Examining the spatial spread of *Lantana camara*

in the Mudumalai Tiger Reserve

Report submitted to the Tamilnadu Forest Department

June 2014

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Introduction

Lantana camara L. (referred to as Lantana from here on), a shrub native to South America, has become one of the worst weeds in recorded history. It was first introduced in India in 1807 (Thakur et al., 1992). Lantana has now spread to become a pan-global weed, reported as invasive in more than 60 countries (Parsons and Cuthbertson, 2001; Day et al., 2003), and identified as one of the top ten invasive species in the world (GISIN, 2011).

Lantana as an Invasive Species

- It exhibits allelopathic properties - puts out chemicals which hinder seedling recruitment and growth of native plants in its vicinity (Achhireddy & Singh 1984)
- When mechanically cut, it quickly produces many new shoots that can grow upto six times faster than the mother plant, producing dense and impenetrable thickets (Sharma et al. 2005).
- It has a vibrant seed bank (each adult plant can produce upto 12,000 seeds, which remain viable for up to 11 years) that is dispersed widely by birds, rodents and other animals, and propagates very well vegetatively (Swarbrick et al. 1998).
- It benefits from soil disturbances associated with destructive foraging activity of mammals such as pigs, cattle, goats and deer, which enhance both germination and vegetative propagation (Thaman 1974).
- It possesses a strong root system, and can regenerate from basal shoots even after moderately intense fires (Day et al. 2003) and seeds also tend to germinate faster if exposed to smoke.
- The leaves and young stems contain lantadene A and B, which are toxic (sometimes fatal) if/when browsed by herbivores (Sharma et al. 1981).
- It is also known to affect economic viability of 14 major crops around the world including coffee, tea, rice, cotton, oil palm, coconut and sugar cane (Sharma et al. 2005).

All these characteristics together make Lantana highly suited to invading novel environments as has happened across most of India, reviewed by Sharma et al., (2005).

Past Management and the Situation in Mudumalai

Various methods of controlling Lantana have been tried across the country, including fire, mechanical removal, chemical and biological control; and reports suggest that these methods or their combinations were successful in some regions (e.g. Coode, 1930). However, reports from the

later part of the 20th century suggest that Lantana continued to spread despite management (Muniappan and Viraktamath, 1986). It has been actively 'managed' for almost a century now (Troupe 1921), yet there appears to be no sign of its spread being contained in Indian forests despite this long history of attempted eradication.

The management of Lantana in Mudumalai Tiger Reserve (MTR) dates as far back as the 1920s, (Ranganathan, 1941) but the weed is still present all through the Reserve (Dogra, 2007). The objective in more recent management plans however, has shifted from that of 'eradication' more towards 'containment' of the Lantana invasion, not allowing it to take over more of the protected area. It has been noted that Lantana is also useful to animals in some cases (Dogra, 2007). Particular efforts were also made by the forest department to mechanically remove Lantana in the grasslands and swamps which are of importance to herbivores (Srivastava, Pers. Comm.).

Local organisations have also worked with tribal communities in the region to help them make furniture out of Lantana. The idea being that an economic driver which made it viable for communities to extract Lantana on their own, would be more effective in controlling the spread of Lantana (The Shola Trust, 2012).

While there appears to be consensus that Lantana poses a threat to native flora and fauna, there is some disagreement as to the extent of the infestation in MTR, and how severe a threat it poses. Some areas though (Eg. North of the Upper Karagudi office) are completely taken over by Lantana, and no other ground vegetation exists as far as one can see (Pers. Obs.)

Other mapping methods have been tried – remotely sensed maps as well as and interpolation (Kriged) based on stem counts at a few sample points, but on preliminary ground truthing these did not seem to very accurate.

Hence this research project was undertaken to map the spread of Lantana through the Mudumalai Tiger Reserve.

As per research permission dated 12/08/2013, the above mentioned mapping exercise was started in August 2013. Field work was undertaken in the months of August and September 2013, and January, February and May in 2014, based on the convenience of the Range Officers. Progress reports were submitted during the field work periods.

Methodology

The methodology used for mapping purposes was as described below.

1. Beat maps were downloaded from the Western Ghats Portal (www.westernghats.in), and a quick survey of staff opinion on level of Lantana infestation in each beat was undertaken, and a map generated (Appendix 1). The beat boundary polygons were then edited using Quantum GIS (v 2.0.1) based on discussions with field staff to match on ground boundaries.
2. Digital copies of 1:25000 topographic sheets were obtained from the Indian Institute of Science.
3. An approximately 0.01 degree square grid (approx. 1.1 km) was created and overlaid onto the topographic sheets for each beat. These were used as field reference. A sample gridded beat map is attached as Appendix 2.
4. Each beat was travelled through by either foot or vehicle, ensuring every grid was covered.
5. Every 500m, a GPS (Garmin etrex 10) waypoint was marked, and a qualitative visual assessment of the level of Lantana infestation was made as follows:
   (a) 0 – No Lantana
   (b) 1 – Few scattered plants
   (c) 2 – Many plants
   (d) 3 – Dominated by Lantana
   (e) 4 – Impenetrable

Lantana was cleared from the immediate sides of roads by the forest department, and these cleared areas were ignored in the assessment. Each such waypoint was also plotted on the gridded beat map mentioned above to ensure full coverage of the area.

6. Presence or Absence of some other common invasive species were also noted, namely *Chromolaena odorata, Parthenium hysterophorus, and Opuntia spp*. Any other interesting/relevant information was also noted.
7. These waypoints and corresponding data were entered into a spreadsheet (Libre Office v 3.5), as well as saved in ESRI shapefile using Quantum GIS (v 2.0.1). Appendix 3 shows the map of all the points taken during the course of the research.
8. Inverse Distance Weighted Interpolation was then carried out in the same software using Level of Lantana Infestation as the input. A distance coefficient (p) of 6 was used and a cell

size of about 50 m (0.0005 degrees). The resulting raster layer was converted into vector and cropped to the range boundaries. A map was generated to visualise the spread of Lantana through the Reserve, attached as Appendix 4.

