

Mapping the Distribution of *Lantana Camara* in the Bandipur Tiger Reserve, Karnataka



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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).

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).

Understanding the extent of the Lantana invasion is essential to plan any management interventions relating to the plant. Following from discussions Karnataka forest department and as per the permission letter (FCS/PT/GL 899/2013-14, dated 17/7/2013) this mapping exercise was implemented. The field work was undertaken From March 2014 to September 2015, with a break for the monsoon seasons. The permit was extended as per the letter XXX.

Methodology

The methodology used for mapping purposes was as described below.

1. Preliminary maps and digital copies of 1:25000 topographic sheets were obtained from the Field Director, Bandipur Tiger Reserve, and used as a field reference to plan the survey on the ground.
2. An approximately 0.01 degree square grid (approx. 1.1 km) was created and overlaid onto each beat boundary. These were used as field reference. A sample gridded beat map is attached as an appendice.
3. Each beat was travelled through by either foot or vehicle, attempting to cover every grid.
4. Every 500m, a GPS (Garmin etrex 10 and etrex 30) waypoint was marked, and a qualitative visual assessment of the level of Lantana infestation was made as below:
 - (a) 0 – No Lantana
 - (b) 1 – Few scattered plants
 - (c) 2 – Many plants
 - (d) 3 – Dominated by Lantana
 - (e) 4 – Impenetrable
5. Areas that were recently cleared of Lantana 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* (formerly *Eupatorium*), *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 2.8). A map showing all the points taken during the course of the research is attached as an appendice.
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 50m (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 an appendice.

9. Areas of each of the levels of Lantana infestation were calculated for each range, and corresponding graphs prepared (see appendices).
10. The presence/absence of *Chromolaena odorata*, *Parthenium hysterophorus*, and *Opuntia spp.* at each of the data points is also shown in the appendices.

Possible shortcomings

1. The qualitative assessment of the level of Lantana infestation may not be uniform ie if two different people walk 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 possible 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/percentage cover in quadrats) is 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.
5. Two areas in AM Gudi Range were not adequately covered due to high rainfall. In an effort to complete the mapping exercise without further delay we have proceeded without it. We don't believe it will make a difference of more than 2% in the overall assessment of the areas infested by Lantana.
6. Area calculation may vary slightly based on the Projection and Coordinate Reference System used in the GIS software. We have used WGS 84 (EPSG:4326) for the GPS units and maps, and WGS 84/World Mercator (EPSG:3395) to compute areas of polygons. We have also noted the full areas of each Range and percentages infested to overcome this issue.

Despite these shortcomings, we are confident that is the most accurate and appropriate methodology for mapping lantana.

Results

The following sampling effort was undertaken:

Range	Total Area (ha)	Sample points	Dist. on Foot (km)	Dist. in Vehicle (km)	Notes
Kundkere	9582	230	90	55	Reasonably well covered, except for steep slopes in moyar gorge. But Lantana absent in those areas.
Bandipur	5730	220	55	110	Well covered. But mostly along roads, since the range was heavily infested with Lantana and has extensive road network.
G. S. Betta	7531	295	110	90	Well covered. Easy to walk in grasslands.
Moolholle	11251	435	195	120	Well covered except for Moorband beat, where dense vegetation hindered movement.
Maddur	8553	315	130	95	Well covered.
Hediyala	10239	436	185	115	Well covered.
Nugu	2803	120	25	55	Well covered, but mostly by road. Also to note is that about 22% of the range, or 633 ha is covered by water.
Om Kara	7541	246	70	95	Well covered.
Moliyur	8851	245	80	85	Well covered, except one gap in Dadadahalli beat.
A. M. Gudi	10488	285	75	90	Some gaps in the Kalkere and Hullegalgadde beat on account to unusual rainfall that hindered field work.
N Begur	6486	200	40	80	Well covered, but mostly by road on account of extensive road network.
Gundre	6180	170	35	75	Well covered, but mostly by road on account of extensive road network.
Entire Division	94625	3197	1090	855	

This was the total sampling effort in the reserve. The total effort including pick up/drops, repeat walks and travel to field site about 1500 km on foot 2600 km in the Jeep.

From these 3197 points, based on the interpolation the following results were obtained:

Range / Lantana Level		None	Few Plants	Many Plants	Dominated by Lantana	Impenetrable	Total Area
Gundre	Area	0	361	1114	1177	3529	6180
	%	0	6	18	19	57	
N Begur	Area	0	77	473	844	5091	6486
	%	0	1	7	13	79	
AM Gudi	Area	6	514	2984	3859	3126	10488
	%	0	5	28	37	30	
Moliyur	Area	159	1031	3965	3048	648	8851
	%	2	12	45	34	7	
Omkara	Area	412	3956	2982	159	32	7541
	%	5	52	40	2	0	
Nugu	Area	87	743	969	312	61	2171
	%	4	34	45	14	3	
Hediyala	Area	583	3389	4027	2113	128	10239
	%	6	33	39	21	1	
Maddur	Area	298	3022	3420	1524	289	8553
	%	3	35	40	18	3	
Moolholle	Area	3400	3101	2470	1780	499	11251
	%	30	28	22	16	4	
GS Betta	Area	933	2017	1888	1661	1055	7553
	%	12	27	25	22	14	
Bandipur	Area	49	127	618	1593	3342	5730
	%	1	2	11	28	58	
Kundkere	Area	5473	2172	1594	342	0	9582
	%	57	23	17	4	0	
Entire Division	Area	11400	20511	26504	18411	17799	94625
	%	12	22	28	19	19	

Notes:(1) All areas are in hectares. (2) Area calculations are only approximate, and may vary on the coordinate-reference system used in the GIS software. This may vary with official figures, hence percentages are total range/division area that we have computed is also shown. (3) Area figures for Nugu Range and Entire Division do not include about 633 hectares covered by water/the Nugu Reservoir.

Further visual results are enclosed in the appendices We have also included the Lantana maps from neighbouring reserves of Mudumalai and Sathymangalam for comparison.

Other Invasive Species

The presence/absence of three other invasive species was also noted at each of the Lantana waypoints, namely *Chromolaena odorata*, *Parthenium hysterophorus*, and *Opuntia spp.*

Interpolation was carried out to produce some maps, but it is important to note that the scale of sampling (500 m – 1 km between points) was not ideal for these species, and there may be finer scale variation.

Some observations of relevance:

- *Parthenium* seems to show a high correlations with anthropogenic features like roads/temples etc. In Bandipur range for example, though it is shown as present near almost all the roads it is absent in most other parts, where Lantana dominates.
- *Opuntia* is only in the dry regions, and does not seem to be spreading too much or having and adverse effect on forests.. In Bandipur range we found just one plant – maybe this can be removed to prevent further spreading of the plant.
- *Chromolaena* (*Eupatorium*) is very widespread all through the Reserve. In the wet forests like moolholle range, where Lantana is lower, it is dominated by *Chromolaena*. In some ways this is worse than Lantana; while some animals browse fresh leave of Lantana nothing at all eats *Chromolaena*.

The maps are attached in the appendices.

While all these invasives are problems for the forest, Lantana clearly seems to be the worst problem.

Conclusion and Management Interventions

Overall, about 38% of the Bandipur Tiger Reserve, or 362 sq km (36210 hectares), dense Lantana (either 'dominated by Lantana' or 'Impenetrable'), and 50%, or 470 sq km (47015 hectares) had moderate Lantana ('few plants'/'many plants'), and only 12% 114 sq km (11400 hectares).

The complete results with range-wise information about the Lantana spread along with maps and graphs are included in the appendices.

We find it quite hard to make concrete suggestions about the management of Lantana, since almost all interventions aimed at 'eradicating' the plant over the last 100 years have failed.

However, some general observations about management are worth discussing:

- The current 'eradication' effort is based on uprooting Lantana in area that are heavily infested, at a rough cost of between Rs.25,000 to Rs. 40,000 per hectare. The cost of removing Lantana from all the heavily infested areas in the Bandipur Tiger Reserve will therefore be between 90 and 145 crore rupees. This is clearly not a realistic sum of money that can be spent. Further, any large scale disturbance in a forest could have cascading, unforeseen effects on the native flora and fauna, and is not advisable.
- If about 50 lakh rupees is spent every year on Lantana removal to clear 125-200 hectares, it will take between 180-290 years to clear just the heavily infested areas alone.
- Clearing of Lantana is done in small patches based on availability of funds, where the patches are selected mostly based on convenience of field staff. This is perhaps a futile effort, as Lantana will surely come back if removed in a small patch in a landscape that is otherwise full of Lantana. We suggest that a rationale is clearly put down as to why Lantana is going to be cleared in a particular area. There could be many reasons for targeted clearing – like around water bodies, or in tourism areas for better wildlife viewing, or in areas where Lantana is starting to spread etc. These areas should be identified for each range independent of the funding, and then should be targeted year after year on an ongoing basis.
- Follow weeding/clearing is essential, and all new clearing should be perhaps be undertaken only after it is established that previous cleared areas are Lantana free.

- Yearly monitoring of Lantana is essential to ensure the plant is not spreading further. Long term data on the spread of Lantana will be very useful for management.
- Other options that involve local communities using Lantana could also possibly be looked into if the forest department has the manpower. This will give employment to the local tribals, and make the removal of Lantana a financially self sustaining process. Other NGOs could also be potentially involved. Numerous such uses for Lantana have already been experimented with - to make furniture, or shredded Lantana to be made into briquettes/sold to plywood industries, or the extraction of essential oils/amino acids. All of these have significant potential.

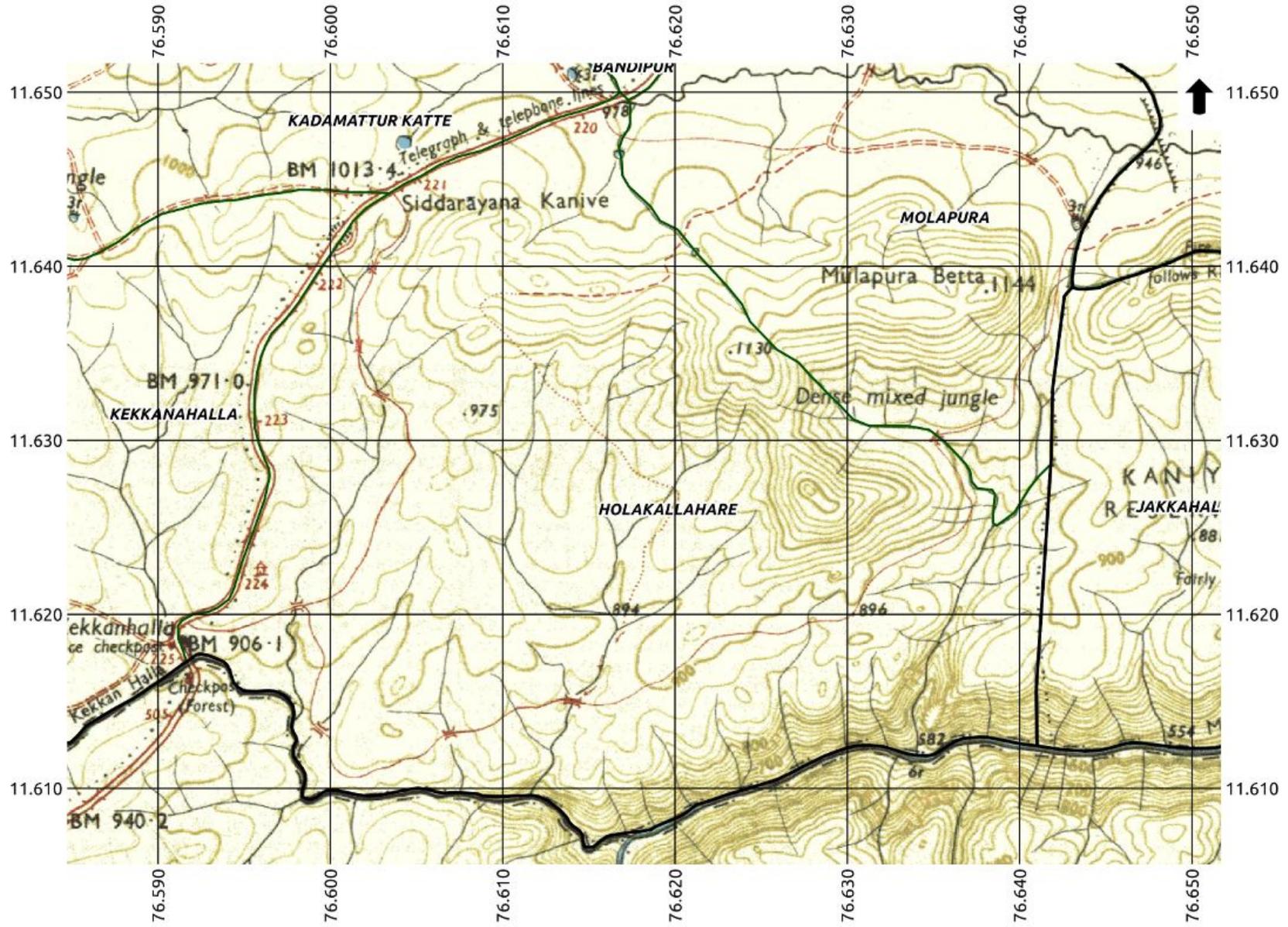
Some other specific observations relating to Lantana that maybe useful for management:

- In the dry areas, particularly Kundkere Range, we found significant correlation between Lantana and water bodies. That is Lantana is largely absent from the landscape except near water bodies. There are only around 2-3 perennial waterholes in the whole range, and all of them are surrounded by thick Lantana. This will be an easy target for removal.
- In Bandipur Range, which is also the tourism zone, almost 90% is taken over by Lantana. This could be because of the extensive road network Here again the best areas for removal are perhaps along water bodies, to maximize wildlife viewing.
- In Gopalswamy Betta Range, almost all the valleys/low lying areas are taken over by Lantana, and the hill tops/grassland areas are mostly Lantana free. But there are some areas in the hills around the temple that have clumps of Lantana. This may spread further into the grasslands, so it is best to target this area for removal.
- In Moolholle range, which is very wet, there seems to be a correlation between streams/roads and Lantana, where the infestation is high close to streams and roads and not much in other places. *Chromolaena odorata* was present everywhere through the Range, and is in some ways a more serious problem than Lantana in this range.

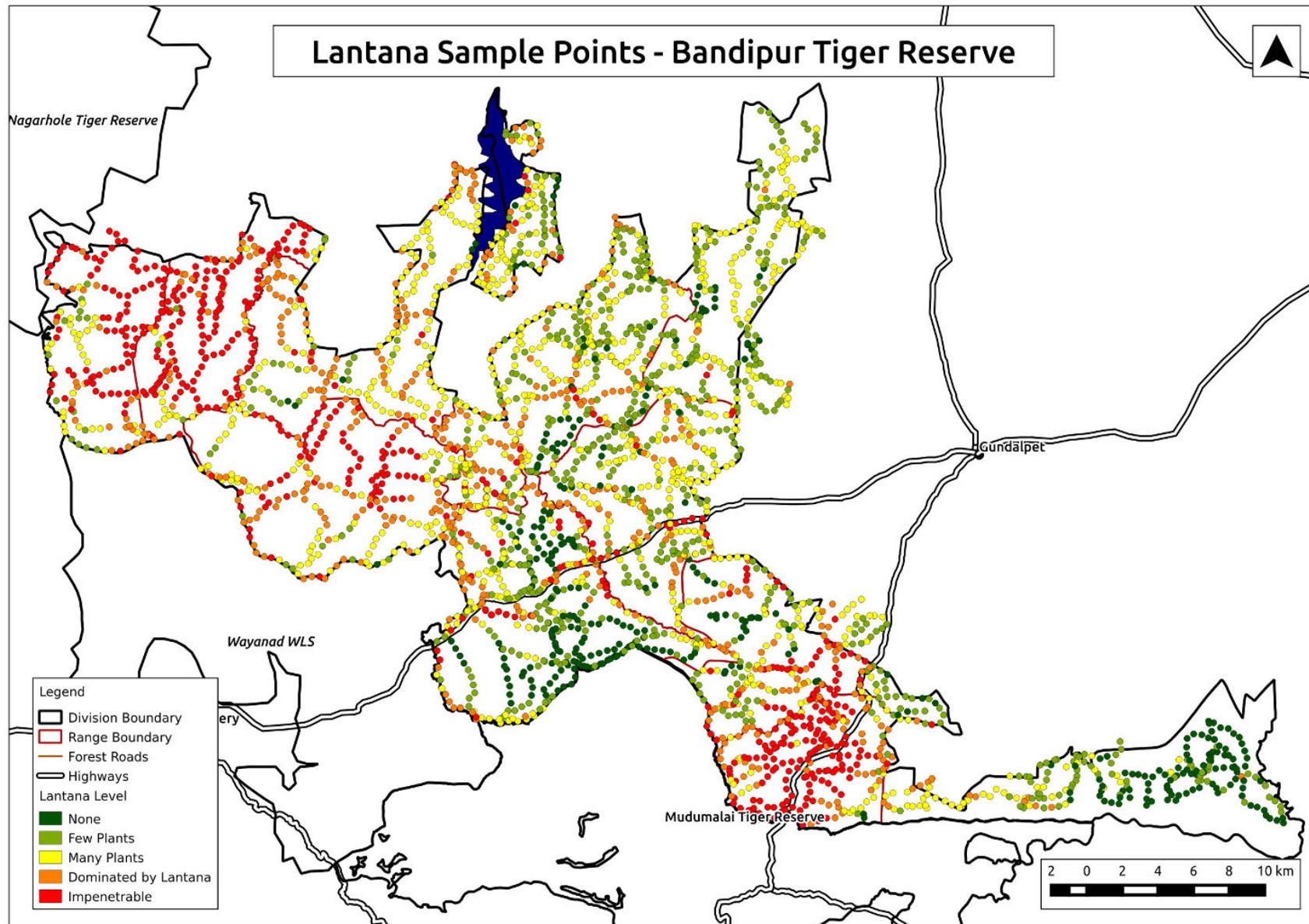
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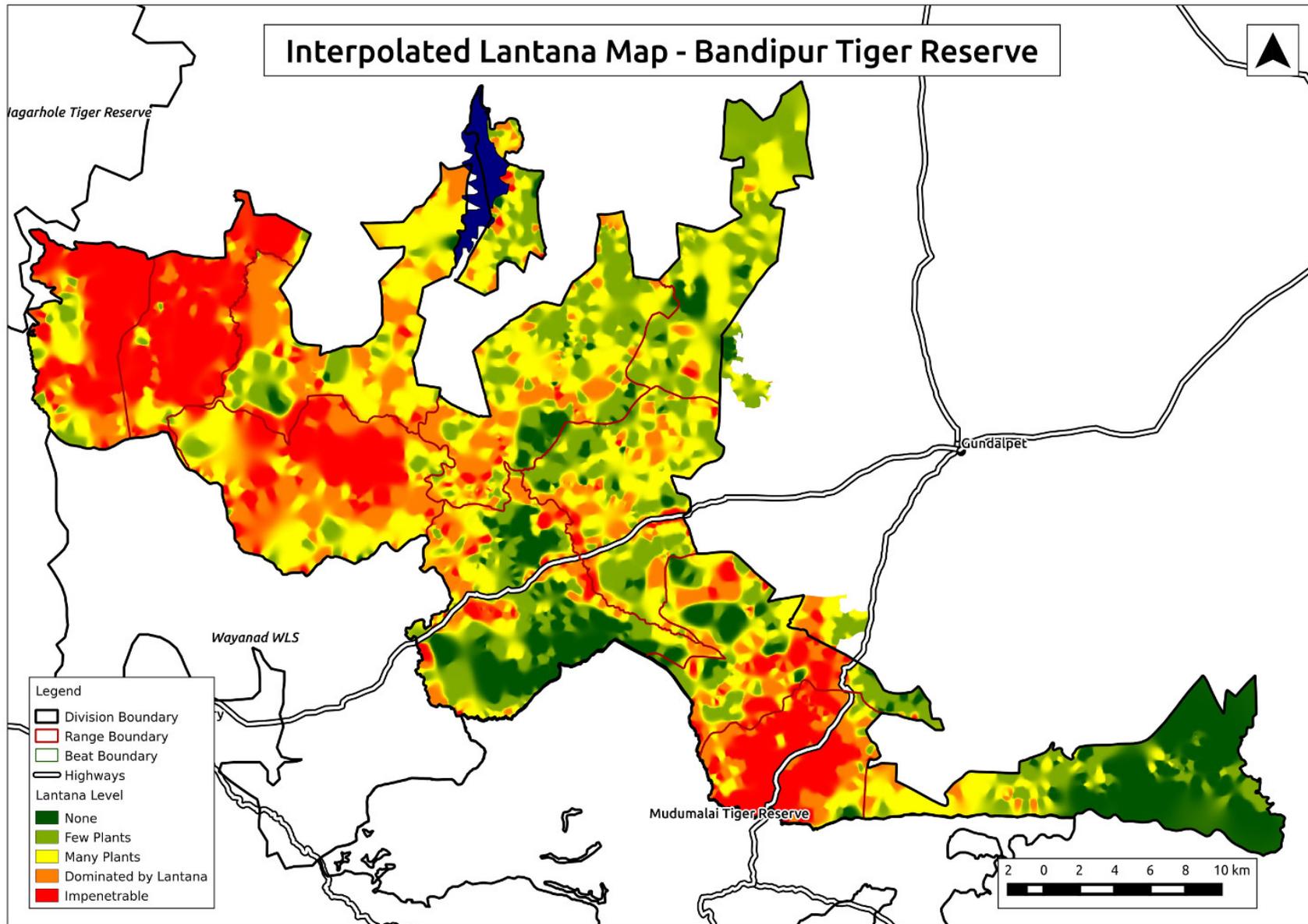
Appendix 1: Sample Beat Map



