.08.2016	66	292
TATR sub- adult female	21597	06.03.2017	Active	409	2638
TATR sub- adult male	21601	09.03.2017	19.03.2018	375	2135
Bor female T27 cub1	21598	29.07.2017	14.10.2017	78	3312
Chaprala female	21934	29.08.2017	03.11.2017	75	1998

Table 2: Home range of collared tigers in EVL

Tiger ID	Place	Home Range	
		95% Kernel Estimation (sq. km)	50% kernel Estimation (sq. km)
T1	Umred-Karhandla Wildlife Sanctuary	1386.84	362.22
T9 (post dispersal)	Brahmapuri Forest Division	298.32	43.00
T10 (post dispersal)	Pauni Territorial and BRH	408.52	106.48
T07-Tara	Tadoba-Andhari Tiger Reserve	56.47	16.71
T42-Gabbar	Tadoba-Andhari Tiger Reserve	148.67	43.67
TATR sub-adult male	Tadoba-Andhari Tiger Reserve	63.53	10.11
TATR sub-adult female (post-dispersal)	Umred-Karhandla Wildlife Sanctuary	44.52	8.06
Brahmapuri male	Brahmapuri Forest Division	139.53	28.18
Brahmapuri female	Brahmapuri Forest Division	80.91	18.53
Bor female	Bor Tiger Reserve	3068.03	663.93
Chaprala female	Chaprala Wildlife Sanctuary	146.70	73.10

Umred-Karandla Wildlife Sanctuary

Umred-Karhandla Wildlife Sanctuary (UKWLS) is situated in Nagpur and Bhandara district of Maharashtra covering a total area of 189 km². The sanctuary covers two divisions; one comes in the Nagpur (Kuhi and Umred Range) and other in Bhandara (Pauni Range) division. The Pauni Range (Bhandara Division) is divided from the other two ranges by the Maru river and flows into Wainganga river. Most of the park boundary is surrounded by human settlement and agricultural fields. The Wainganga river and Gosikhurd Dam surrounds the northeastern part of the Wildlife Sanctuary. The eastern part of the park (Pauni Range) is however connected to the Pauni Territorial forest through a small stretch of forest along the state highway 271. On the south, the State Highway 9 runs parallel with major township Bhiwapur and Umred in the west. A narrow 10 km long range of hill (600-800 m) forms the northwest park boundary.

To understand the movement pattern, dispersal route and underlying processes in Eastern Vidarbha Landscape, UKWLS was selected as the starting point of the project. Because of its centrally located, strategic location in the landscape, UKWLS proved to be a logical choice to initiate the project. Interestingly, this small stepping stone had also started to act as a source population of tigers in the region. The first tiger collared was T1- popularly known as Jai in the UKWLS on 15th September 2015. This individual was born in Navegaon-Nagzira Tiger Reserve dispersed to UKWLS and subsequently became dominant male in the area. The individual was fitted with Vectronics GPS, but within two months of receiving data, the satellite link of the collar failed on 25th November 2015 because of a technical snag. However, the VHF unit was operational and ground tracking, as well as data collections, were carried out till the individual was re-collared on 18th March 2017 and the old collar was replaced. T1 was a dominant male and had relatively large territory which included UKWLS, Pauni Territorial Forest (Bhandara Division) and territorial forest of Brahmapuri Forest Division. He used to visit Umred range of UKWLS once in about 15 days and took on an average 15 days to cover his entire territory. After intensively tracking T1 for more than one month in UKWLS, the satellite link of the new collar failed again on 18th April 2017 when T1 was moving from Pauni range of the Wildlife Sanctuary towards the Pauni territorial forest division. The last location was received from the agricultural field and after that no GPS location or VHF signal was received.