9. Areas of each of the levels of Lantana infestation were calculated for each range, and corresponding graphs prepared (Appendix 5).
10. A similar Inverse Distance Weighted Interpolation was also carried out using presence/absence of *Chromolaena odorata, Parthenium hysterophorus, and Opuntia spp*. These raster layers were cropped to the division boundary, and corresponding maps generated to visually assess the spread of these invasive species in Mudumalai (Appendices 6, 7 and 8).

Some possible shortcomings with the methodology:

1. The qualitative assessment of the level of Lantana infestation may not be uniform ie if two different people walk along the same paths, they may give different scores from 0-4. We tried this in some areas, and found some small variation did happen in about 20% of the points, but the score was only off by 1. That is 'impenetrable (4)' may be exchanged with 'dominated by Lantana (3)' or 'few scattered plants (1)' with 'many plants (2)'. But 'few scattered plants (1)' was never scored as 'dominated by Lantana (3)', so we think it is not too serious a problem.

2. For best results in interpolation, the sampling points have to be uniformly spaced out. This is not really possibly in the forests that are dominated by Lantana or other thick undergrowth, and we have let the field staff guide us as best possible, ensuring maximum/even coverage.

3. Interpolation is also not ideal with non parametric/qualitative variables, but we are reasonably confident about the results given the extensive coverage, and believe this is the best that can be achieved. A quantitative assessment (like stem counts or percentage area cover in quadrats) is really not a feasible undertaking if you want such extensive coverage/sampling.

4. The selection of distance coefficient (p) of 6 is somewhat arbitrary, but a higher value was chosen since Lantana level at a point is very strongly influenced by neighbouring points, and almost independent of points further away.

Results

The following sampling effort was undertaken:

Range	Area (ha)	Sample points	Distance on Foot	Distance in Vehicle	Notes
Masinagudi	7971	258	109 km	20km	Whole range covered well, with enthusiastic participation from range officer and field staff. Morganbetta beat was mostly sampled along the road in the vehicle, as it is largely impenetrable and walking is not possible.
Thepakadu	6652	205	84 km	42km	Most of the range covered except the northern most edges along the Karnataka border in Dodagatty and Imberhalla beats. These areas are mostly Lantana-free, and additional sampling is not needed.
Nellakotta	4603	155	68 km	26 km	The very thick undergrowth, leeches and undulating terrain made the sampling effort quite challenging, but all the staff were tribals with excellent knowledge and field capabilities, and the forester was very cooperative.
Kargudi	5496	179	74 km	22 km	Well covered, with good cooperation from field staff. Was relatively easy since it was close to the highway.
Mudumalai	7388	188	88 km	35 km	Reasonably well covered, though field work was somewhat challenging since the range was not easily accessible and staff were not easily available.
Total		**985**	**423 km**	**145 km**	

This was the total sampling effort, but the total effort including pick up/drops, repeat walks etc. was about 600 km on foot and 350 km in a vehicle.

From these 985 points, based on the interpolation the following results were obtained:

Lantana Level/Range	Kargudi		Masinagudi		Mudumalai		Thepakadu		Nellakotta		Entire Reserve	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
No Lantana	0	0	530	7	932	13	2039	31	403	9	3905	12
Few Scattered Plants	242	4	1605	20	2401	32	1117	17	1052	23	6417	20
Many Plants	2490	45	1611	20	1358	18	1307	20	1090	24	7857	24
Dominated by Lantana	914	17	2708	34	1825	25	1128	17	1685	37	8260	26
Impenetrable	1850	34	1517	19	871	12	1060	16	373	8	5671	18

Note: Area calculations are only approximate, and may vary on the coordinate-reference system used in the GIS software. Graphs showing Lantana spread attached.

Further visual results are enclosed in the appendices.

Other Observations

1. Overall, field staff's 'opinion' of Lantana infestation was reasonably accurate, and is perhaps a very good starting point, since we do not have any good maps of invasive species anywhere in India.

2. Along some streams, particularly in Kargudi Range, we have noticed that bamboo is making a very good comeback, even through Lantana. We believe this may reduce the Lantana levels in the future, and should possibly be monitored/studied more closely.

3. The field staff were all very knowledgeable about the forests on the whole and their beats, but many of them are unclear about the exact beat boundaries, and their map reading capabilities are quite low. Many beats do not even have access to reasonable beat maps. It would be useful to conduct some skill up-gradation sessions in this regard.

4. In most parts of the Reserve, the transect lines for wildlife surveys are 'cut' through Lantana, and could be biasing the results. This should possibly be looked into by the relevant experts.

5. We found that *Chromolaena odorata* is even more widespread that Lantana. And while some herbivores tend to nibble at the fresh leaves of Lantana, nothing at all eats Chromolaena. This is also perhaps worthy of more research.

6. In some parts of Masinagudi range there appears to be some disease/pest attack on Lantana. This would be worth examining more closely.

7. On the whole we found there was no accurate map of Mudumalai that showed the roads, camps, beat boundaries etc. This would have made our work much easier, and is essential for any mapping exercise. We have made such a map at the end of our work (Appendix 9), and are happy to improve on it with suggestions from the Forest Department if required.

Conclusion and Management Implications

On the whole the scenario with Lantana is quite serious, with about 14,000 hectares, or 44% of the Mudumalai Tiger Reserve being either 'dominated by Lantana' or 'Impenetrable', and only about 4000 hectares, or 12% of the reserve being completely Lantana-free. What should be done about this in terms of management is a hard question to answer particularly since it was not one of the aims of this study. But since the Field Director's permission letter asked for management suggestions, we have put down some of our thoughts below.

1. The current 'eradication' effort is based on uprooting Lantana in areas that are heavily infested with Lantana, at a rough cost of about Rs. 40,000 per hectare. This is perhaps a futile effort, as removing Lantana from all the heavily infested areas in Mudumalai will cost about Rs. 56 crores. Further, after removing, if there is no follow up weeding effort, the area will get even more intensely dominated by Lantana than before. Examples of this are visible in areas near 'Game Hut' and also along the highway between Thorapalli and Abhayaranyam. Other than in some specific areas that have some special interest – possibly in the tourism zone, around water bodies etc. – we don't think it is a wise allocation of funds to continue with the Lantana clearing.

