

Elephant Behavior in Victoria Falls, Zimbabwe

Sam Shuster



Introduction & Background

- Elephants are one of the most persecuted wildlife species on the planet
- Despite being classified as a protected species, they are still hunted for their tusks
- Human development of land has unintended consequences on wildlife



Introduction

- **Research Question 1: What factors influence elephant movement patterns?**
 - Seasonal changes?
 - Resource changes?
 - How do the various elephants interact with the urban area?
- **Research Question 2: What portion of land do elephants roam and occupy relative to the portion of land set aside for conservation?**







Feature Classes

- 1. Urban land Coordinate System - Arc 1950 UTM 36S
- 2. Rangeland
 - a. Herbaceous Rangeland
 - b. Shrub and Brush Rangeland
 - c. Mixed Rangeland
- 3. Water
 - a. Streams and Canals
 - b. Reservoirs
- 4. Roads
 - a. Paved
 - b. Unpaved
- 5. Designated Conservation Land
- 6. Not designated Conservation Land

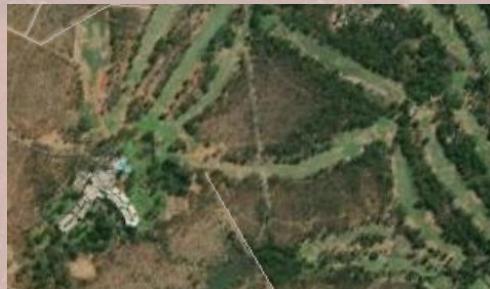


Classification System - Urban

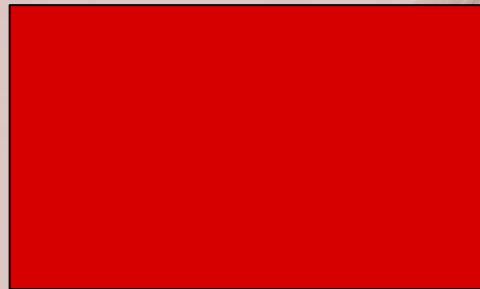
1.11 Residential land



1.12 Commercial land



1.16 Mixed residential and commercial



Classification System - Rangeland

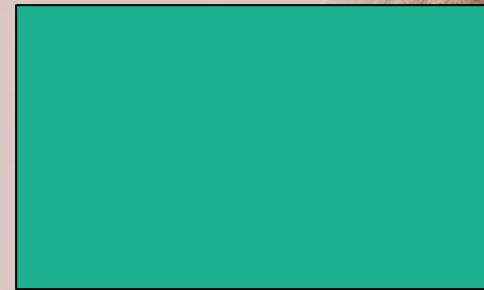
3.31 Herbaceous rangeland



3.32 Shrub and brush rangeland



3.33 Mixed rangeland

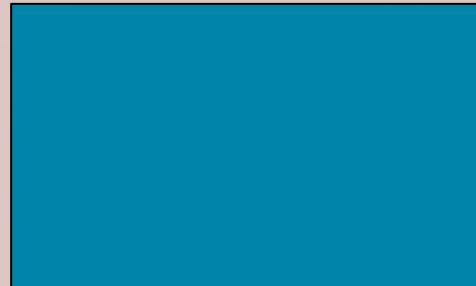


Classification System - Water and Barren Land

1.17 Garbage Dump

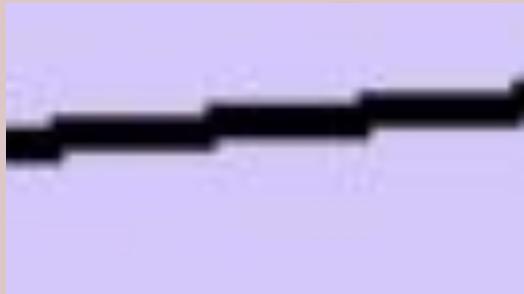


5.53 Water treatment Facility



Classification System - Roads

Paved roads



Unpaved roads



Classification System - Conservation Land

Designated Conservation



NOT Designated Conservation



Methods

- Transformed Loki 1-6 kml files to point feature shapefiles
- Digitized Basemap to create layout of Greater Victoria Falls Region
- Loaded Raster data of KAZA and created custom color palette
- Converted Study area image clippings from JPEG to TIFF
 - Large KAZA
 - Google map descriptive study area
- Georeferenced images
- Digitized 2 features based on study area images
 - Designated Conservation
 - Not designated Conservation
- Performed a union function on features of same class for continuity and to account for human error

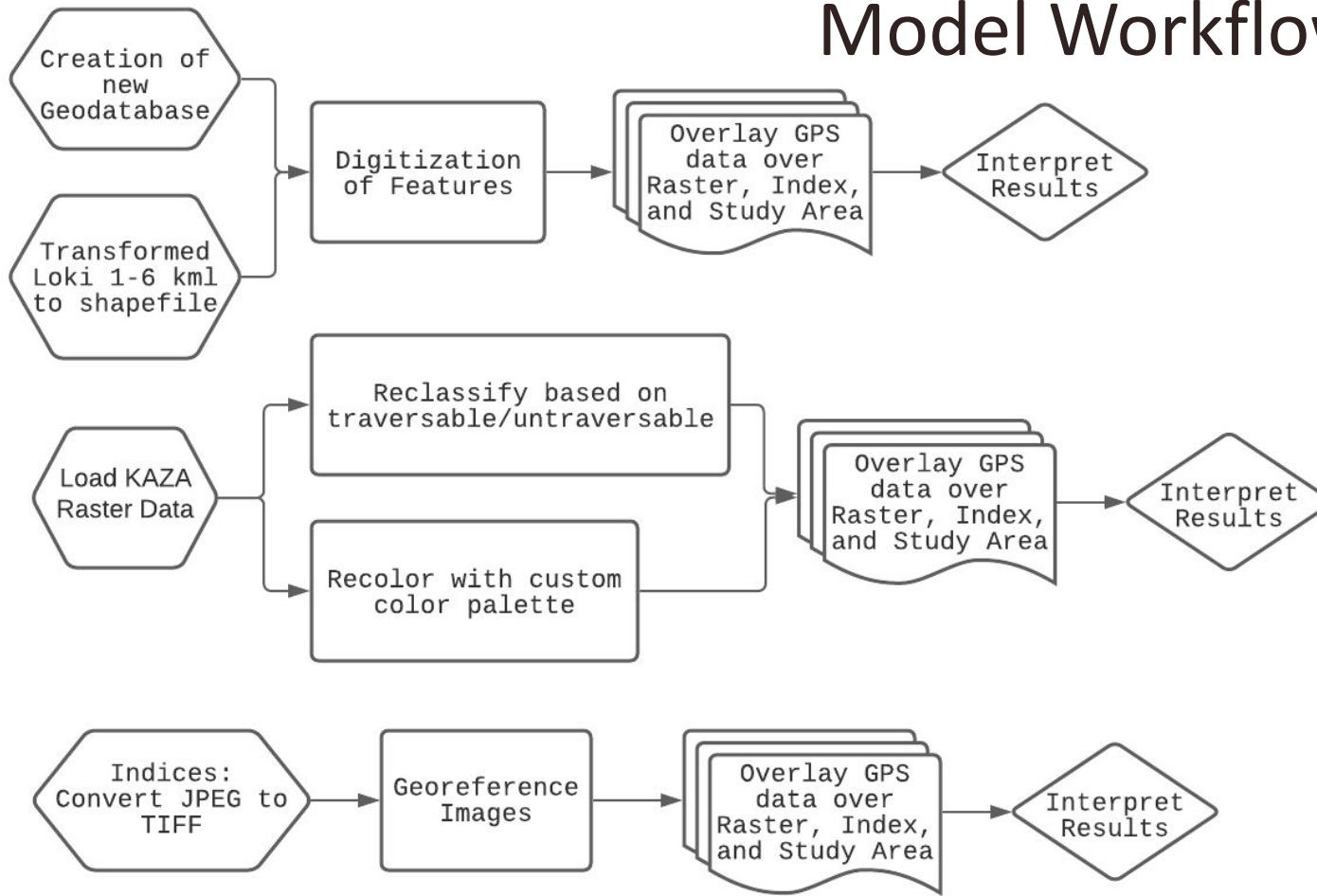


Methods cont.