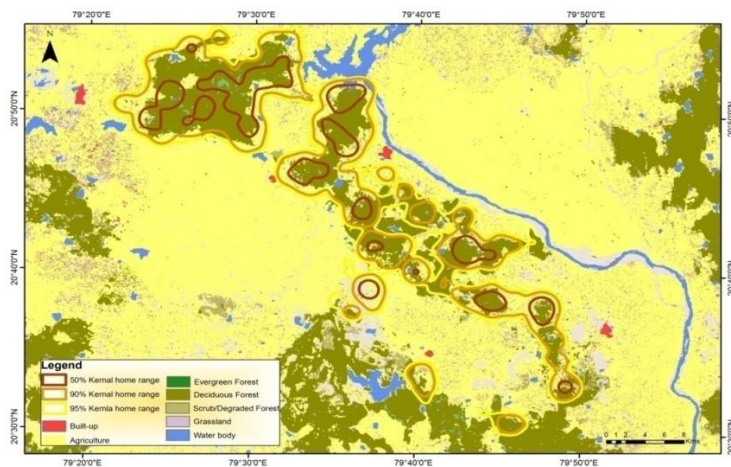


Figure 2: Kernel home range map of T1 in the Umred-Karhandla Wildlife Sanctuary and adjoining landscape (95% kernel home range: 1386.84 sq. km)

We collared two sub-adult males sired by T1 and T3 in the Umred-Karhandla Wildlife Sanctuary in March 2016. Both the sub-adults were located near the Tola Kutti in the Kushi range. The first individual T9 was collared at 06:25 hrs (N20°52'54.0" and E79° 27'52.6") on 17th March 2016. Once the collar was set, standard measurements were recorded. This male tiger weighed 140kg. The second sub-adult male- T10 was then located at 17:25hrs and collared (N 20°52'36.6" and E 79°27'52.6"). T10 was smaller in size as compared to T9 and weighed 125 kg.

After tracking and receiving data for more than 10 months both the individuals were re-collared in the Brahmapuri Forest Division. T9 was the first individual to be re-collared in the Nagbhir range on 5th December 2016. In the Talodhi Range, T10 was re-collared on 13th January 2017. Details about the movement parameters of both the collared individual are given in table 4 and table 5.

Table 3: Monthly movement data of T1 from 15th September 2015 to 19th April 2016

Month	Average minimum displacement/day (m)	Average maximum displacement/day (m)	Total distance travelled (km)	Average distance travelled (km)/ day
2015				
September	459.25	3170.69	95.42	5.96
October	110.81	3754.03	233.55	7.53
November	320.70	3520.50	222.64	7.42
December	149.13	4127.52	280.58	9.05
2016				
January	245.35	5954.94	394.10	12.71
February	236.41	5645.52	350.02	12.07
March	145.03	5275.61	325.00	10.48
April	336.26	4256.68	176.83	9.31

Table 4: Monthly movement data of T9 from 18th March 2016 to 31st December 2017

Month	Average minimum displacement/day (m)	Average maximum displacement/day (m)	Total distance travelled (km)	Average distance travelled (km)/ day
2016				
March	90	1200	34.95	2.50
April	53	1589	131.81	4.39
May	47	1991	144.73	4.67
June	316	2081	117.73	3.92
July	558	2400	130.86	4.22
August	33	1800	161.45	5.21
September	216	2726	152.92	5.27
October	397	3687	186.89	6.03
November	887	4356	256.97	8.57
December	62	2375	187.60	6.05
2017				
January	3	1639	272.15	8.78
February	16	2229	293.23	10.47
March	25	2208	186.03	6.00
April	22	2510	188.68	6.29
May	28	2531	161.19	5.20
June	138	2489	152.25	5.08
July	151	2110	107.08	3.45
August	156	2141	116.29	3.75
September	328	2133	106.62	3.55
October	241	1713	87.75	2.83
November	130	2481	127.67	4.26
December	423	3376	217.77	7.02

Table 5: Monthly movement data of T10 from March 2016 to 19th April 2017

Month	Average minimum displacement/day (m)	Average maximum displacement/day (m)	Total distance travelled (km)	Average distance travelled (km)/ day
2016				
March	208	1595	47.82	3.42
April	53	1407	118.34	3.94
May	81	2171	186.92	6.03
June	316	2516	123.92	4.13
July	403	3589	179.29	5.98
August	10	2328	215.46	6.95
September	586	2339	135.32	4.51
October	896	3623	175.94	6.07
December	2	2061	365.24	13.53
2017				
January	31	3772	398.83	12.87
February	34	3775	265.78	9.49
March	19	3956	301.71	9.73
April	11	4710	185.28	9.75

Dispersal of T09 and T10



Dispersal is the movement of an animal from its natal range when it reaches the age of independence, and it involves search for new territory, resources and is often associated with a high risk of mortality. Dispersal has important implications for population ecology and conservation through the redistribution of animals. In large carnivores, particularly the tiger, sub-adult males generally disperse greater distances than females which tend to be philopatric (Smith, 1993).