2. Instead we believe all areas that have low levels of Lantana should be targeted for removal, and all management efforts should go into ensuring the small Lantana-free areas remain that way, possibly also being increased. In particular the Eastern part of the Reserve (Masinagudi Range) can be targeted for management. In the northern part, there is one 'vayal' that is heavily infested with Lantana, while most of the other areas are Lantana free. This may also be a good site for Lantana removal.

3. Yearly monitoring of Lantana is essential to ensure the plant is not spreading further, particularly in areas that have been the target of any management interventions.

4. Overall we found the method was quite easy to undertake, and we hope the staff will be able to undertake this effort year after year to be able to monitor the spread of Lantana through the Mudumalai Tiger Reserve. It took considerable effort on our part – 600 km of walking, and 350 km in the jeep, with about 170 human-days. But if all the field staff were involved, the entire operation could be completed in just one or two days.

Acknowledgements

We are grateful to the Range Officers Mr. Sundararajan (Masinagudi) and Mr. Arokiaswamy (Thepakadu), Forester Mr. Gokulraj (Nellakotta), Guards Mr. Chandanaraju (Masinagudi), Mr. Ketan (Kargudi), and APWs Mr. Manoharan (Thepakadu), Mr. Vishnu and Mr. Maran (Mudumalai), Mr. Rajan, Mr. Bomman and Mr. Donson (Nellakotta) for their enthusiastic participation and cooperation in this research.

We are grateful to the Rufford Small Grants Foundation for funding a part of the study.

We are also grateful to Dr. Raman Sukumar and Dr. Geetha Ramaswami (Centre for Ecological Sciences, Indian Institute of Science), Dr. Ravi Chellam, Dr. M. D. Madhusudhan and Dr. AJT Johnsingh (Nature Conservation Foundation), Dr. Devcharan Jathna (Centre for Wildlife Studies) for various ideas/discussions/support during this project; Dr. Shonil Bhagwat (Open University), Dr. Kathy Willis and Dr. Thomas Thornton (University of Oxford) for starting us off on a more rigorous research interest in Lantana.

Many thanks also to our other friends and colleagues at The Shola Trust – Subhash Gautam, Shruti Agarwal, Girish Sampath, Nishita Vasanth and Shubhra Nayar.

Report compiled by Tarsh Thekaekara, 10 June 2014.