- Converted remotely sensed indice images from JPEG to TIFF
- Georeferenced indice images
- Reclass raster to generalize traversable/non-traversable land (for elephants)
- *Overlay Elephant movement data and interpret movement based on interaction with layer*



Model Workflow



Results

- Total Study Area:
 - Area: 2,302,387 Hectares
- Area designated as conservation area
 - 1,137,817.5 Hectares
 - 49.4%
- Area **NOT** designated as conservation area
 - 1,164,570.89 Hectares
 - 50.6%
- NDMI provides significant finding

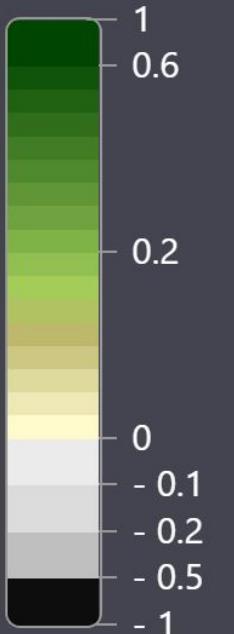




NDVI

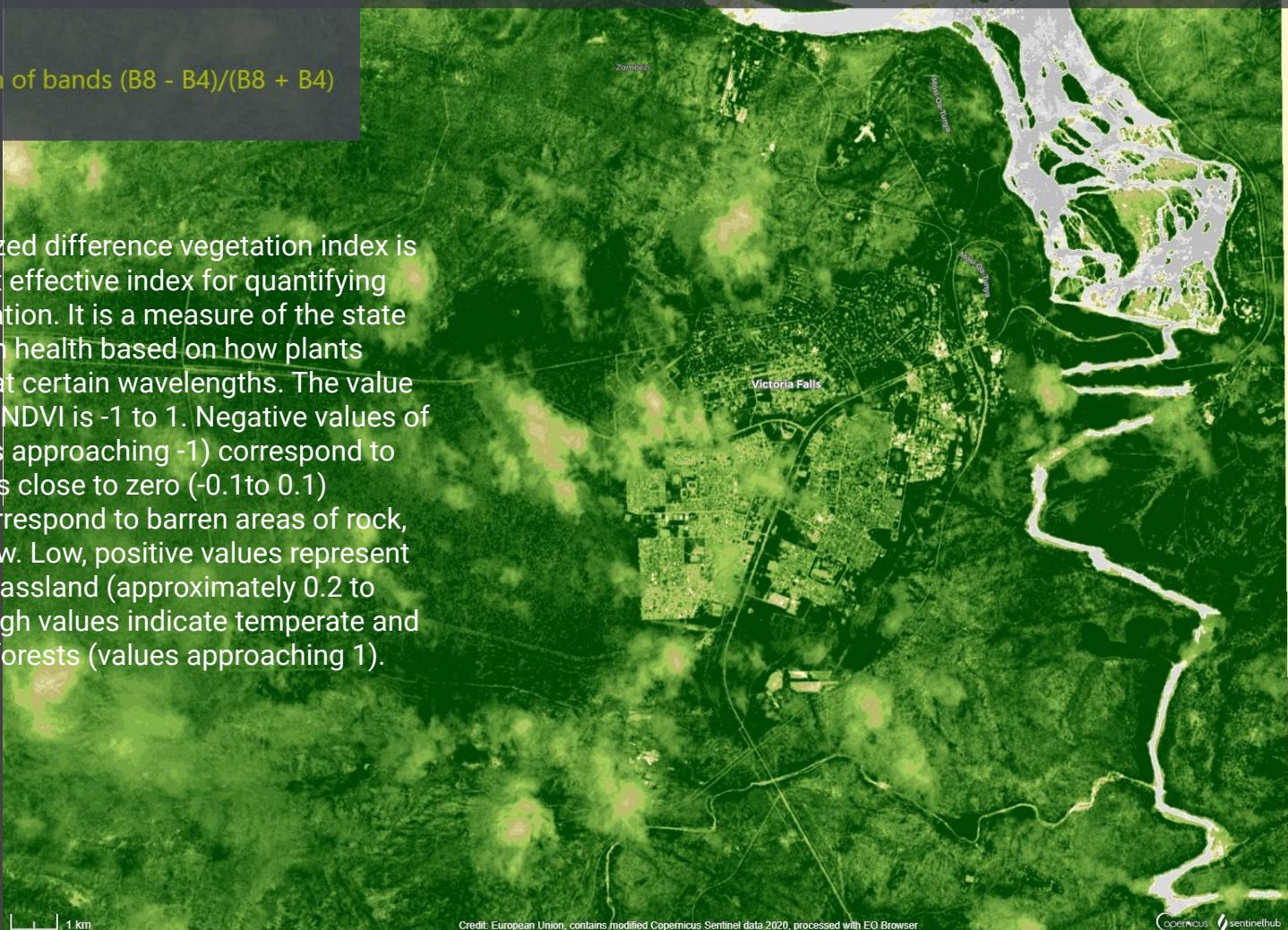
Based on combination of bands $(B8 - B4)/(B8 + B4)$

Source: Sentinel Hub



The normalized difference vegetation index is a simple, but effective index for quantifying green vegetation. It is a measure of the state of vegetation health based on how plants reflect light at certain wavelengths. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).

2020-12-08 00:00 - 2020-12-08 23:59, Sentinel-2 L1C, NDVI

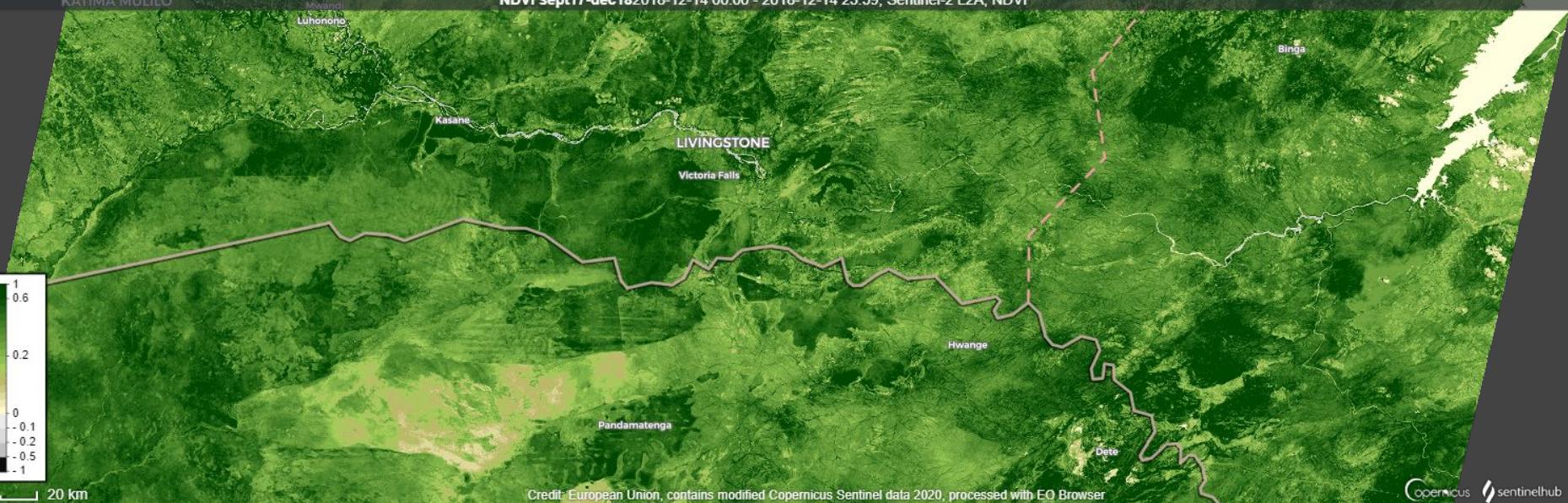


Credit: European Union, contains modified Copernicus Sentinel data 2020, processed with EO Browser