T9 and T10, collared in the Umred-Karhandla Wildlife Sanctuary initially explored the eastern part of the sanctuary (Kuhi Range) which was their natal home range. T10 and T09 both moved out of their natal range separately and started dispersing in early July and August respectively. T10 had undertaken a complex sequence of movements that included crossing the Wainganga river on two occasions and other movement barriers such as National Highways, canals and agricultural fields. Initially, he explored extensively the northern, western and southern part of the Pauni Territorial Forest. T10 was followed by T09, dispersing a month after T10 explored the eastern part of the Pauni Territorial Forest and part of Nagbhir Range, Brahmपुरi Forest Division. However, T10 explored more area in the Pauni Territorial Forest Range and extended its territory in Nagbhir Range thereby pushing out his sibling T09 (figure 3).

After November, T09 started using the Ghodazari area intensively and later moved to the Talodhi range and acquired his territory within the range and part of Sindewahi Range of Brahmपुरi Division. T10 had a huge territory comprising of an area 408.52 sq. km (95% kernel home range) which included the southern Pauni territorial forest and part of Nagbhir range. T09 had a home range of 298.32 sq. km (95% kernel home range). Both the tigers had made territories and settled in their new areas. Unfortunately, on 19th April, T10 was found electrocuted in an agricultural farm on receiving a mortality signal from his collar.

Figure 3: Dispersal of T09 and T10 from UKWLS to Pauni Territorial and Brahmapuri Forest Division (blue line shows the dispersal route of T09 and yellow line shows the dispersal of T10). Green box in the map is the start location and red box is the end location of the collared individual