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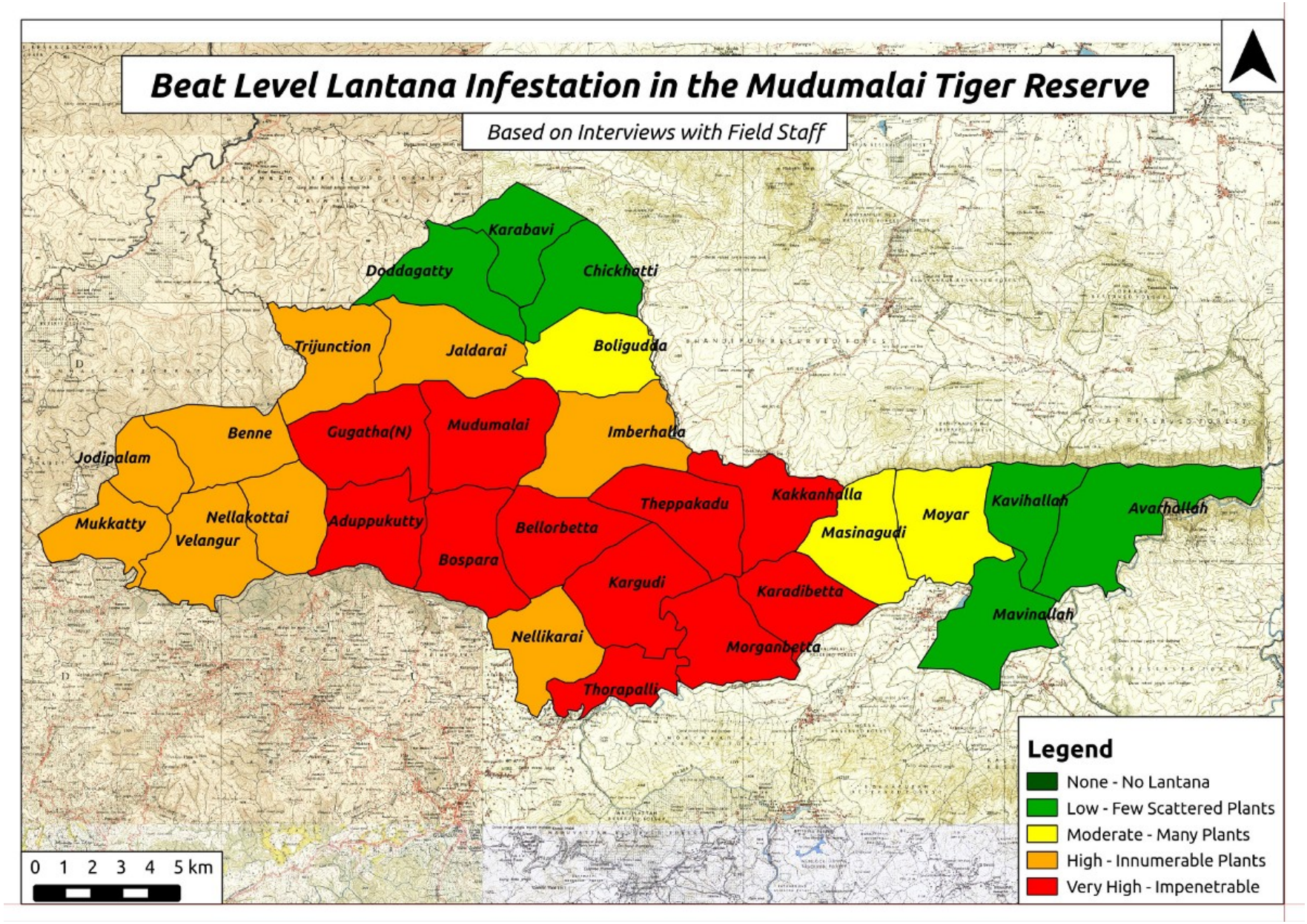
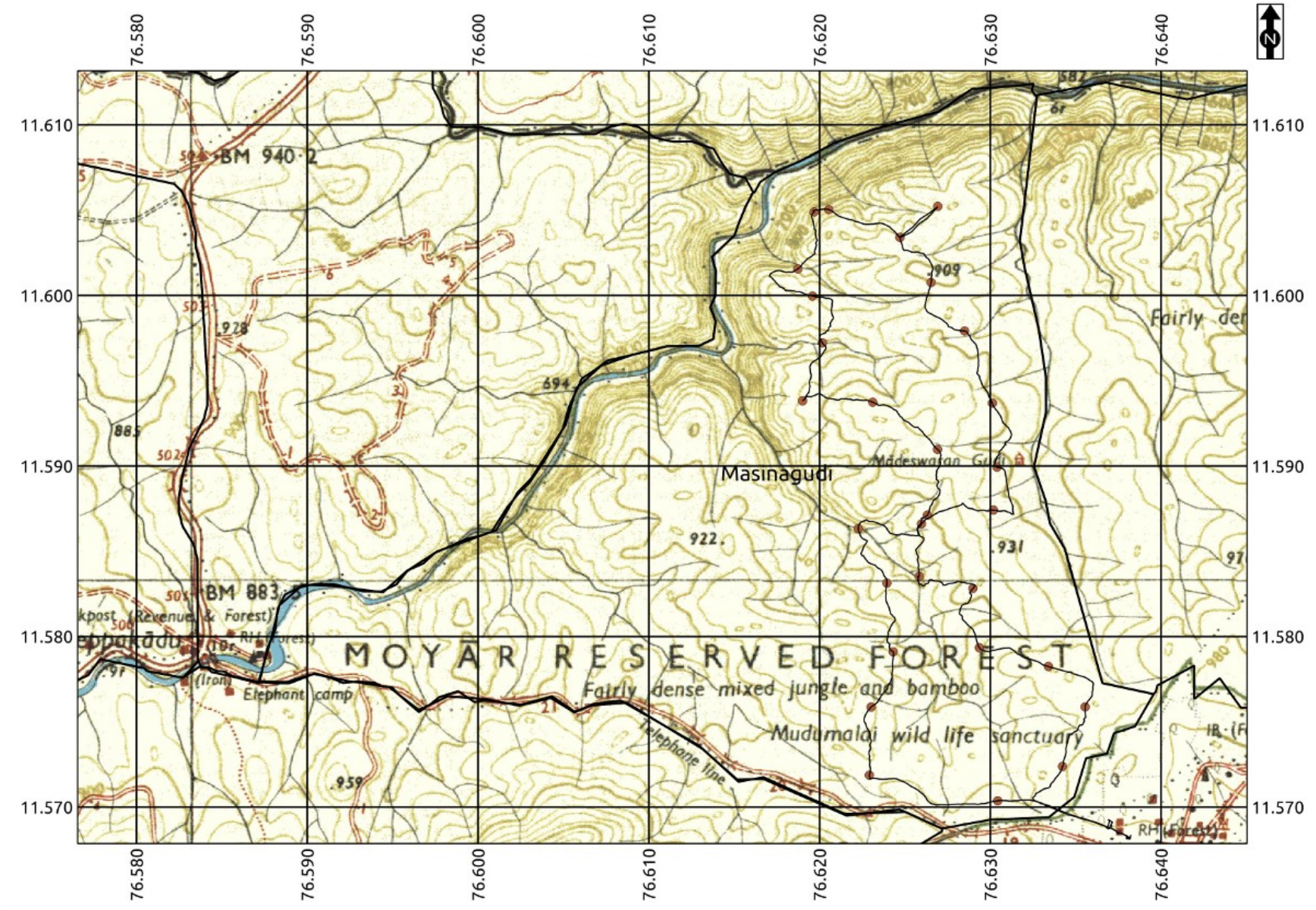
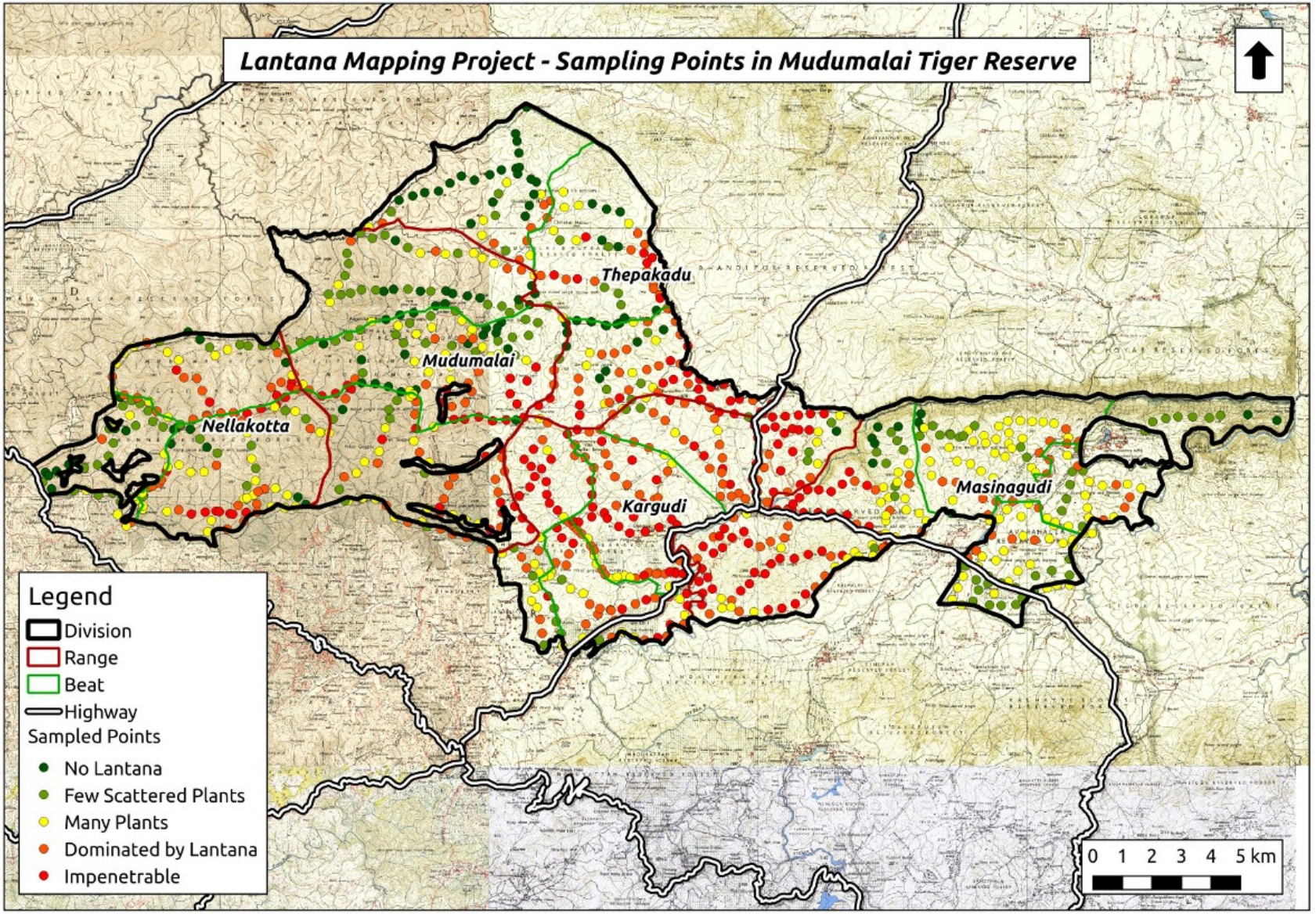
Appendix 1 – Beat Staff's Perception of Lantana Infestation