Copernicus sentinelhub

KATIMA MULILO

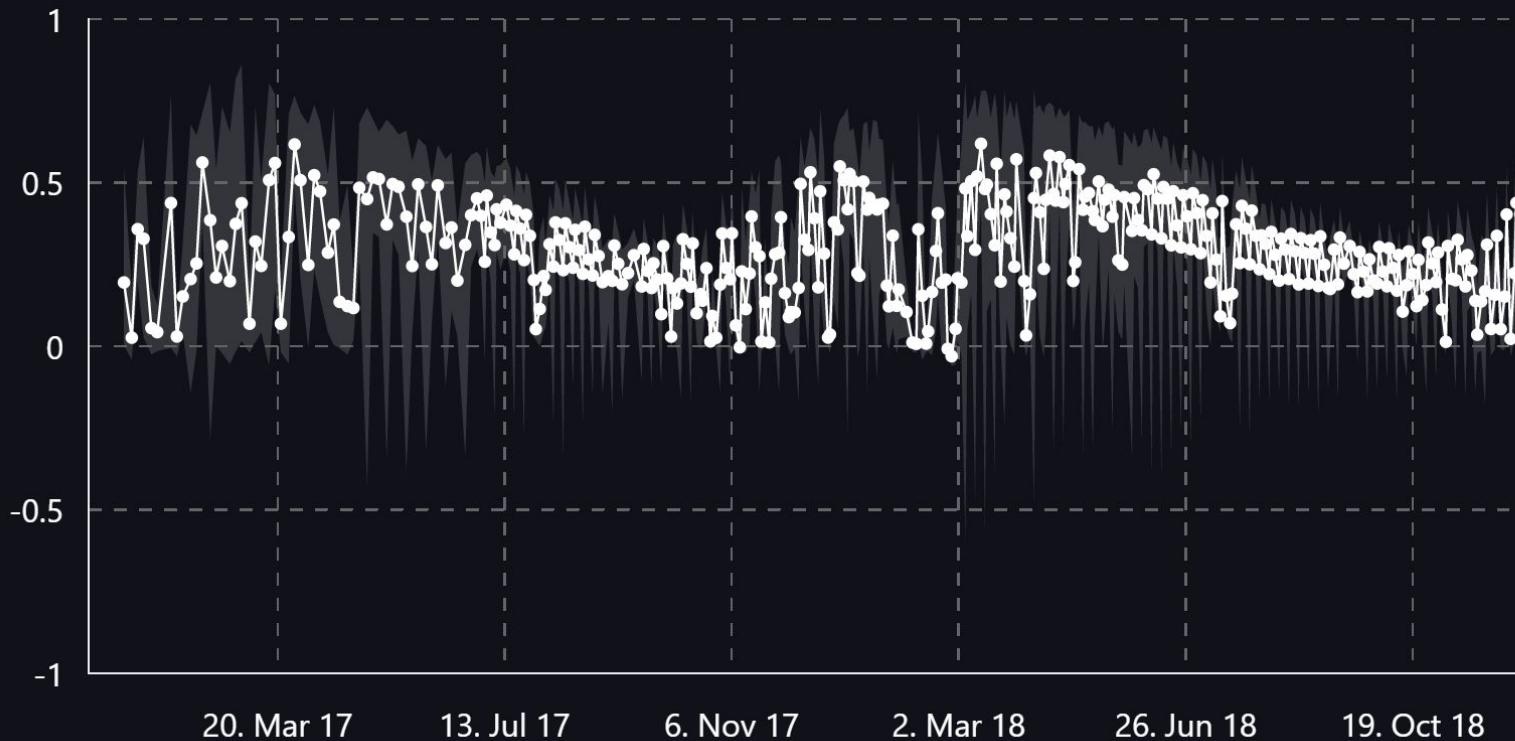
NDVI sept17-dec182018-12-14 00:00 - 2018-12-14 23:59, Sentinel-2 L2A, NDVI



Credit: European Union, contains modified Copernicus Sentinel data 2020, processed with EO Browser

Copernicus sentinelhub

5 years 2 years 1 year 6 months 3 months 1 month



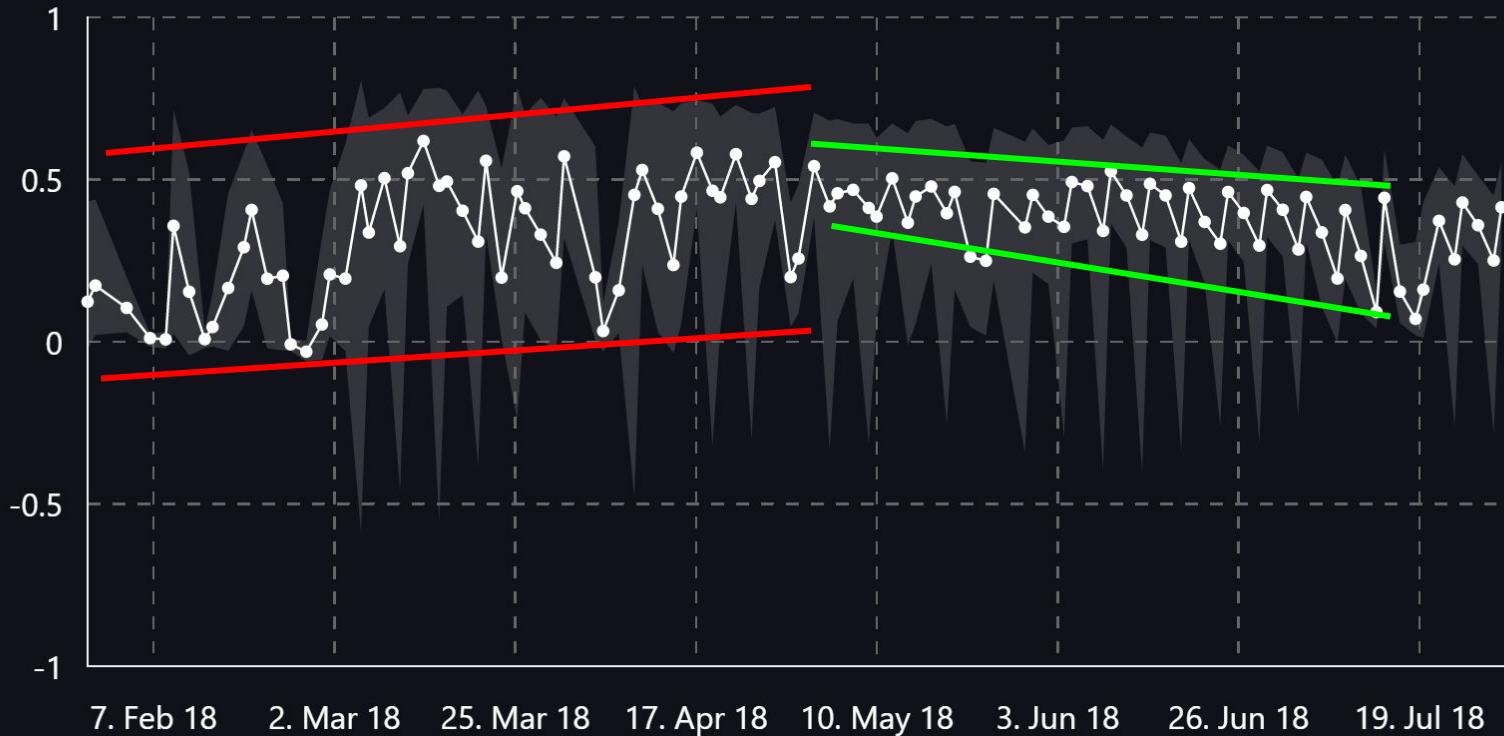
5 years 2 years **1 year** 6 months 3 months 1 month