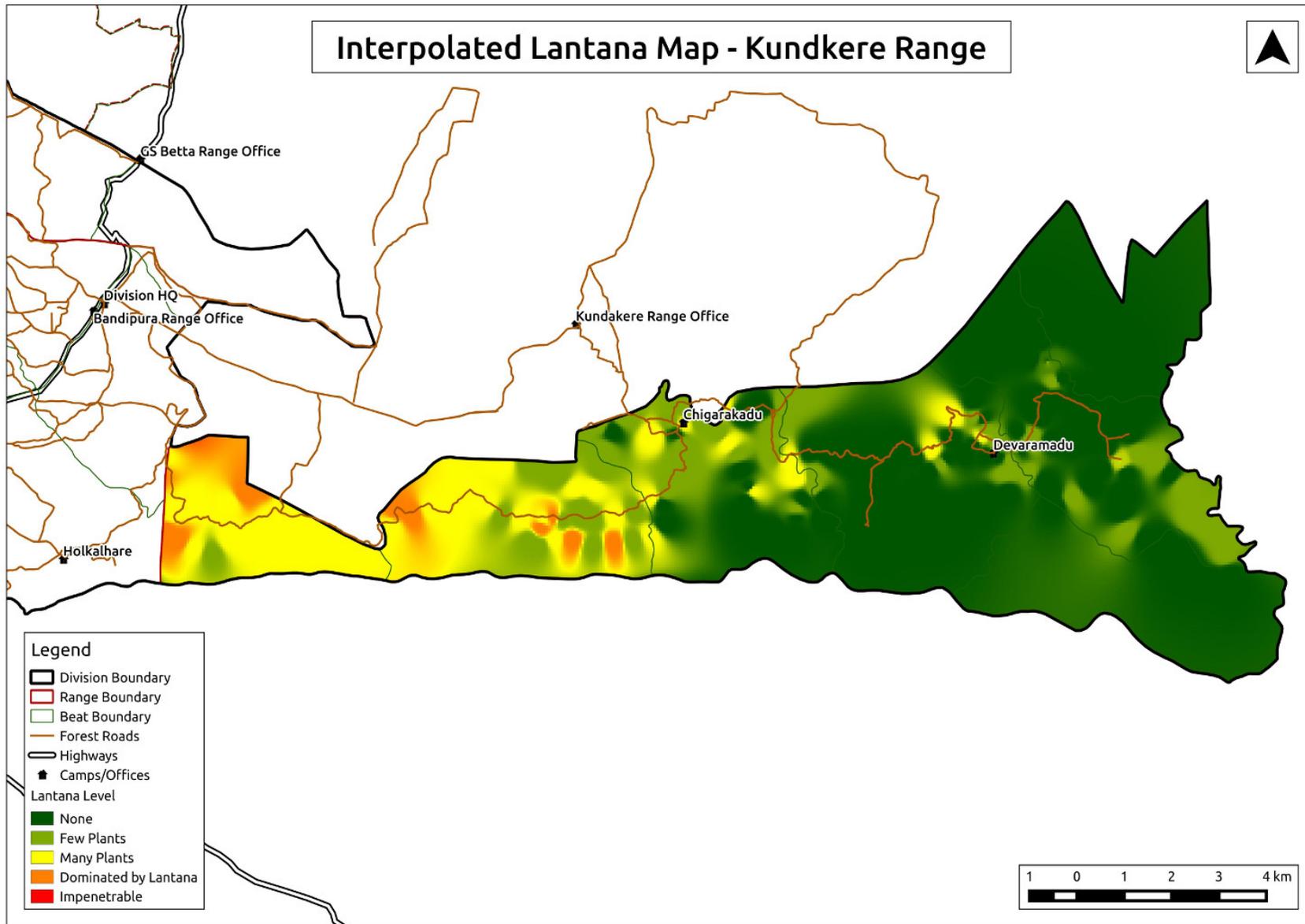
Appendix 2: Distribution of Waypoints



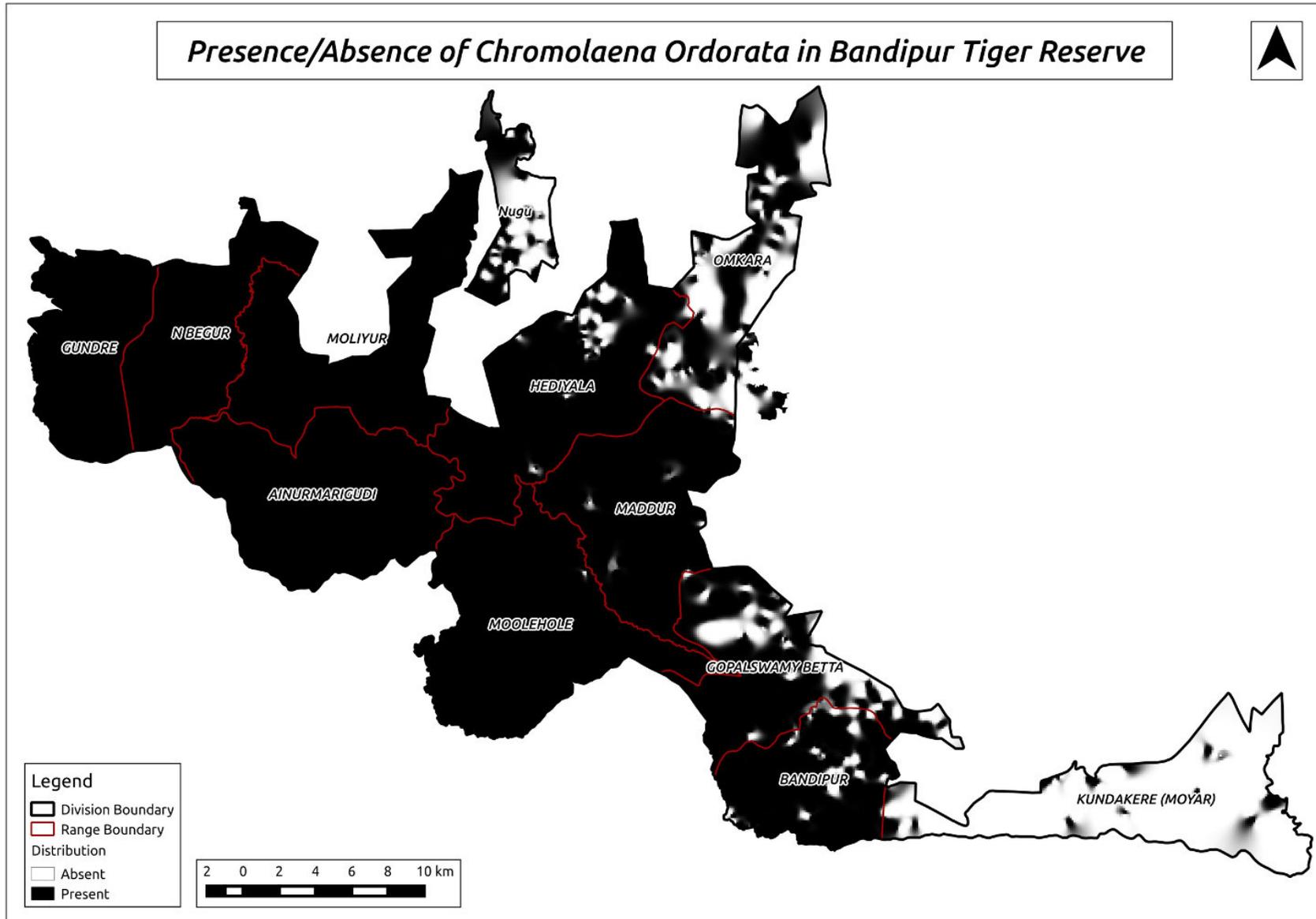
Appendix 3: Interpolated Lantana Map



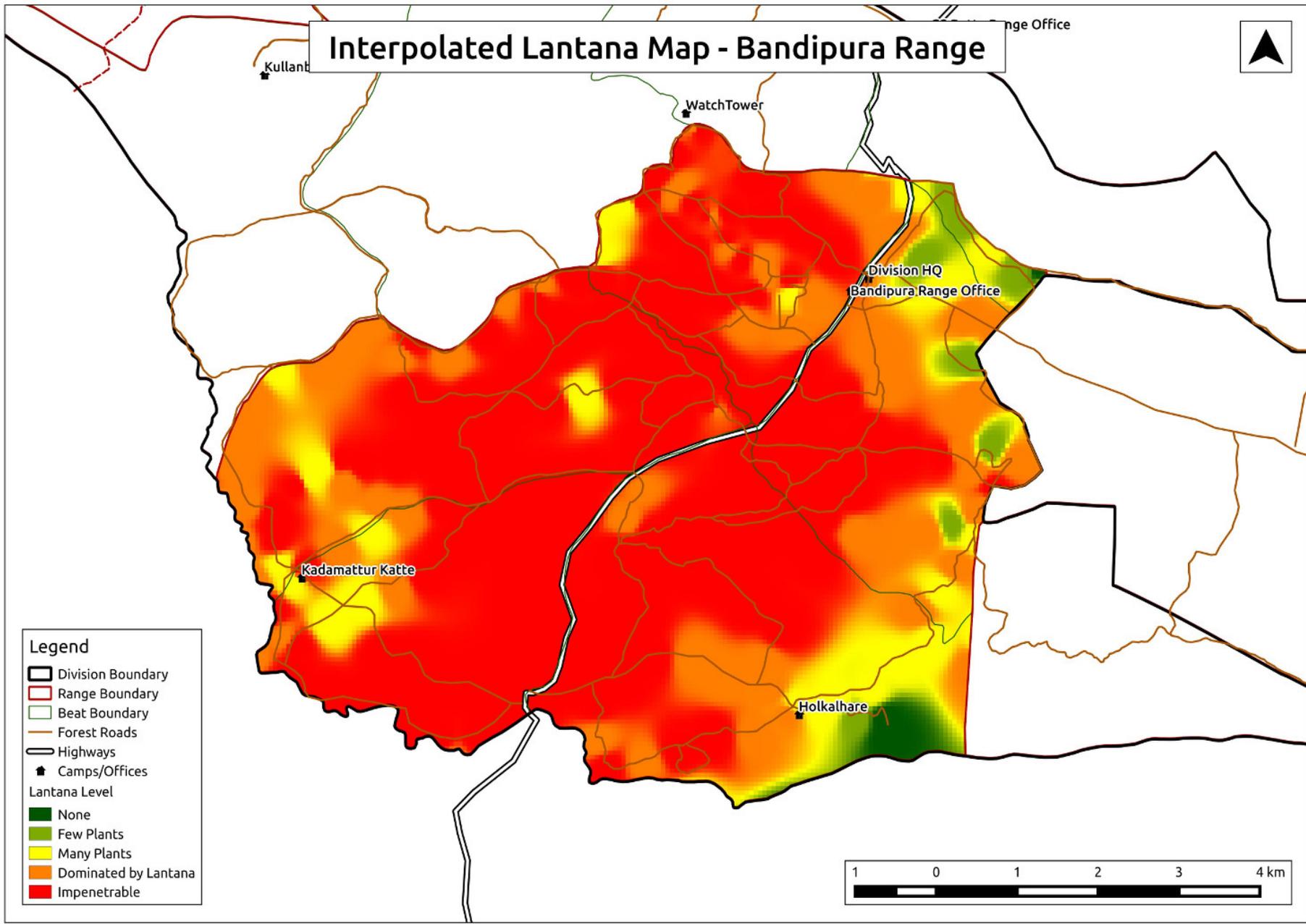
Appendix 4: Interpolated Lantana Map of Each Range