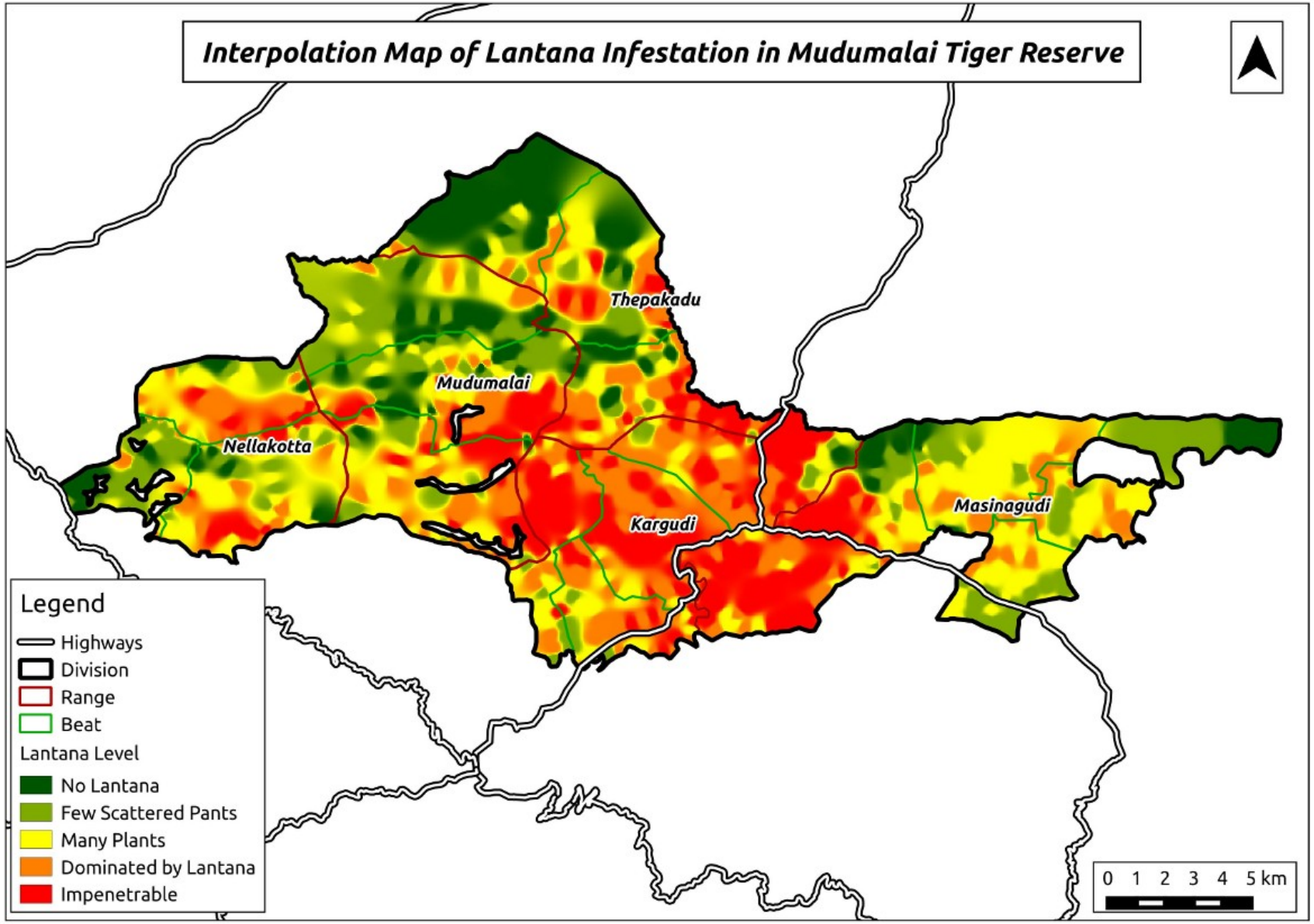
Appendix 2 – Sample Beat Map for Field Reference