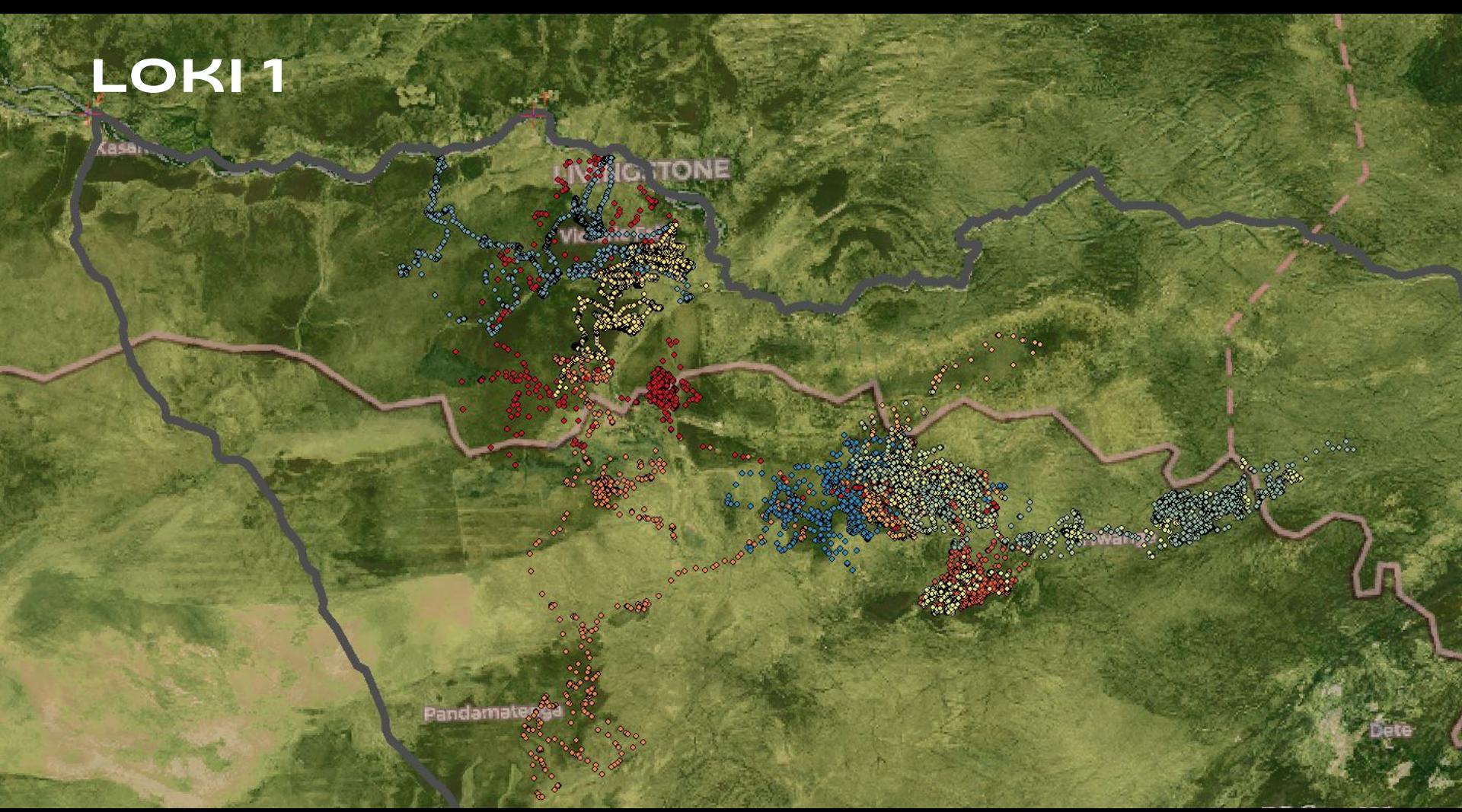
Sentinel-2 L2A - 3_NDVI

⚙️  ☁️ 100 %

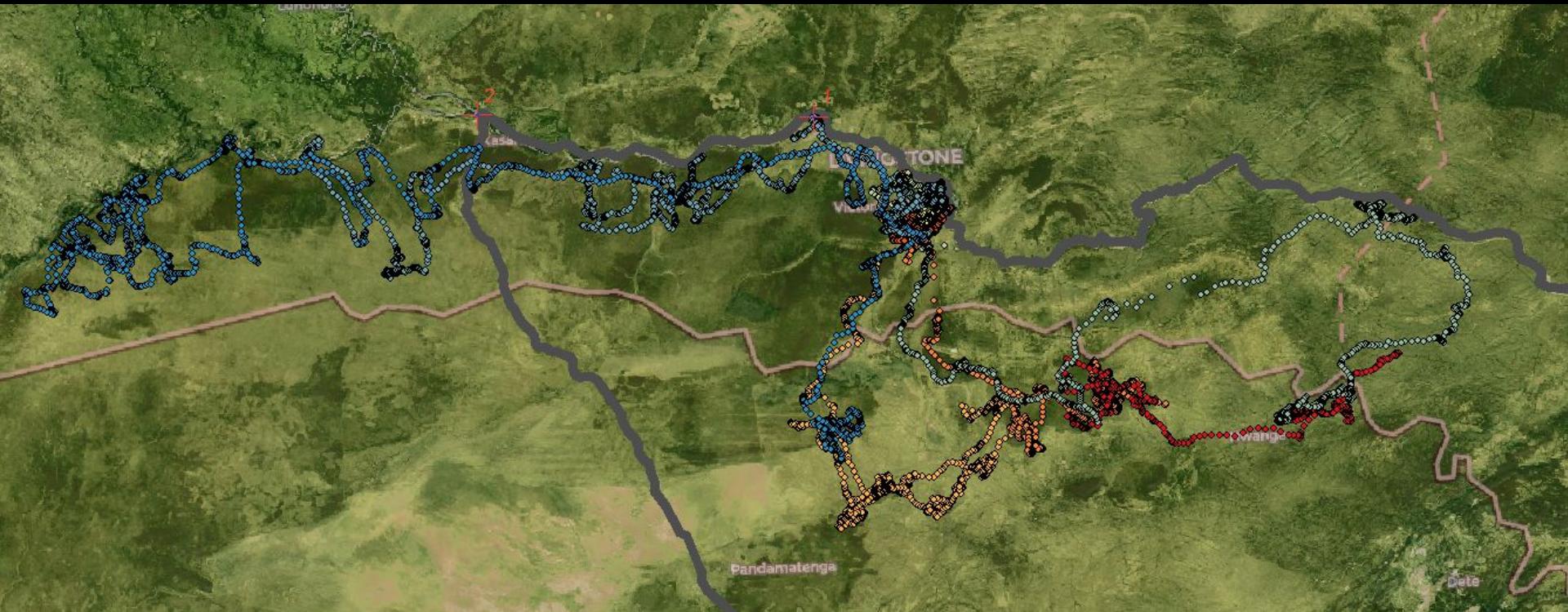
5 years 2 years 1 year 6 months 3 months 1 month