Appendix 7: Distribution of *Chromolaena odorata*

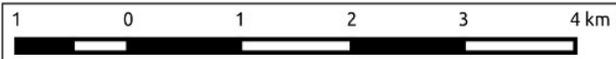


Interpolated Lantana Map - Bandipura Range

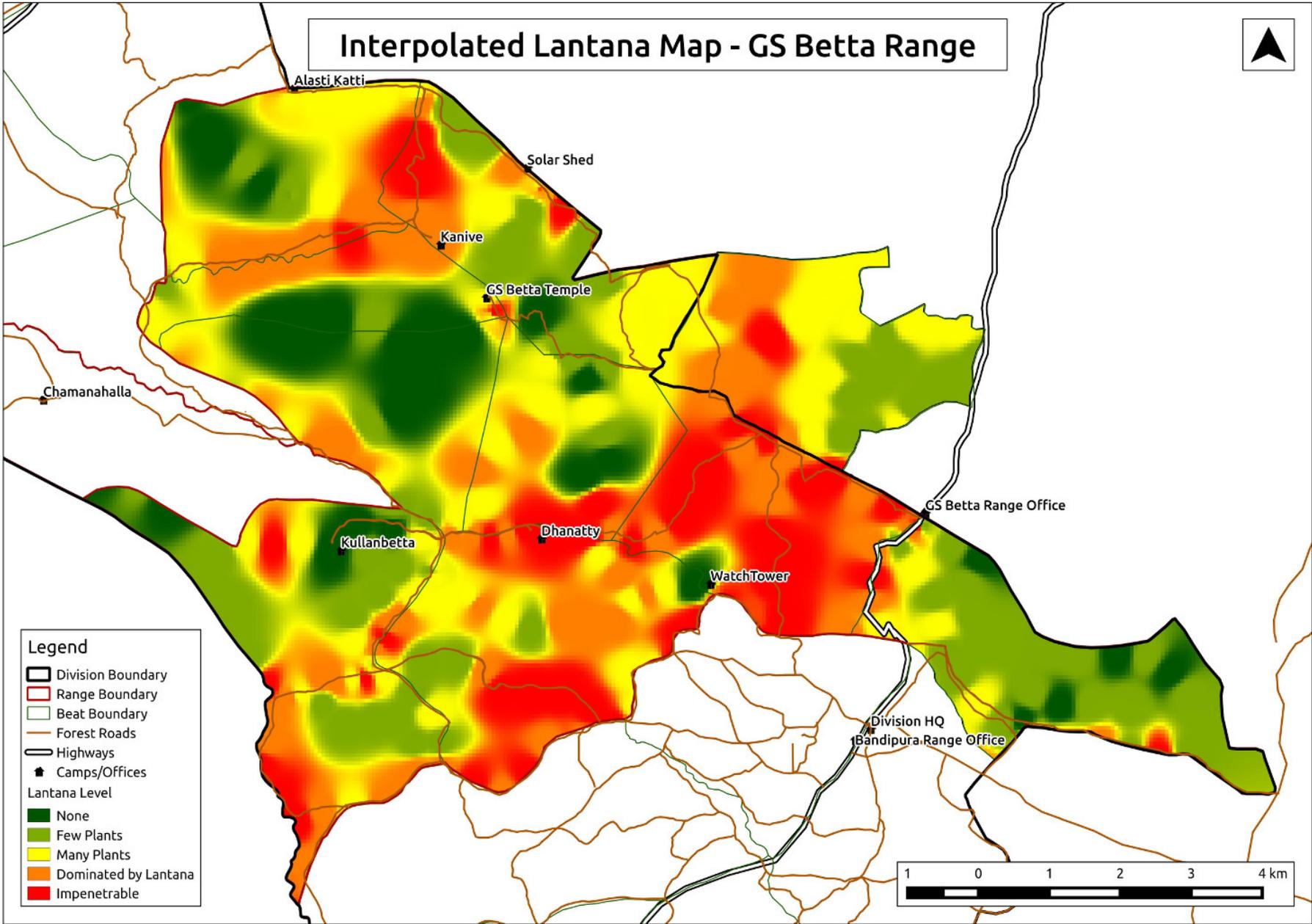


Legend

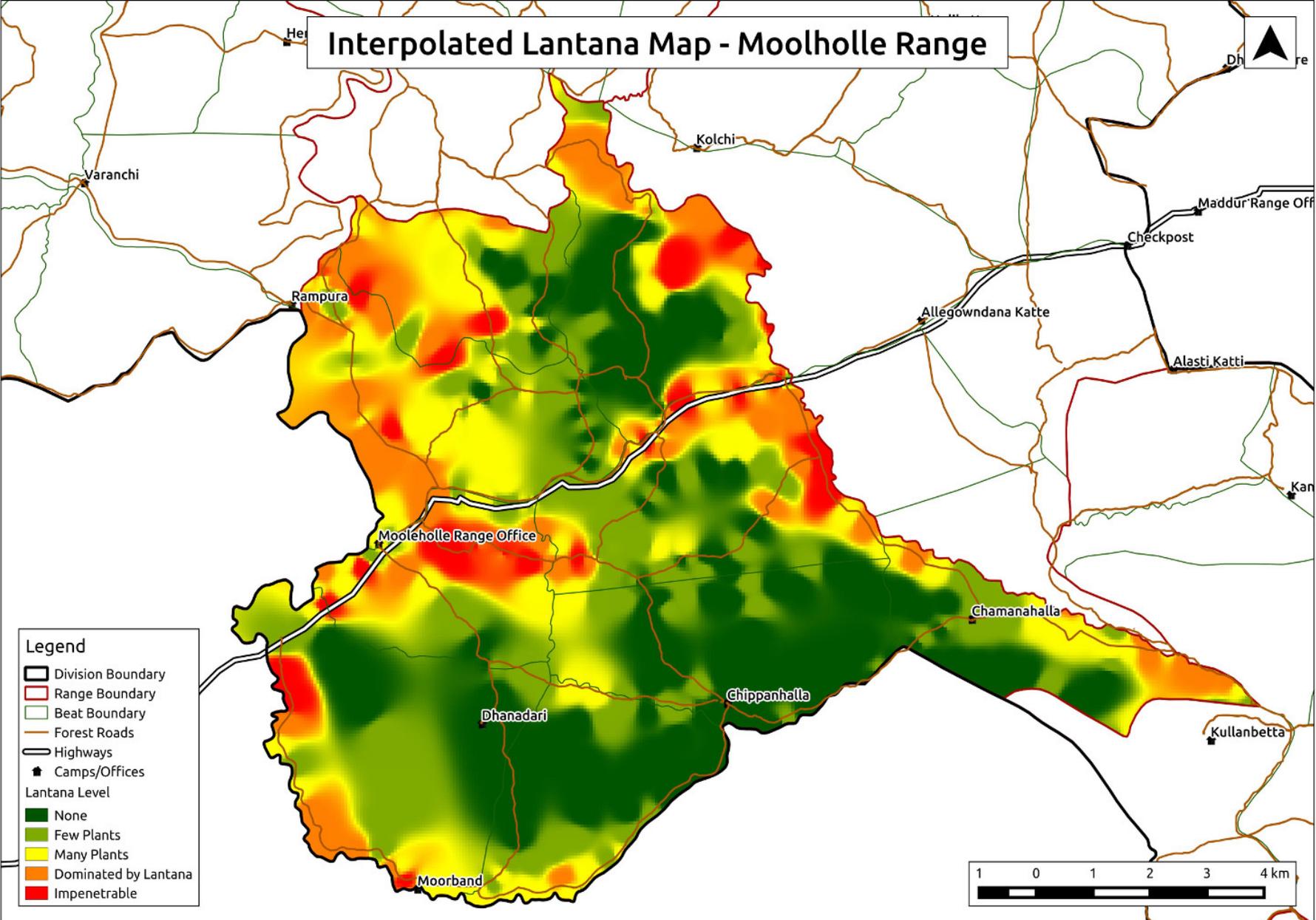
- Division Boundary
- Range Boundary
- Beat Boundary
- Forest Roads
- Highways
- Camps/Offices
- Lantana Level
 - None
 - Few Plants
 - Many Plants
 - Dominated by Lantana
 - Impenetrable



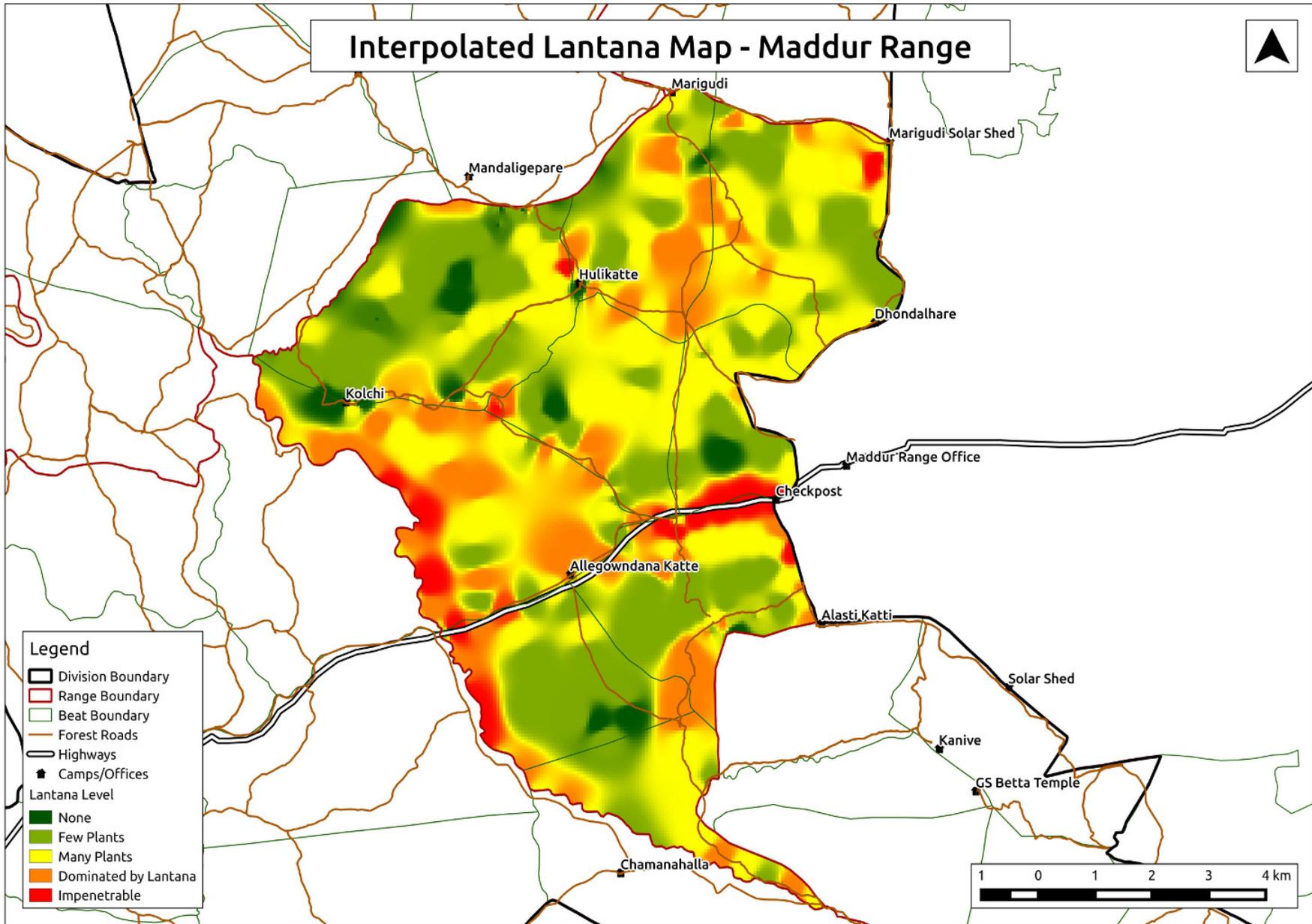
Interpolated Lantana Map - GS Betta Range