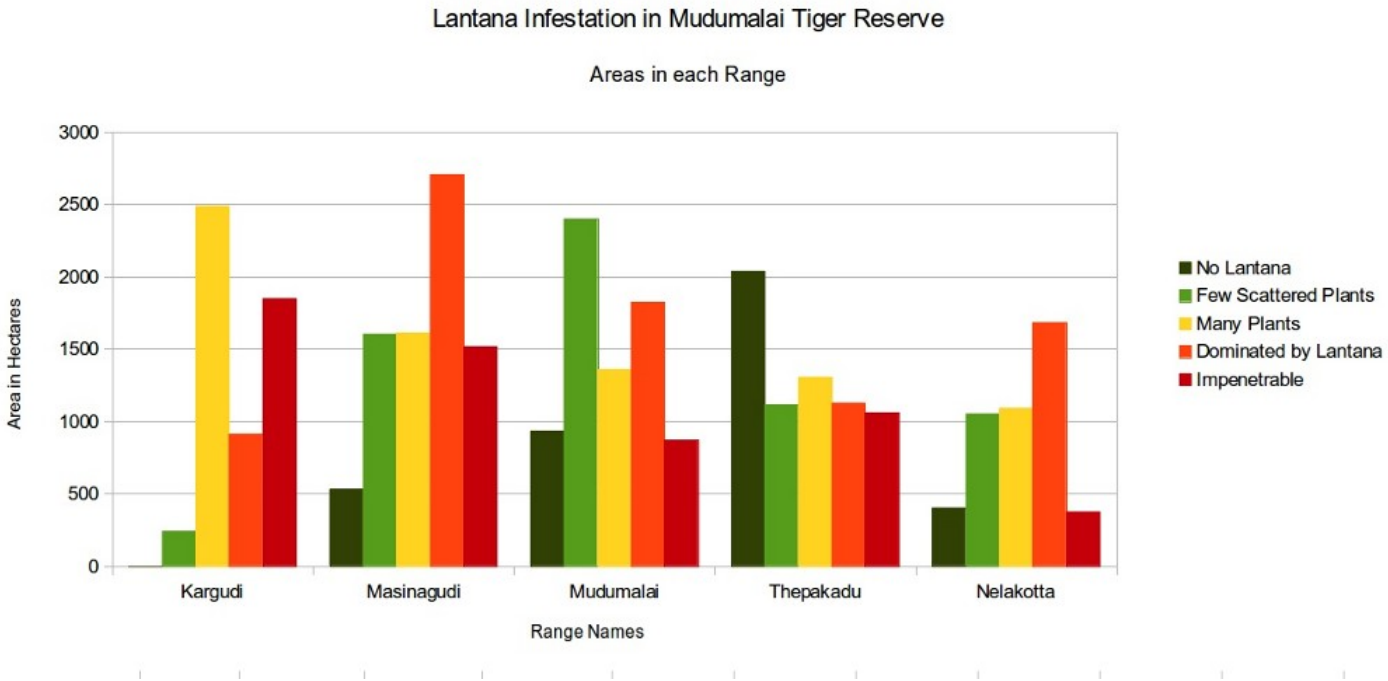
Appendix 3 – Sample Points Across the Mudumalai Tiger Reserve

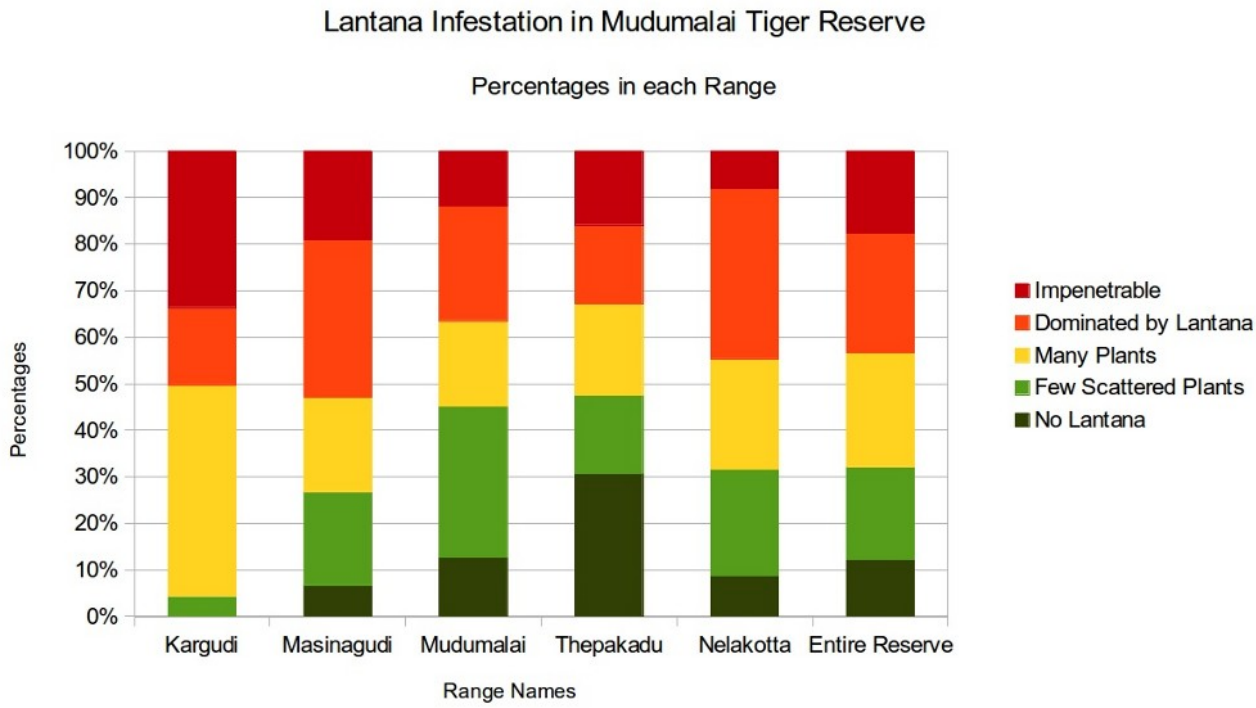


Appendix 4 – Interpolation Map of Lantana Infestation Across the Mudumalai Tiger Reserve