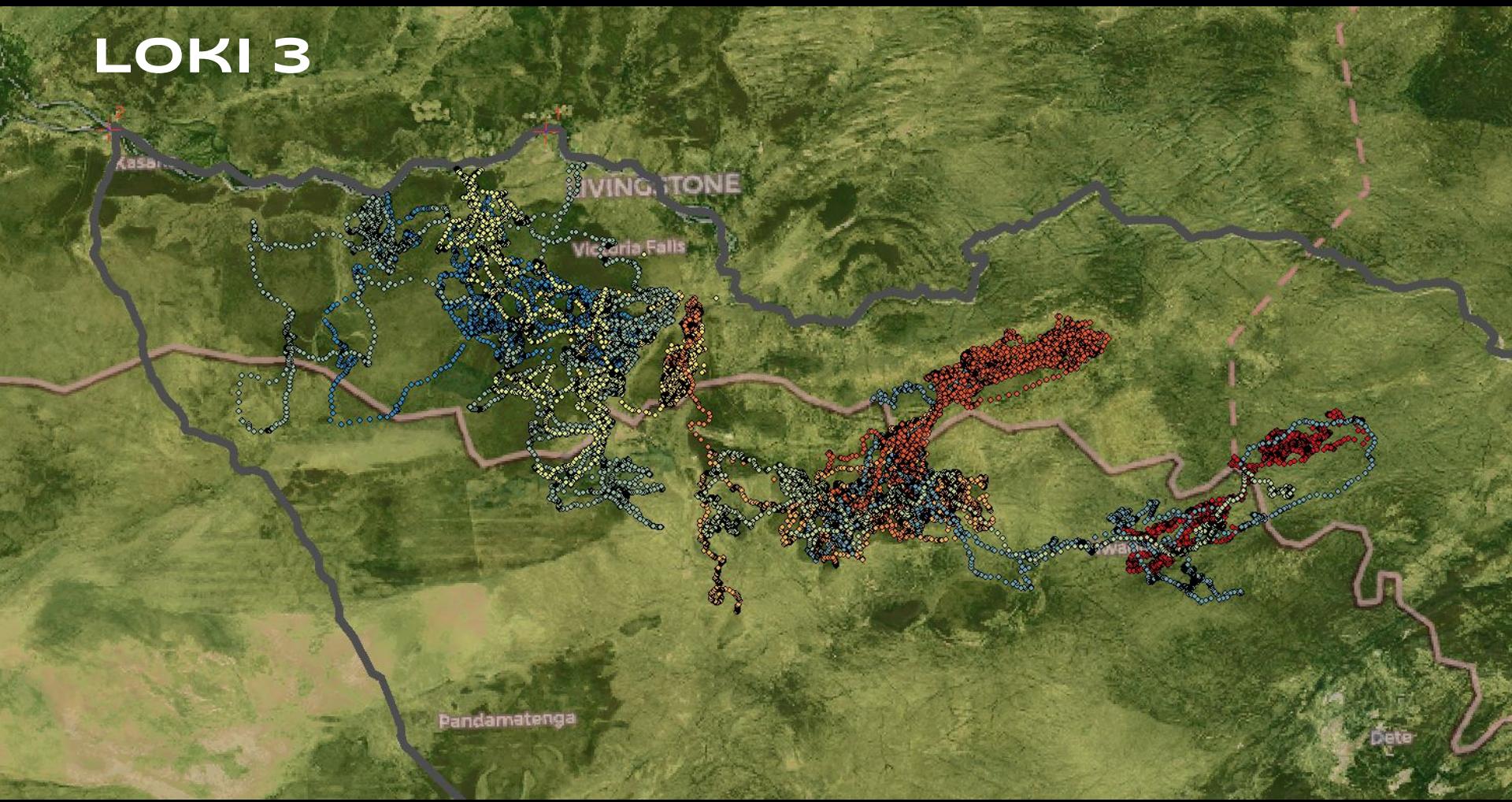
LOKI 1



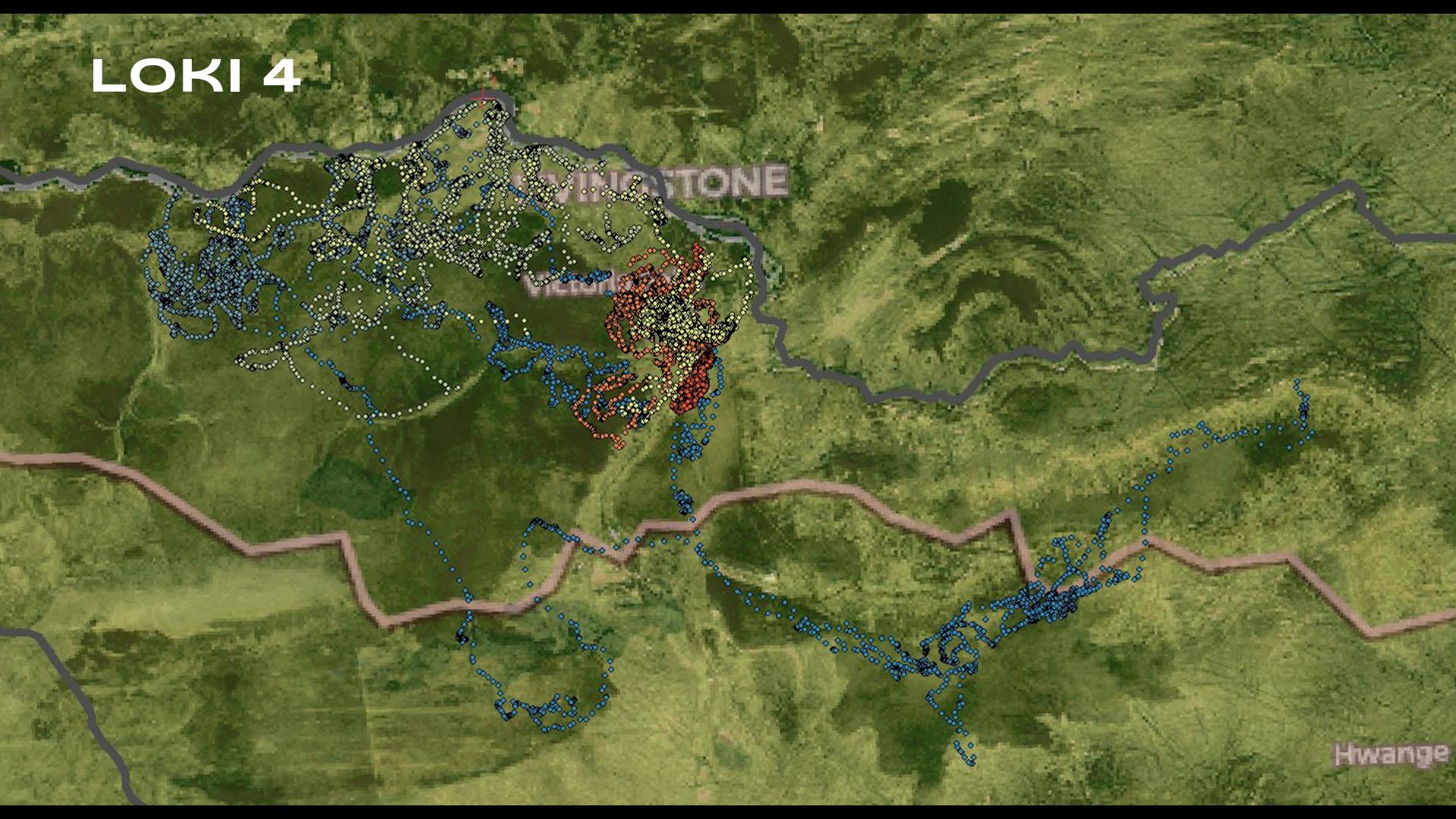
LOKI 2



LOKI 3



LOKI 4



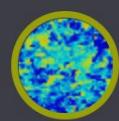
Hwange

LOKI 5

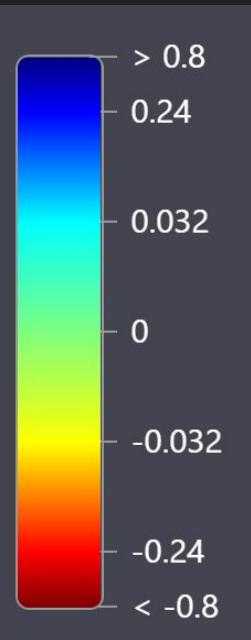


LOKI 6



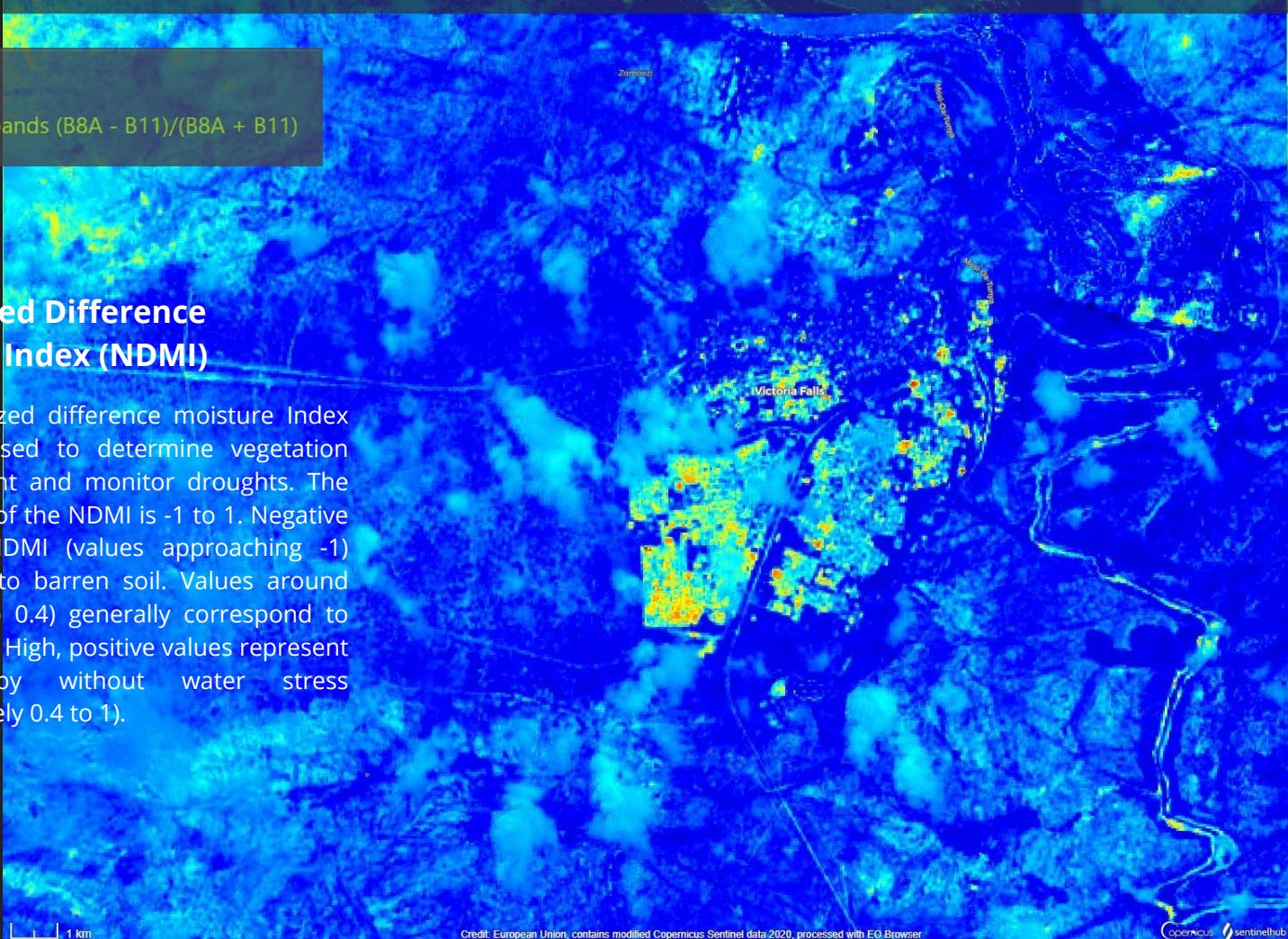


Moisture index

Based on combination of bands $(B8A - B11)/(B8A + B11)$ 

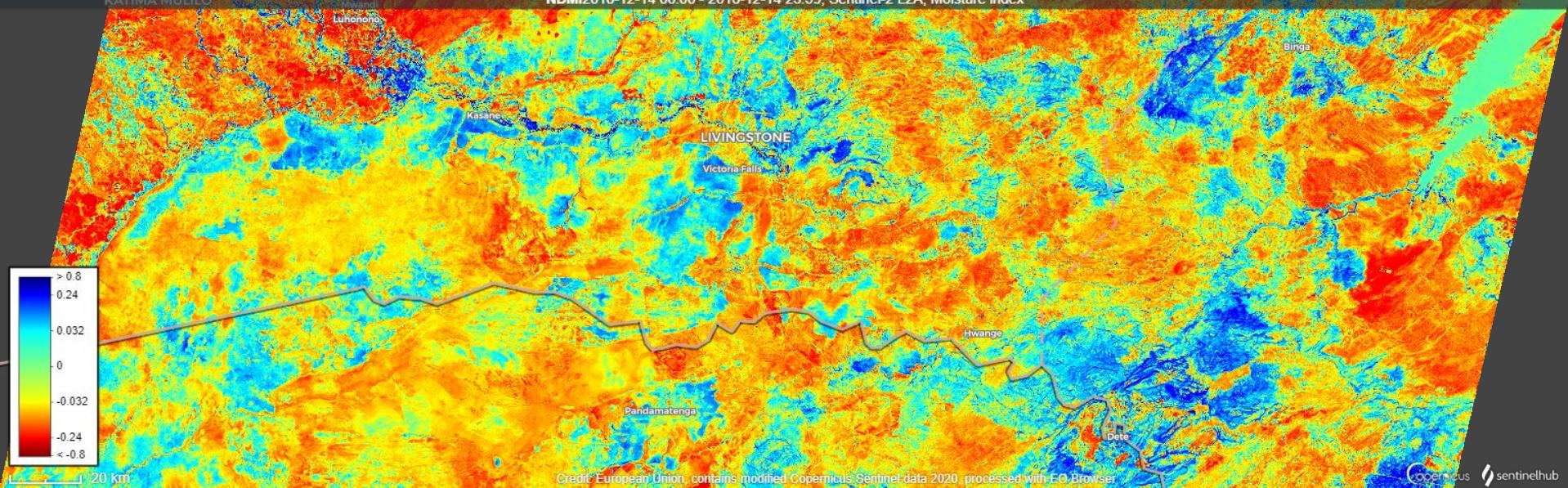
Normalized Difference Moisture Index (NDMI)

The normalized difference moisture Index (NDMI) is used to determine vegetation water content and monitor droughts. The value range of the NDMI is -1 to 1. Negative values of NDMI (values approaching -1) correspond to barren soil. Values around zero (-0.2 to 0.4) generally correspond to water stress. High, positive values represent high canopy without water stress (approximately 0.4 to 1).