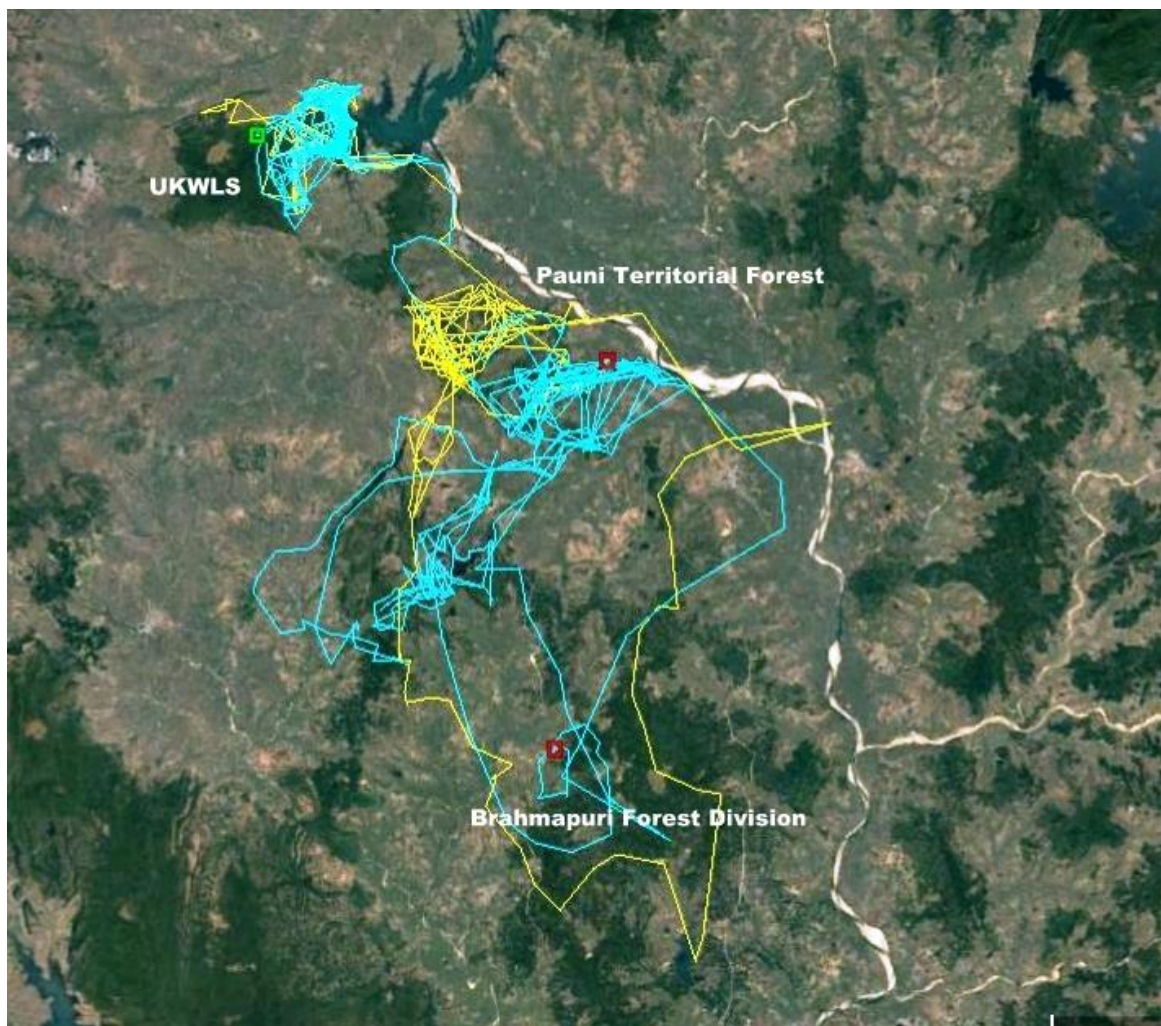
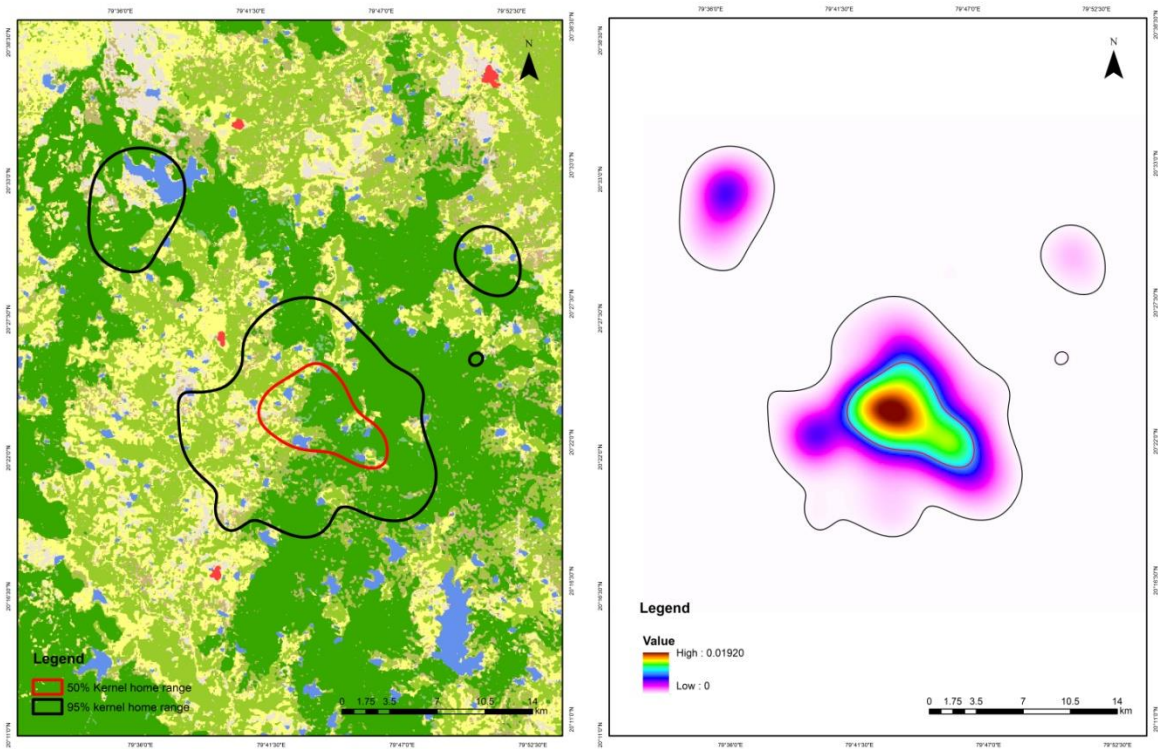
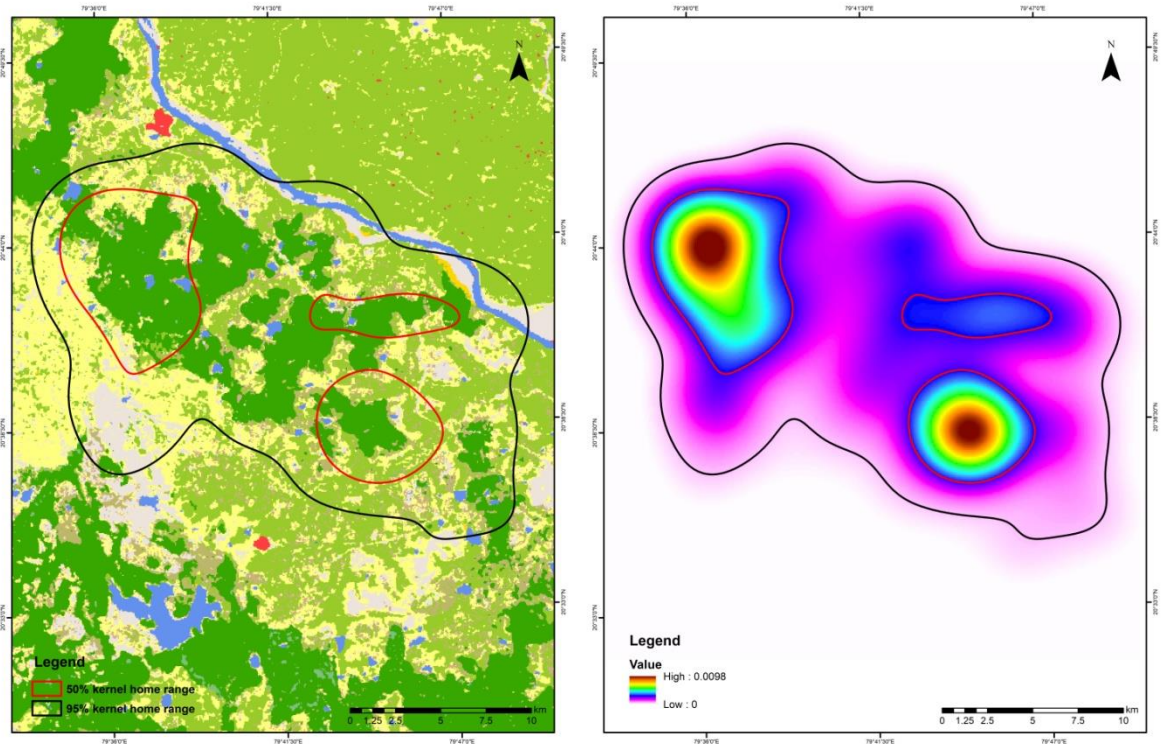


Figure 4: Kernel home range and utilization distribution map of T09 and T10



T09-Bittu (Post dispersal 95% kernel home range: 298.32sq. km)



T10-Srini (Post dispersal 95% kernel home range: 485.80 sq. km)

Tadoba- Andhari Tiger Reserve

Tadoba-Andhari Tiger Reserve (TATR) is considered one of the most important source populations of tigers in the Central Indian Tiger Landscape. This tiger population connects the adjoining tiger populations such as Indravati Tiger Reserve through the forests of Chandrapur - Gadchiroli districts. This connectivity extends all the way to Kanha National Park in the north-west through the forests of Navegaon National Park and also to Pench National Park through the forests of Bor and Umred-Karhandla Wildlife Sanctuaries. It is situated in the Chandrapur district in the eastern part of Maharashtra state, between N20°04'53" to N20°25'51" and E79°13'13" to E79°33'34".

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