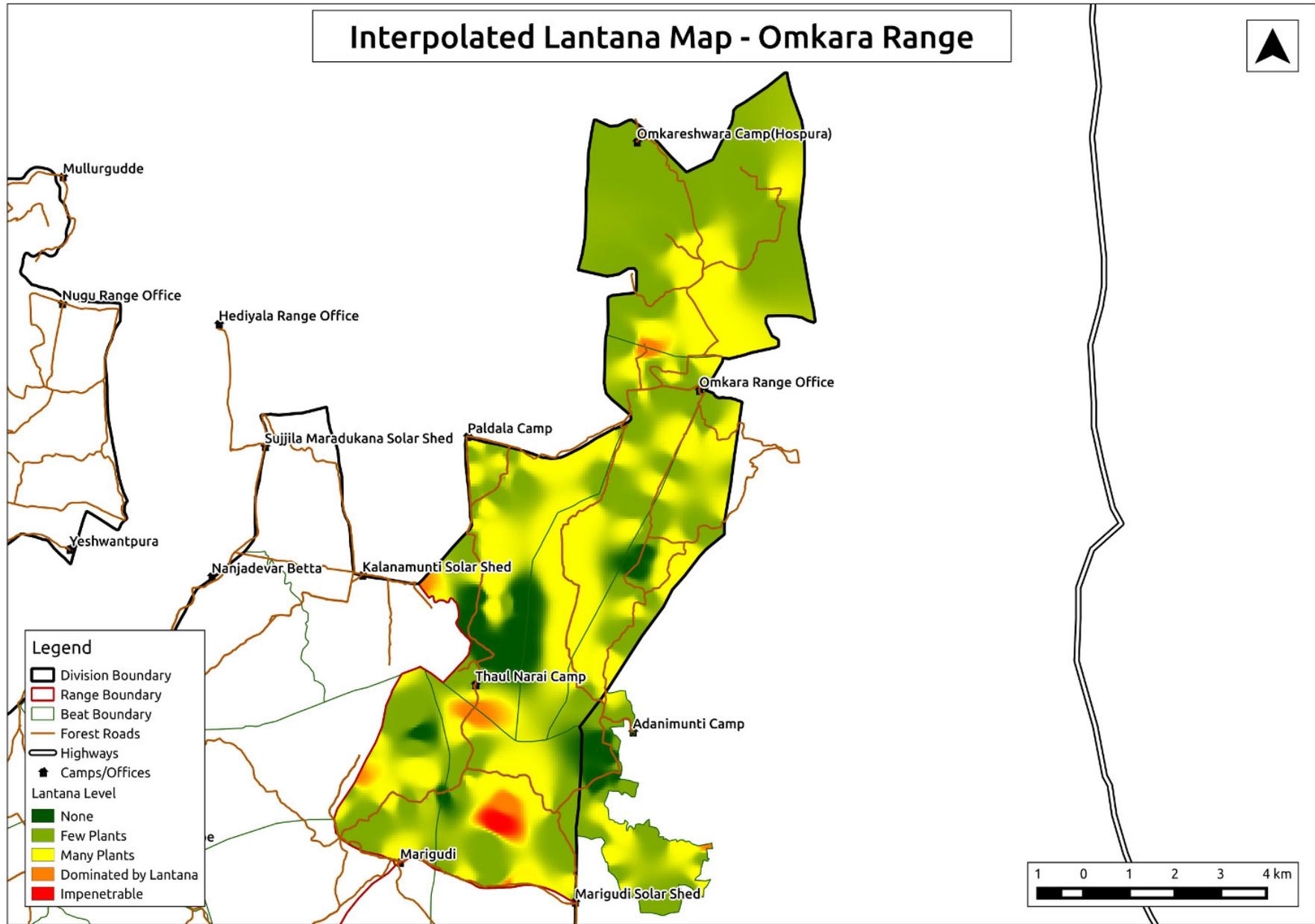
Interpolated Lantana Map - Moolhulle Range