KATIMA MULLO

NDMI 2018-12-14 00:00 - 2018-12-14 23:59, Sentinel-2 L2A, Moisture index



Sentinel-2 L2A - 5-MOISTURE-INDEX1

⚙️   100 %

5 years

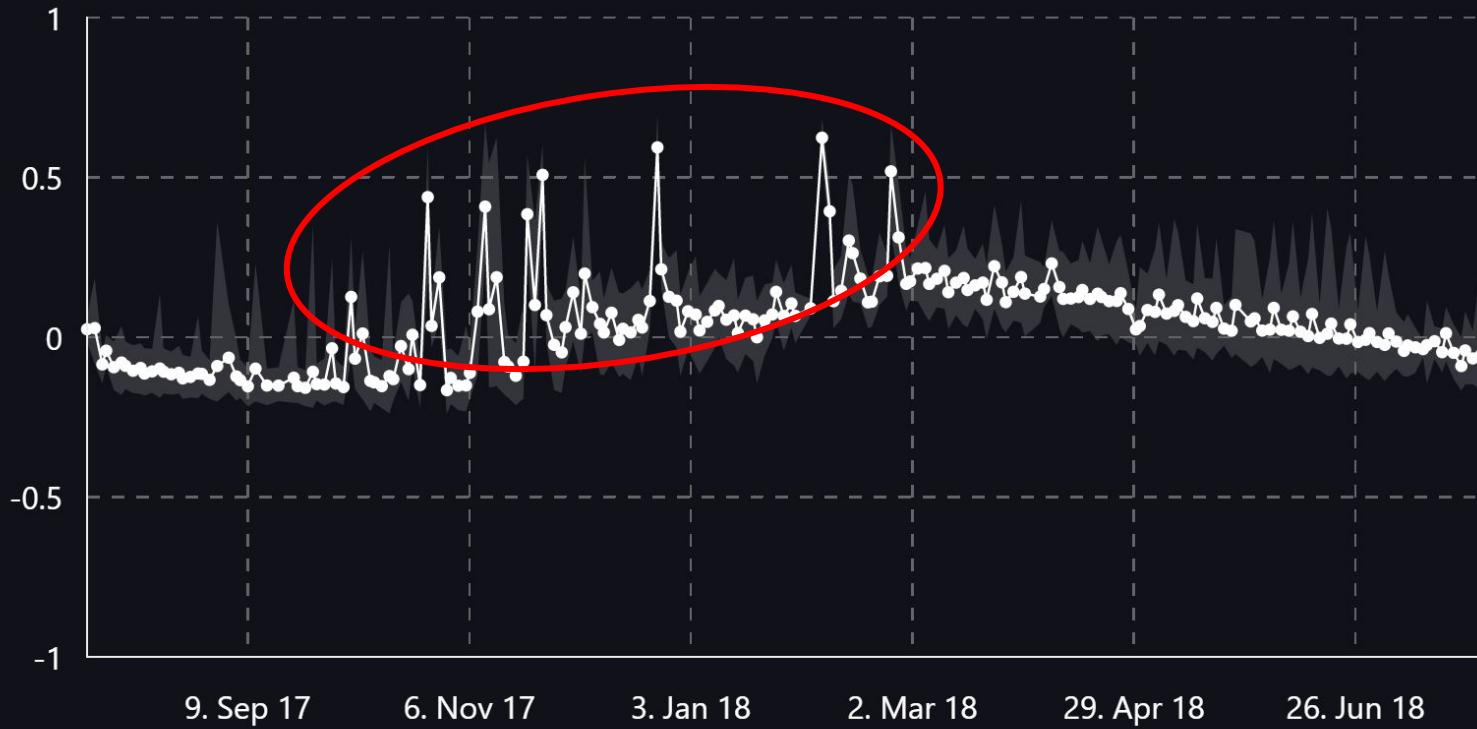
2 years

1 year

6 months

3 months

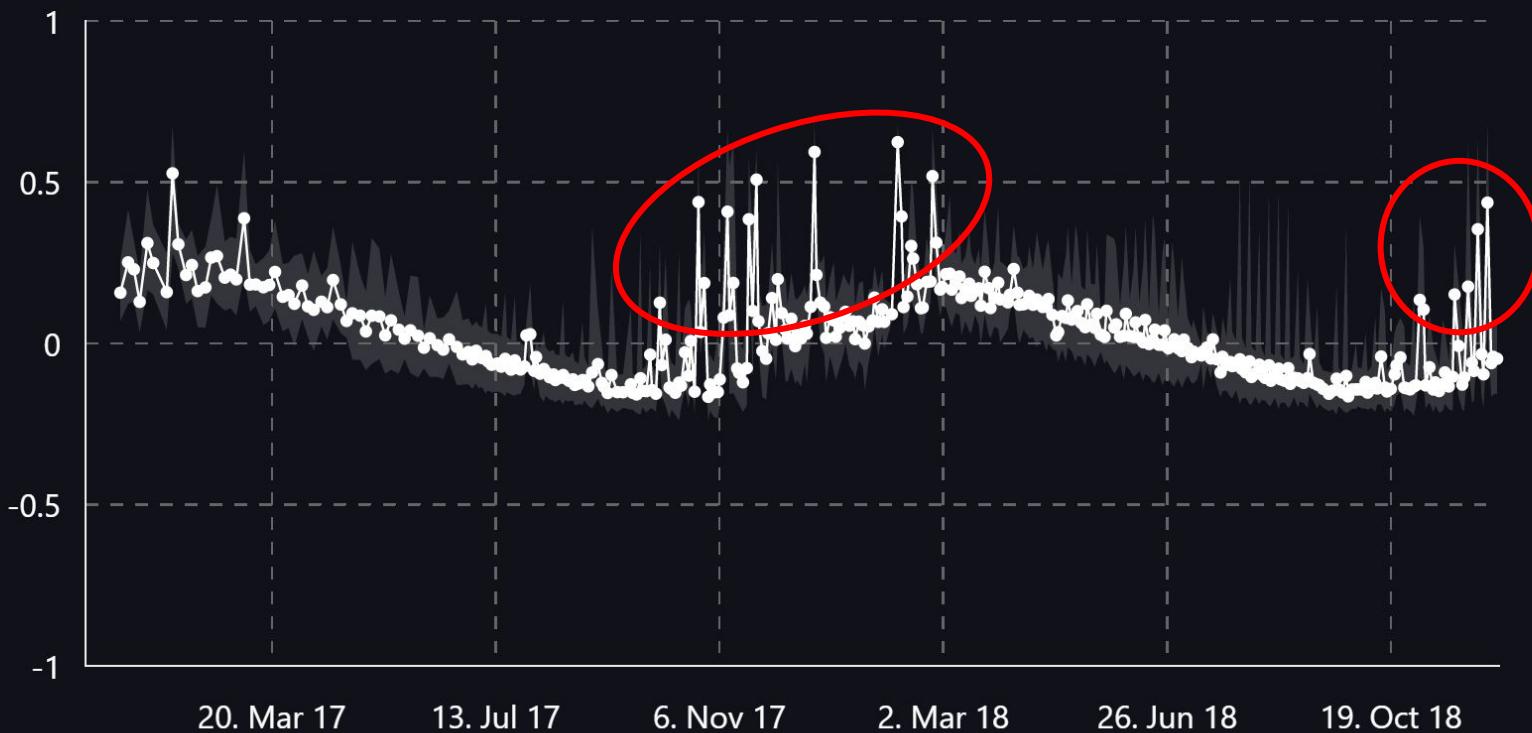