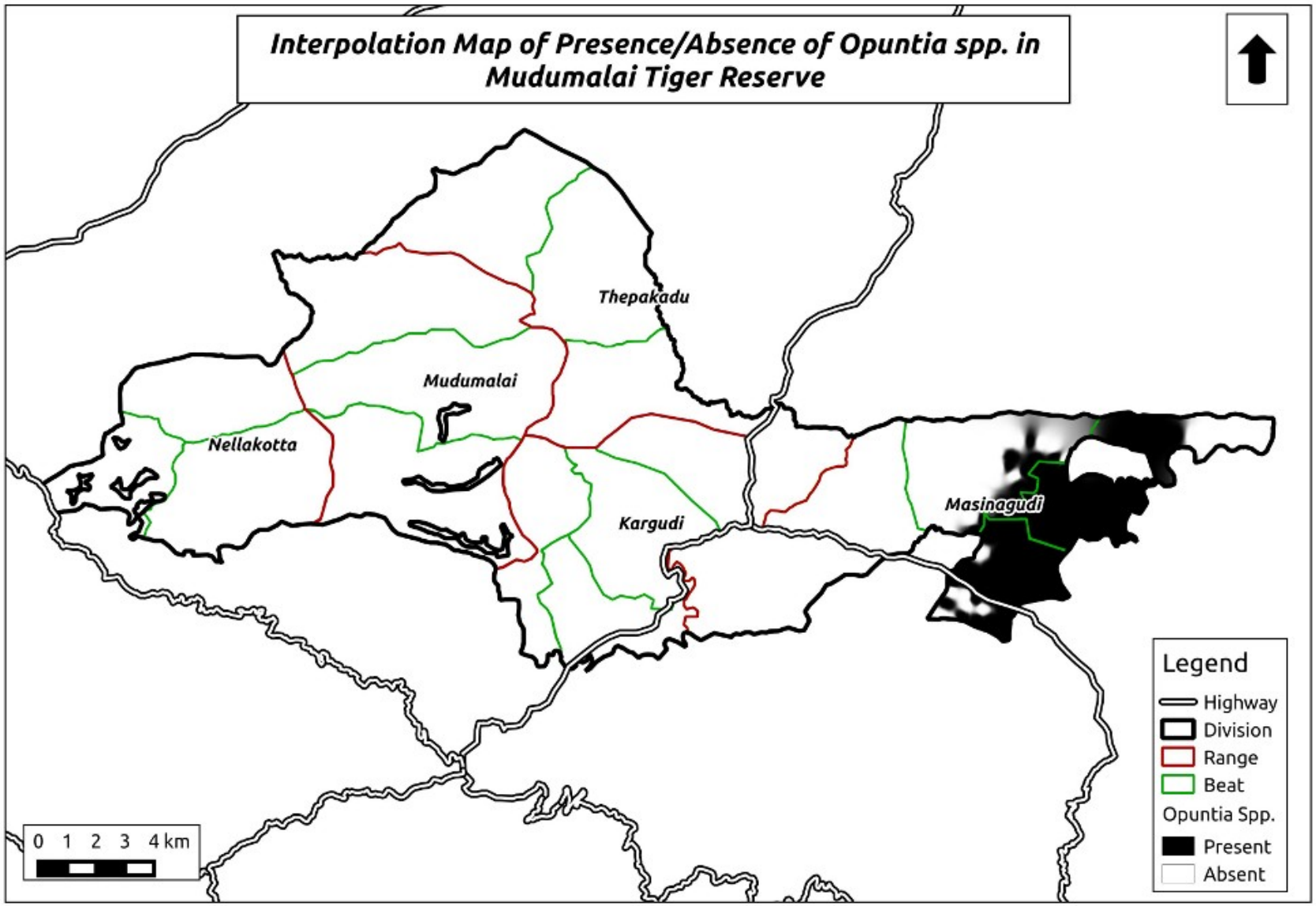


Appendix 5 – Graphs of Range-wise Lantana Infestation

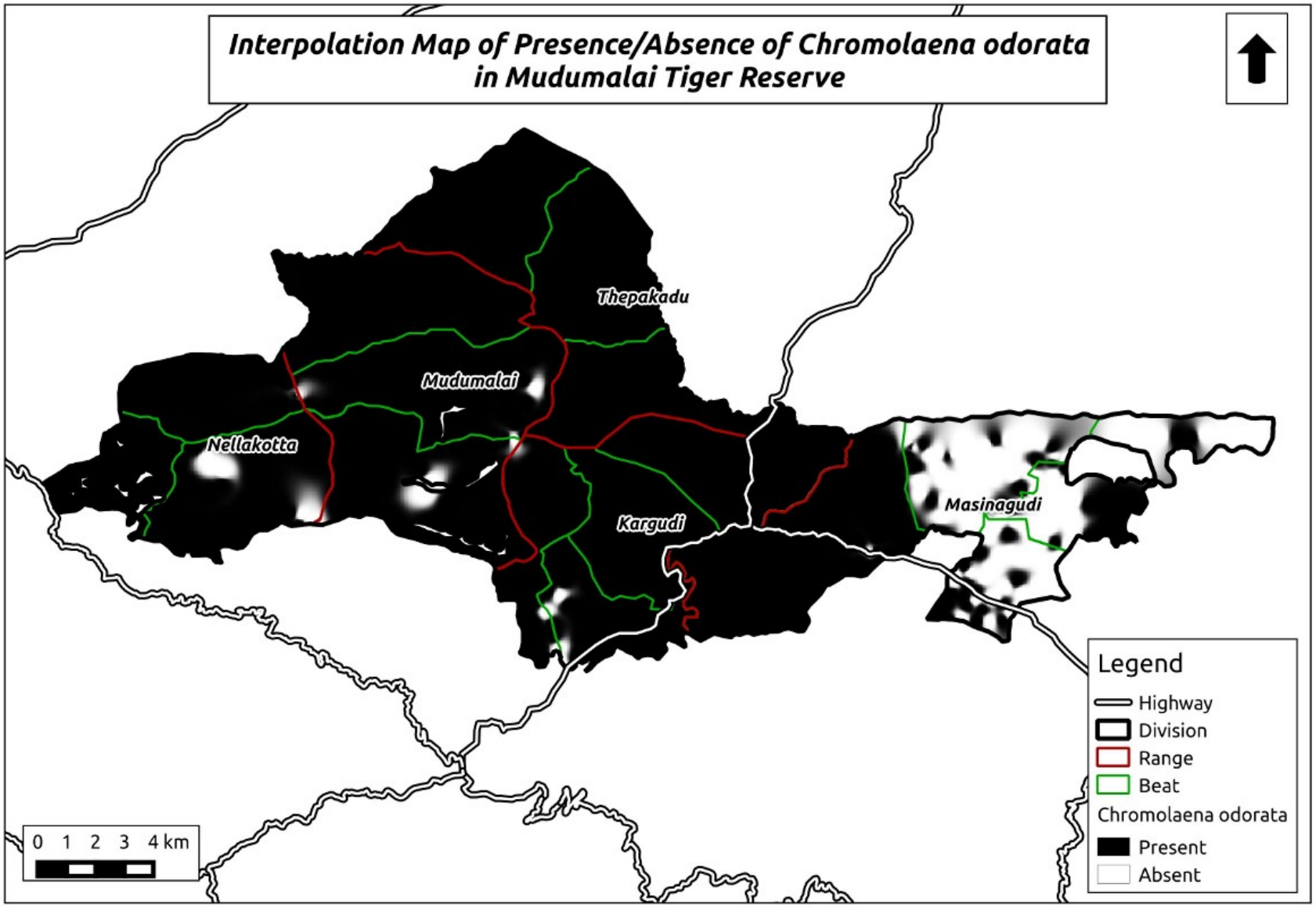




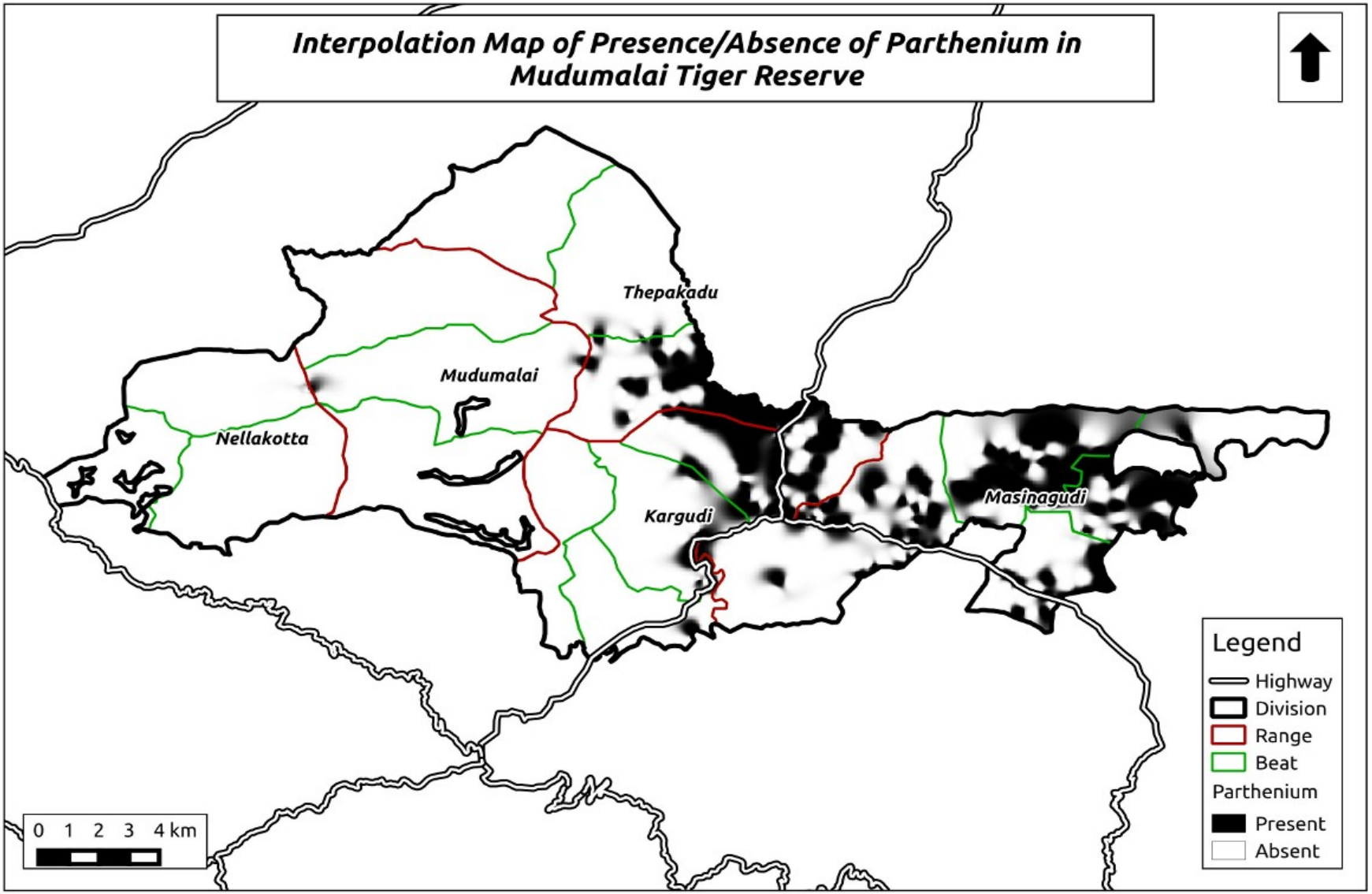
Appendix 6 – Presence/Absence of *Opuntia spp.*



Appendix 7 – Presence/Absence of *Chromolaena odorata*



Appendix 8 – Presence/Absence of *Parthenium hysterophorus*



Appendix 9 – Map of Mudumalai Tiger Reserve with Roads, Camps/Offices and Boundaries