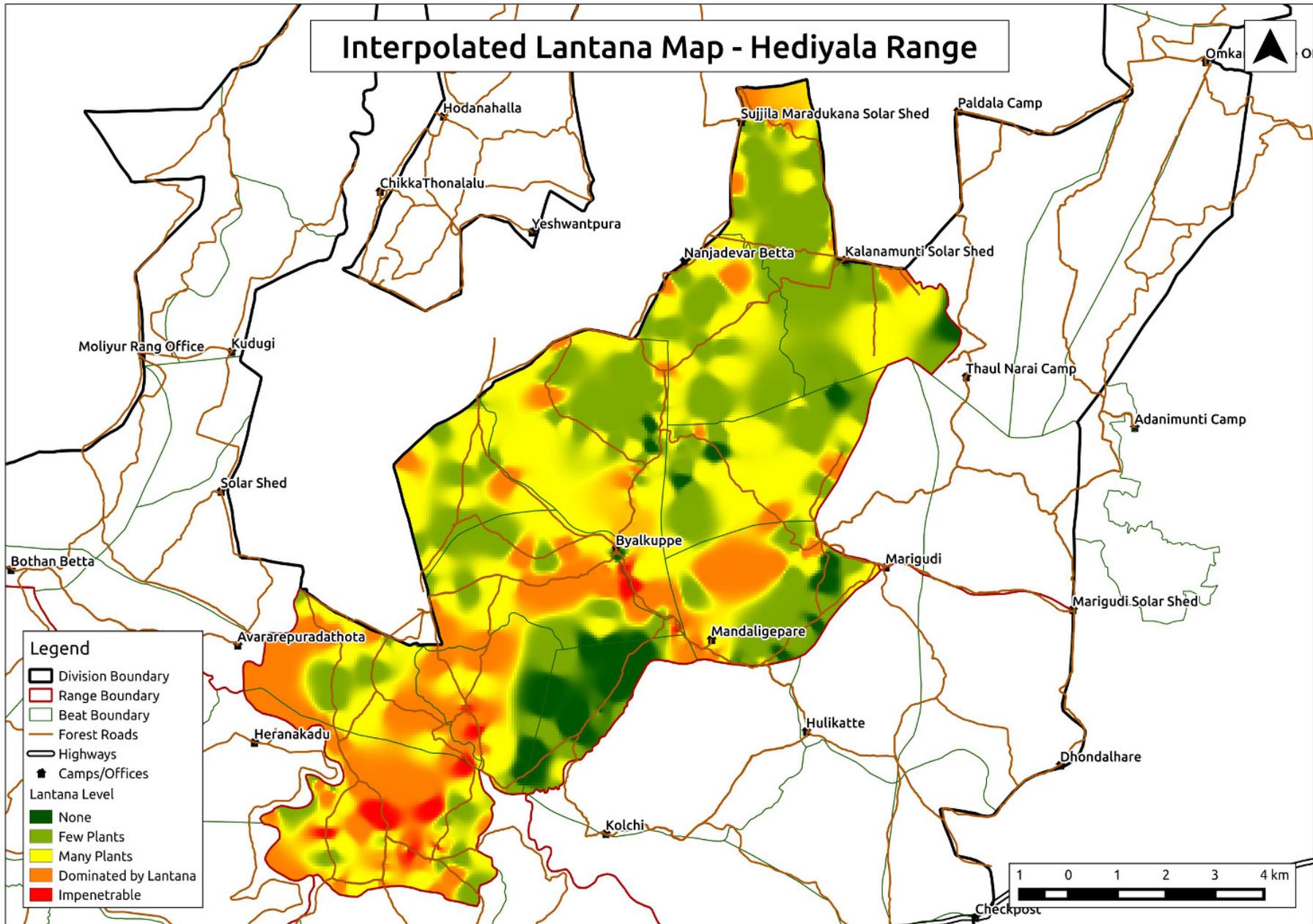
Interpolated Lantana Map - Maddur Range

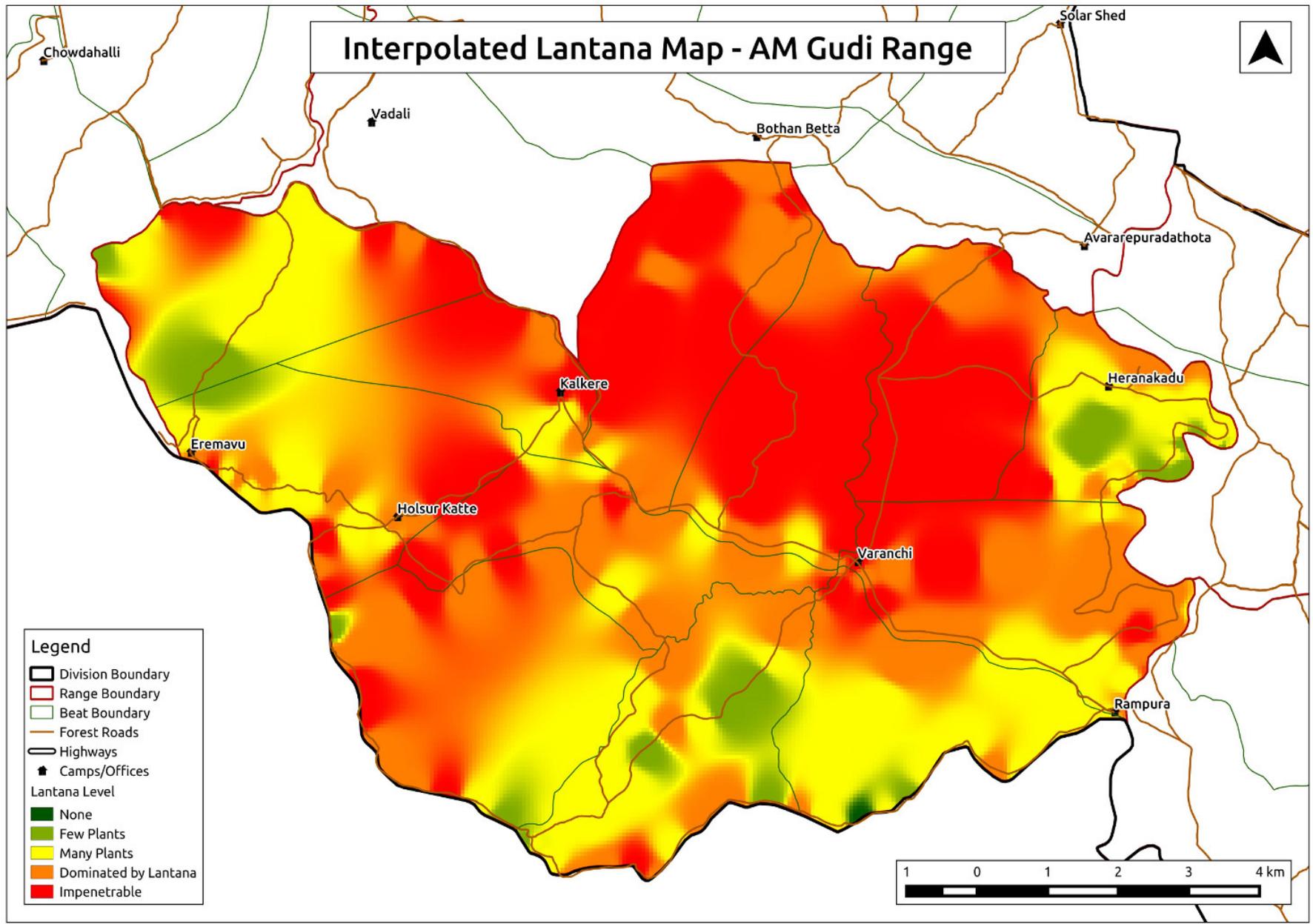


Interpolated Lantana Map - Omkara Range

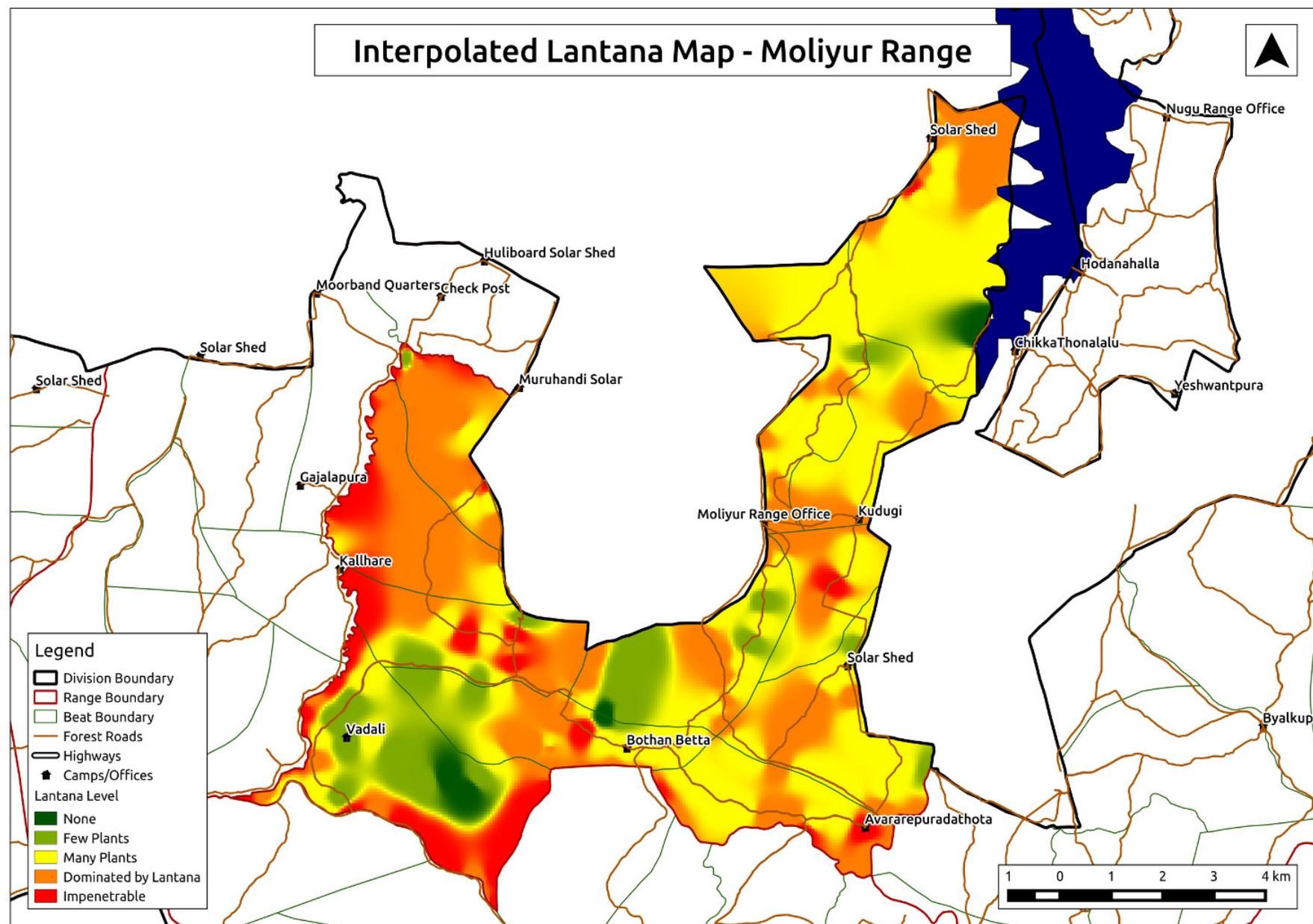


Interpolated Lantana Map - Hediya Range

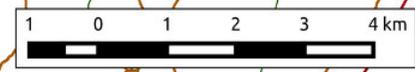




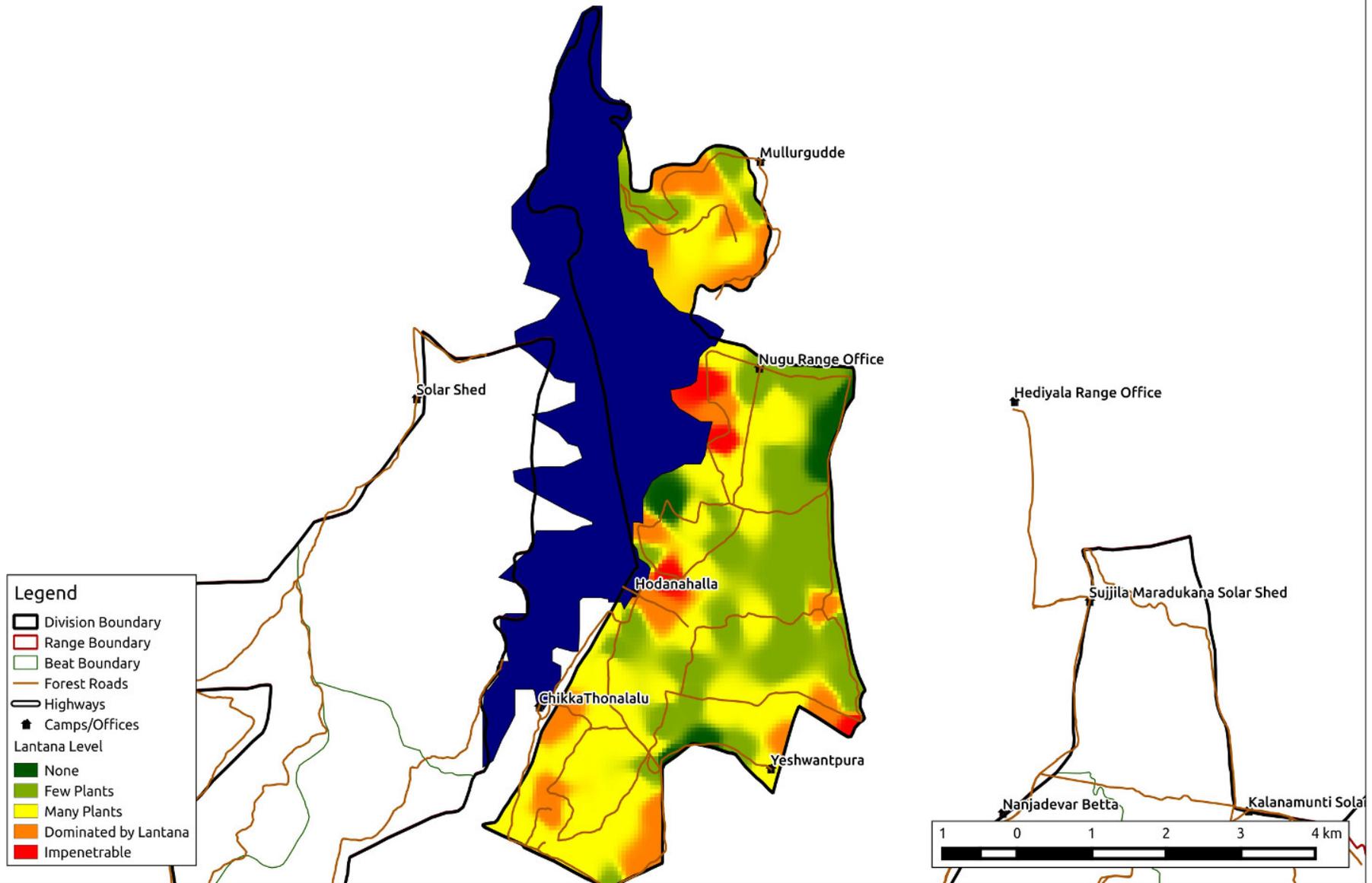
Interpolated Lantana Map - Moliyur Range



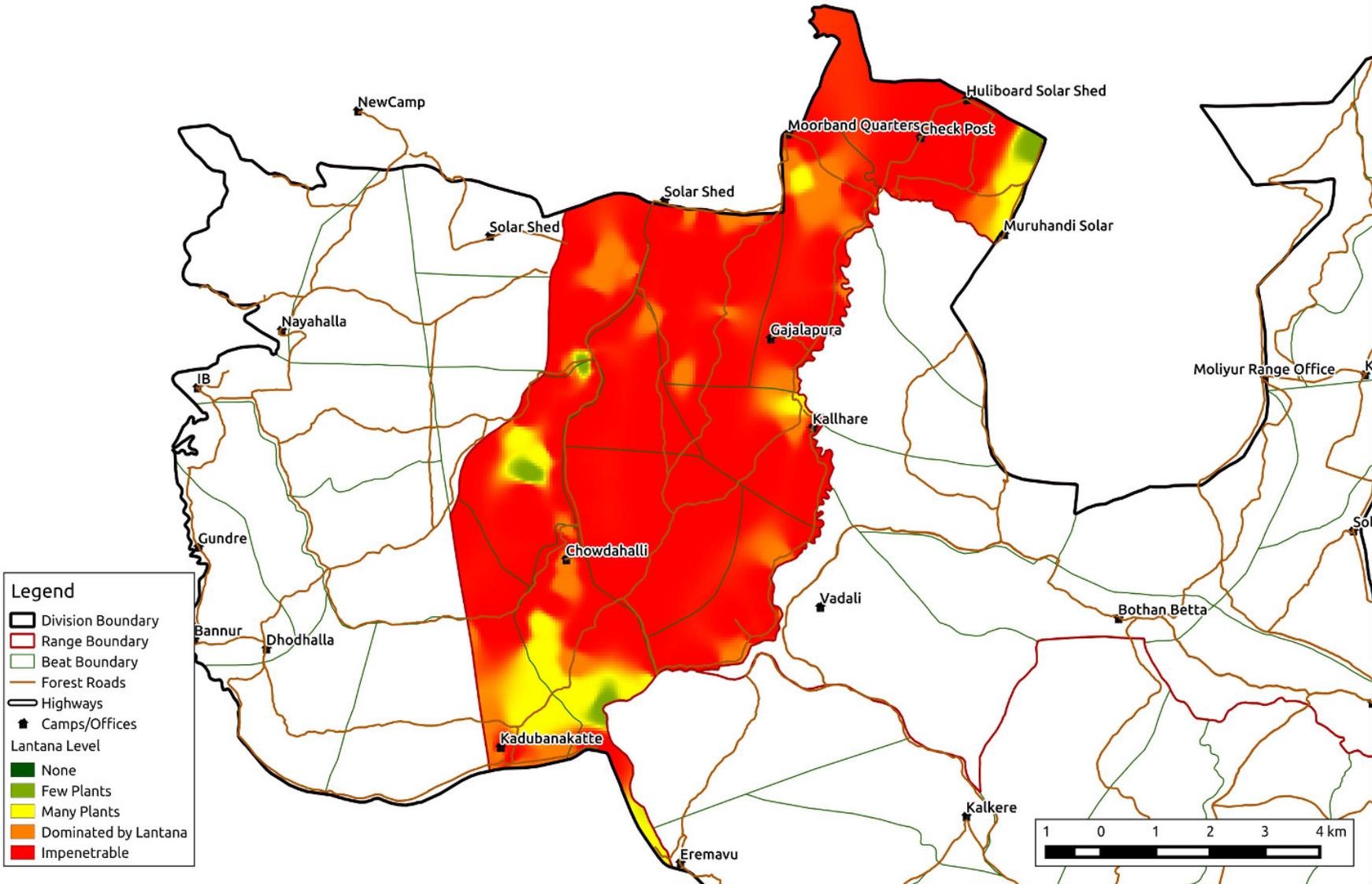
- Legend**
- Division Boundary
 - Range Boundary
 - Beat Boundary
 - Forest Roads
 - Highways
 - Camps/Offices
 - Lantana Level
 - None
 - Few Plants
 - Many Plants
 - Dominated by Lantana
 - Impenetrable



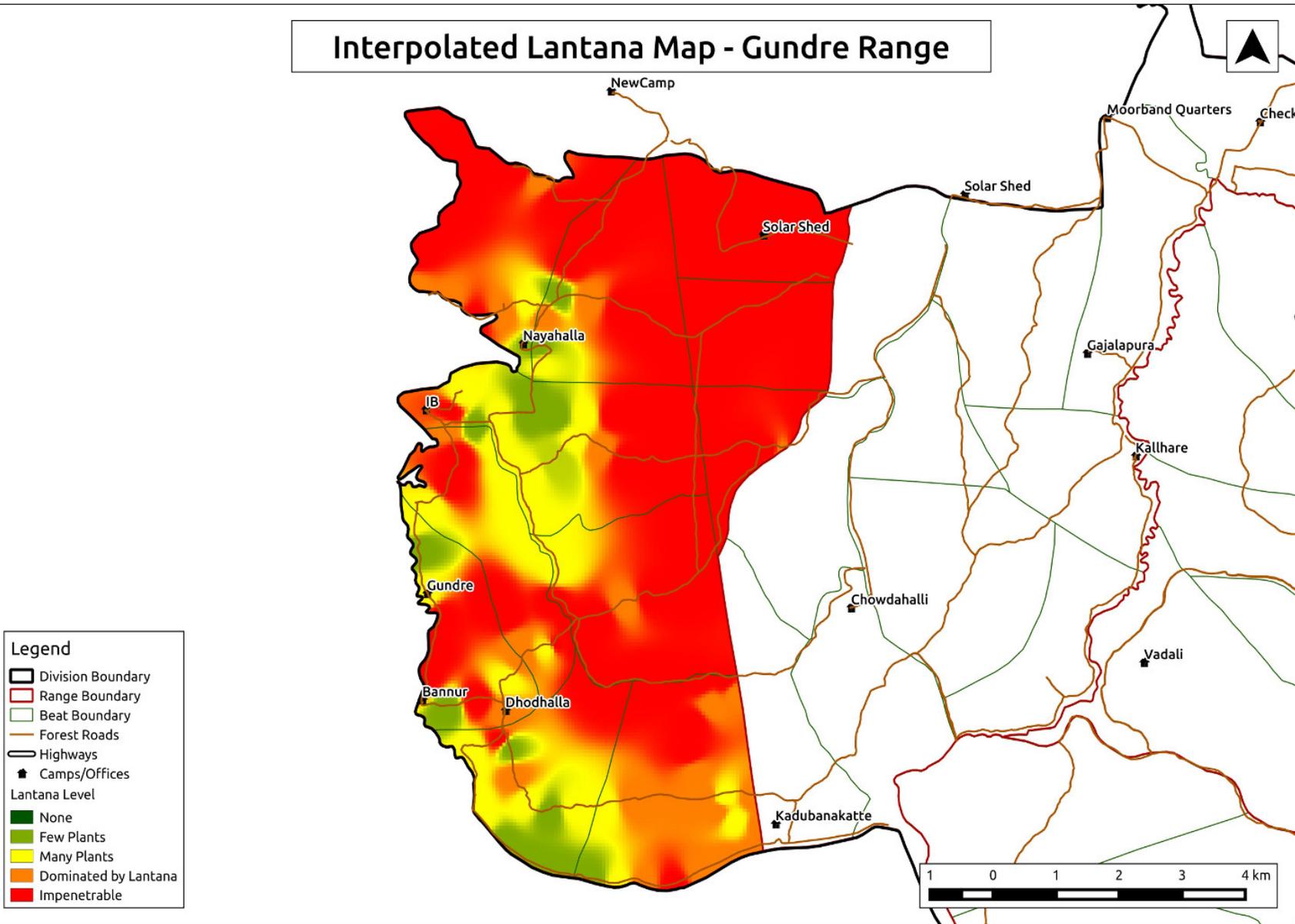
Interpolated Lantana Map - Nugu Range



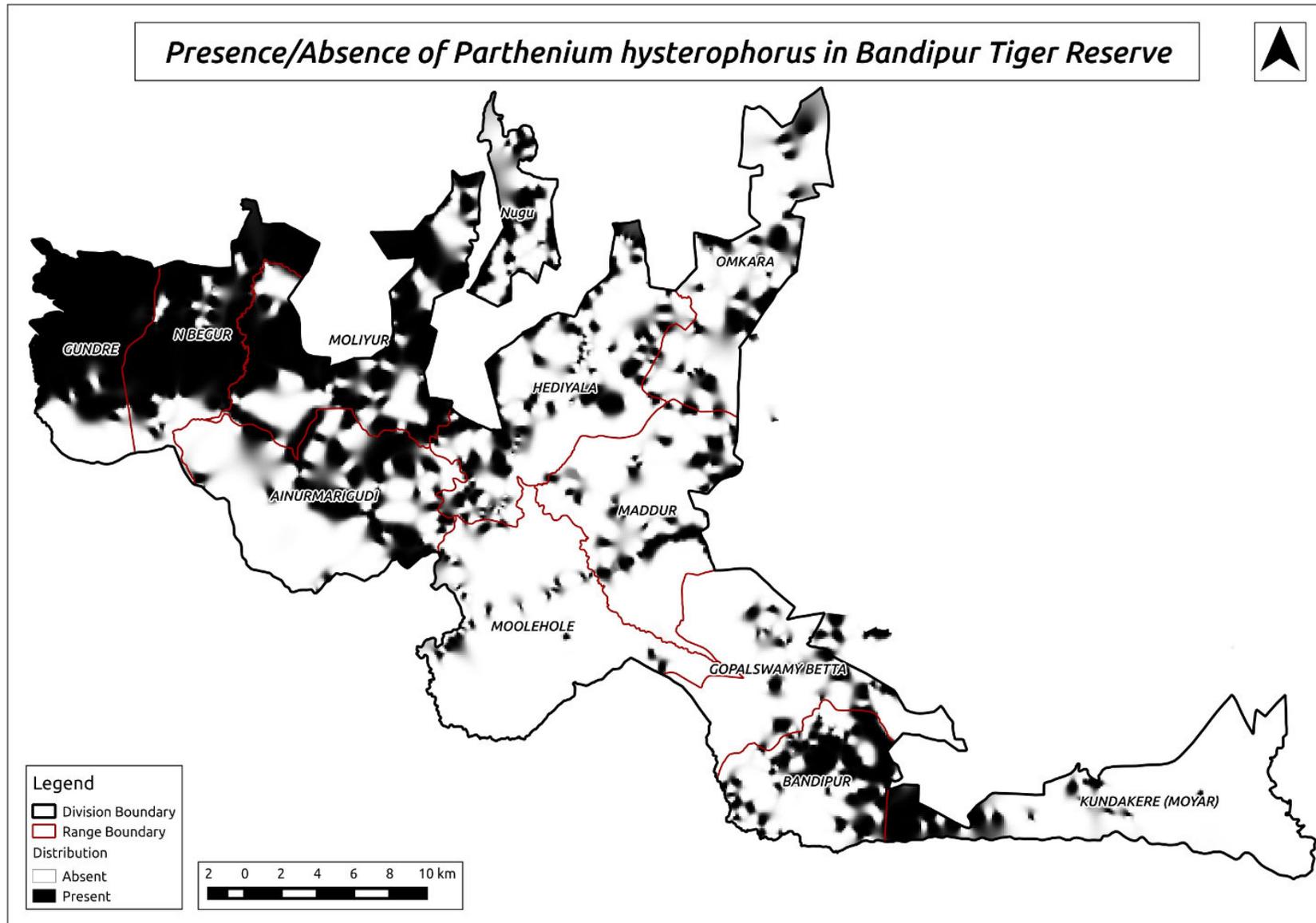
Interpolated Lantana Map - N Begur Range



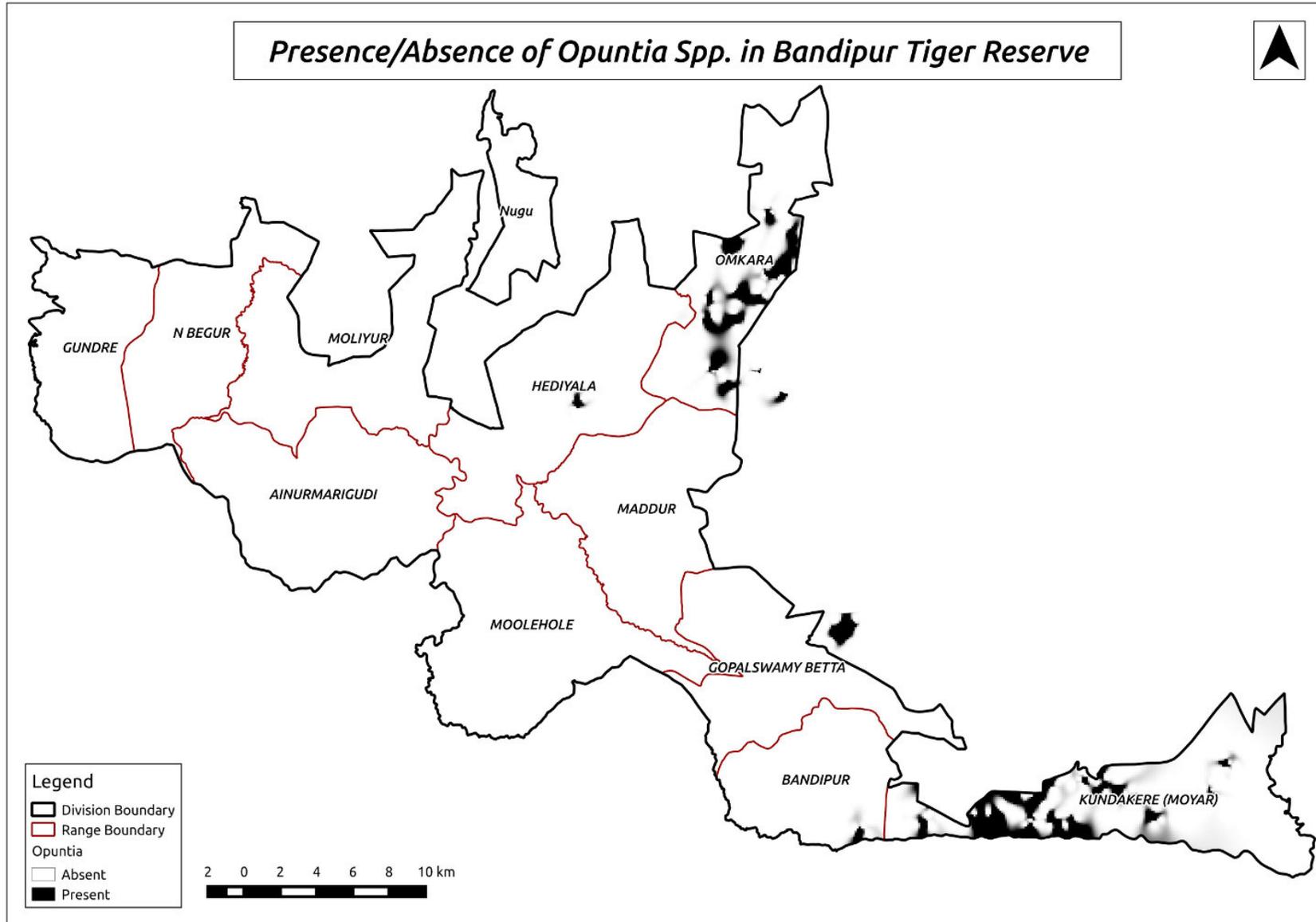
Interpolated Lantana Map - Gundre Range



Appendix 8: Distribution of *Parthenium hysterophorus*



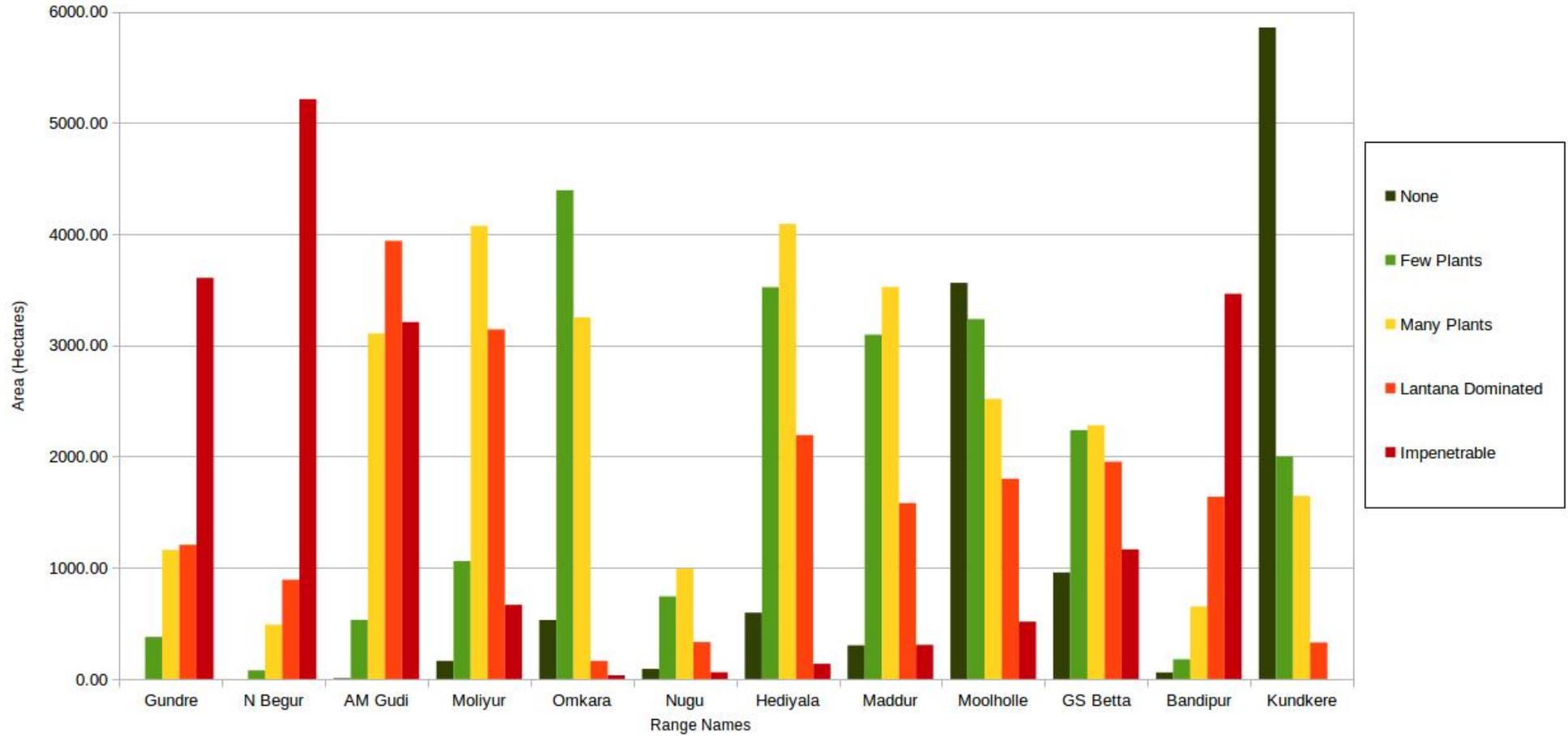
Appendix 9: Distribution of *Opuntia* spp.



Appendix 10: Graphs of Lantana Distribution

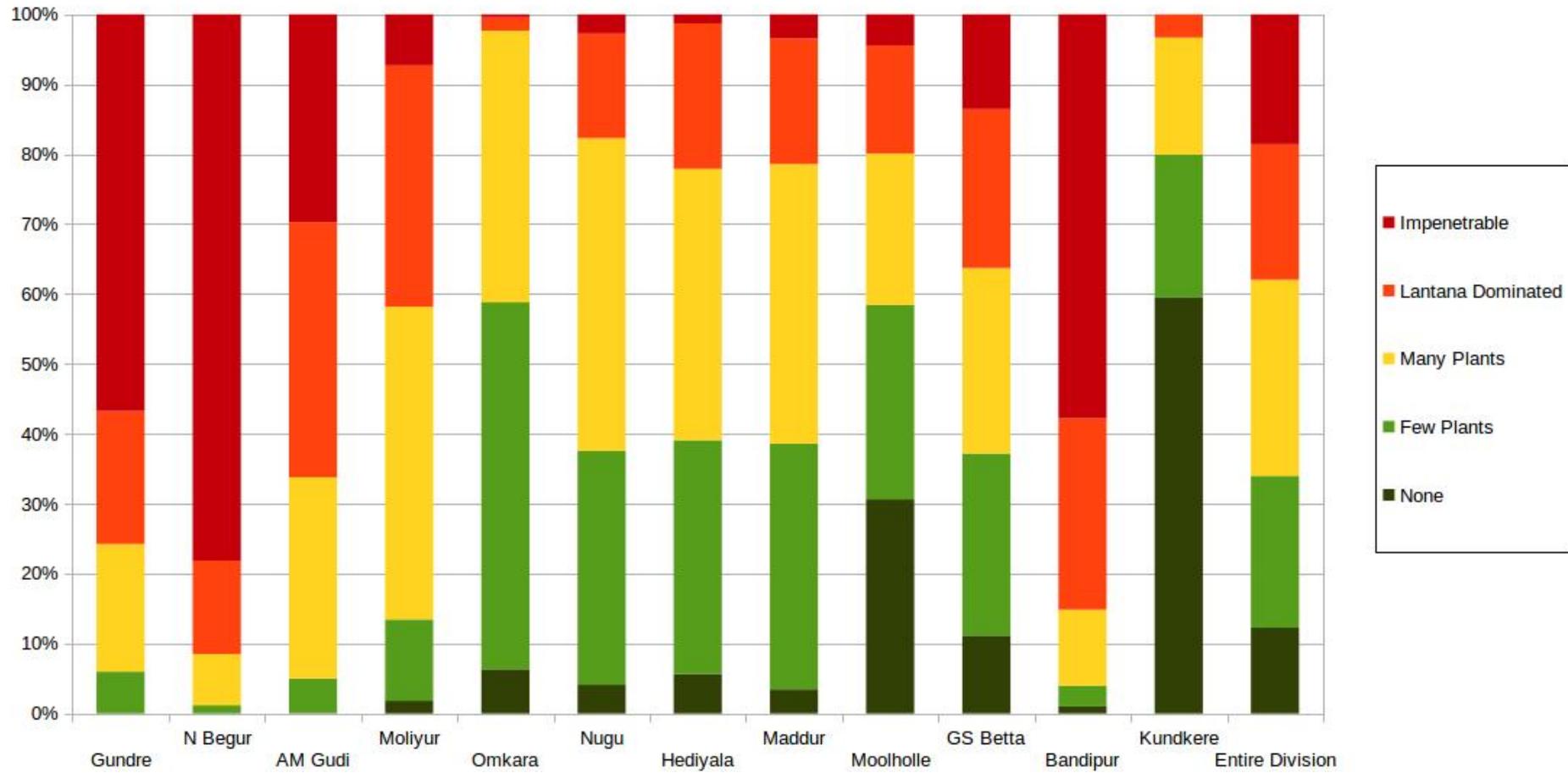
Lantana Infestation in Bandipur Tiger Reserve

Areas in each Range



Lantana Infestation in Bandipur Tiger Reserve

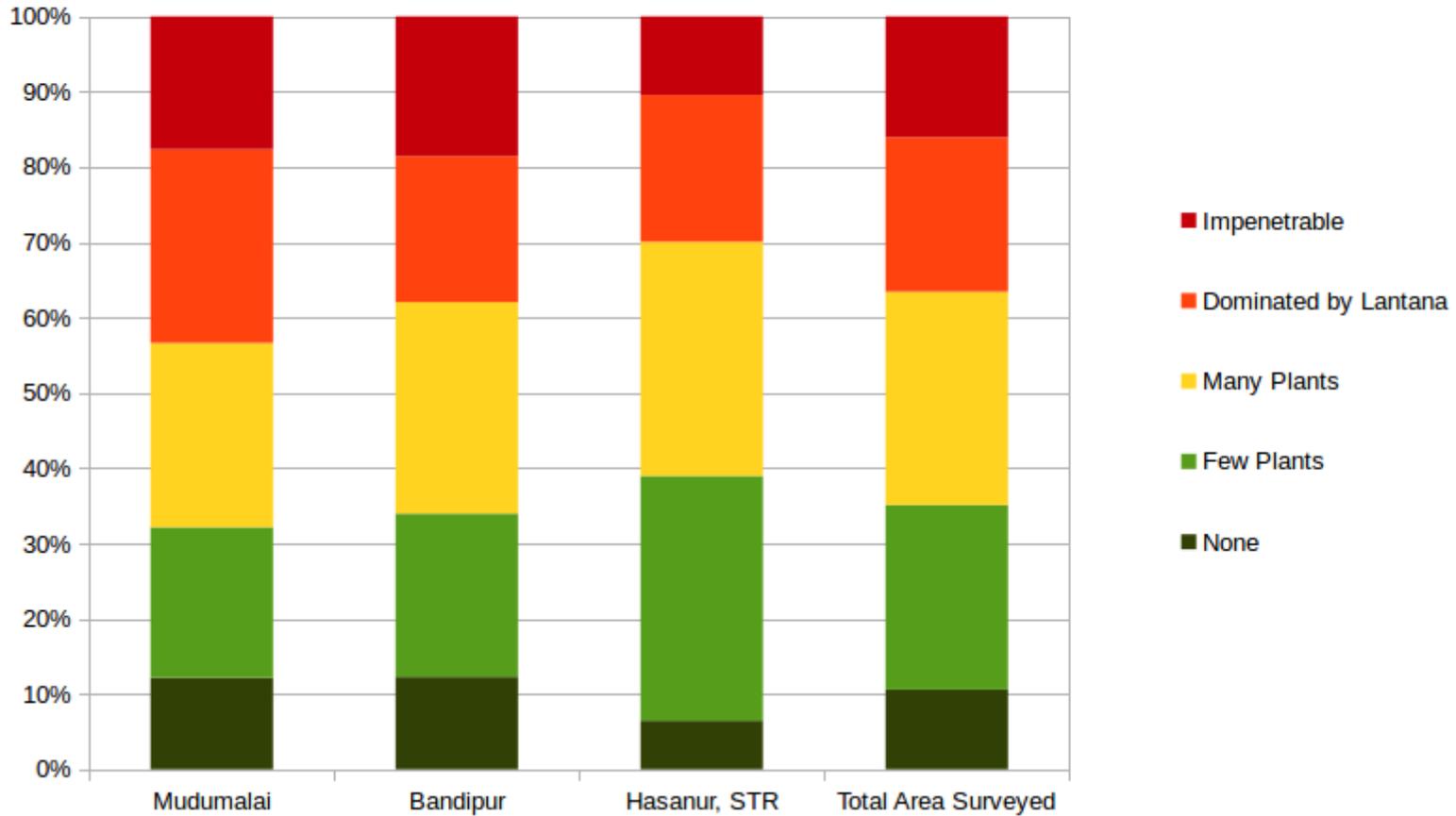
Percentages in each Range



Appendix 11: Comparison of Lantana Spread between Parks

Comparison of Lantana Invasion Between Parks

Mudumalai, Bandipur and Hasanur Division, Sathyamangalam



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