1 month



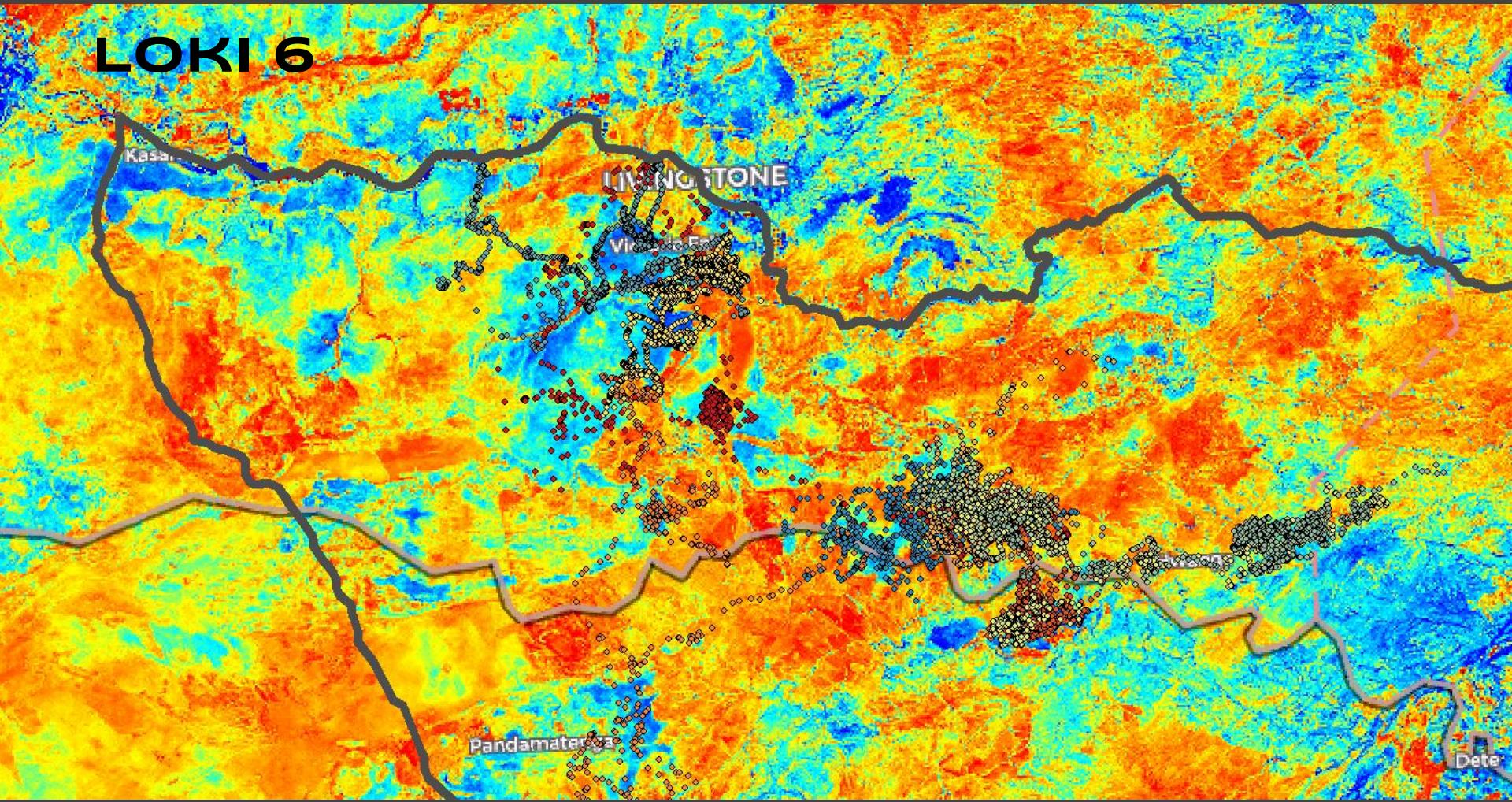
Sentinel-2 L2A - 5-MOISTURE-INDEX1

⚙️  100 %

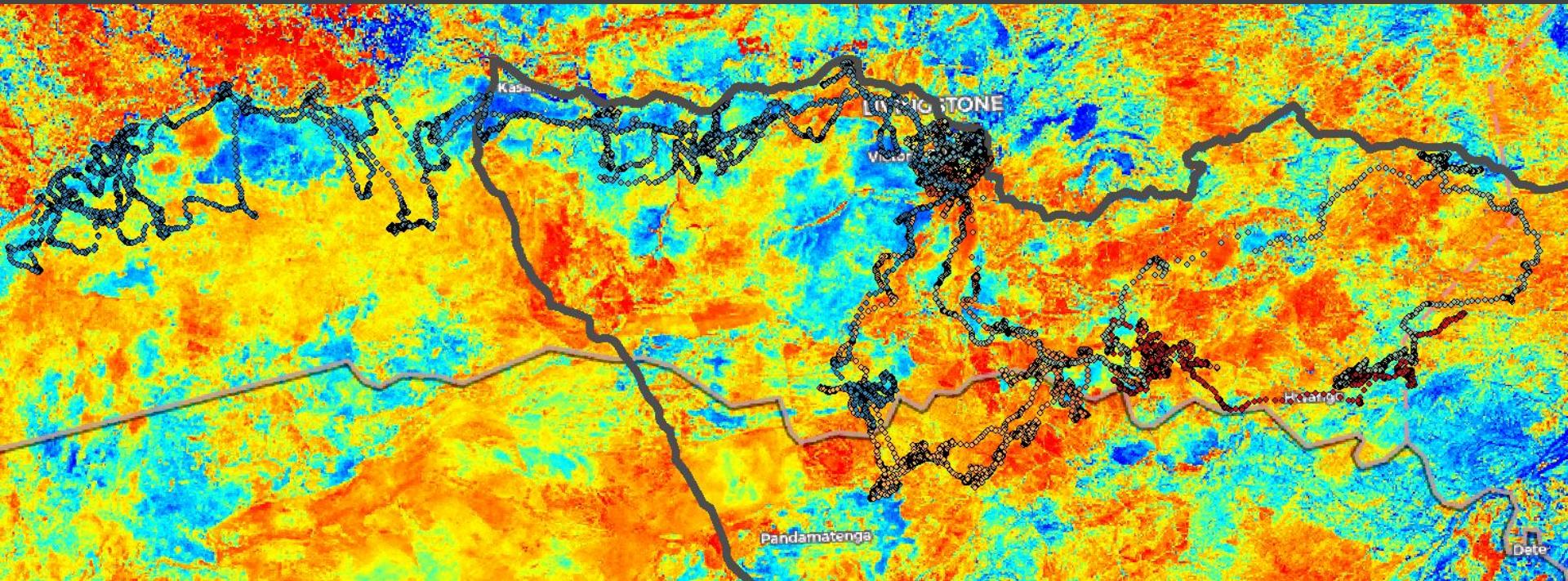
5 years 2 years 1 year 6 months 3 months 1 month



LOKI 6



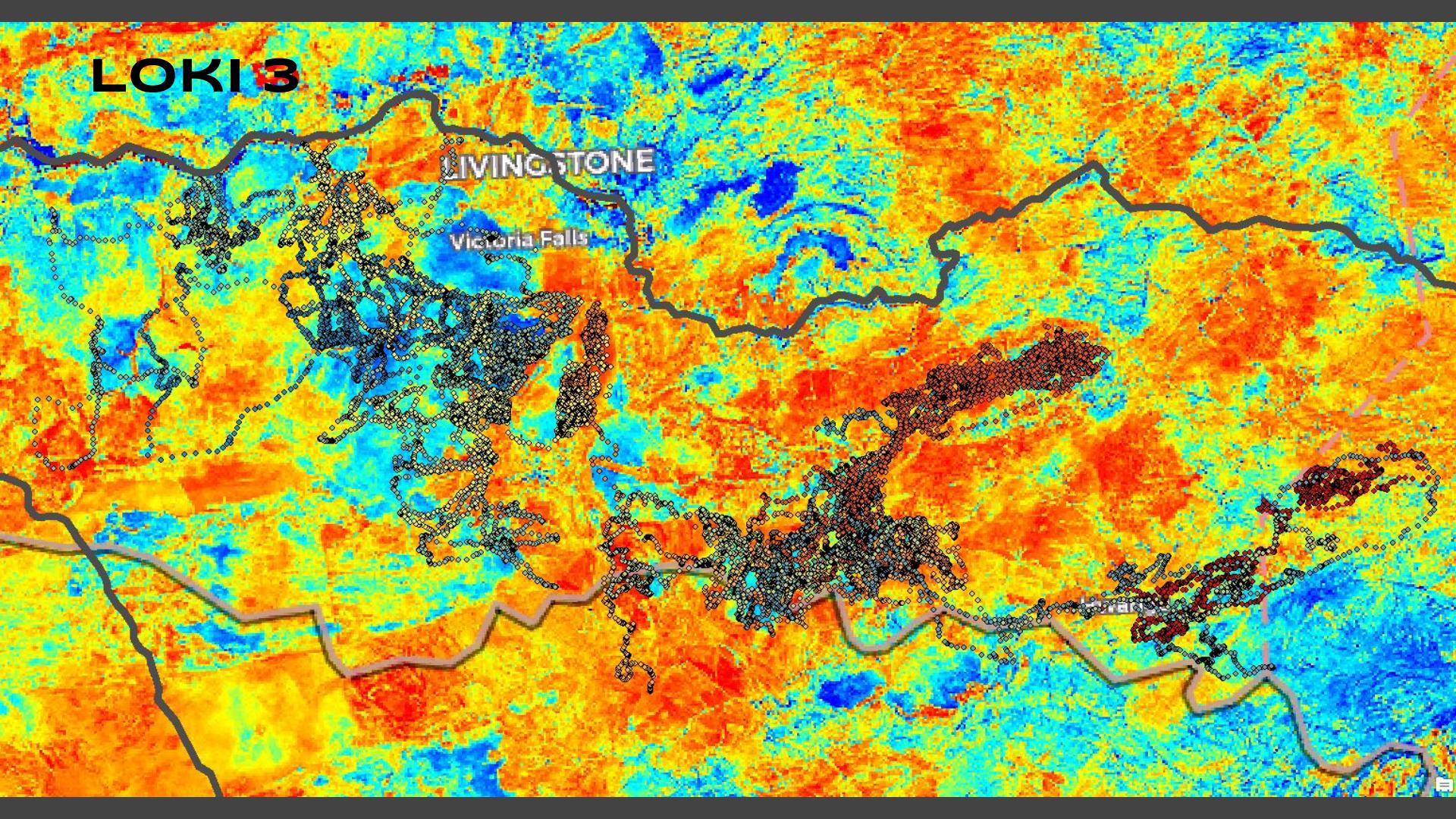
LOKI 2



LOKI 3

LIVINGSTONE

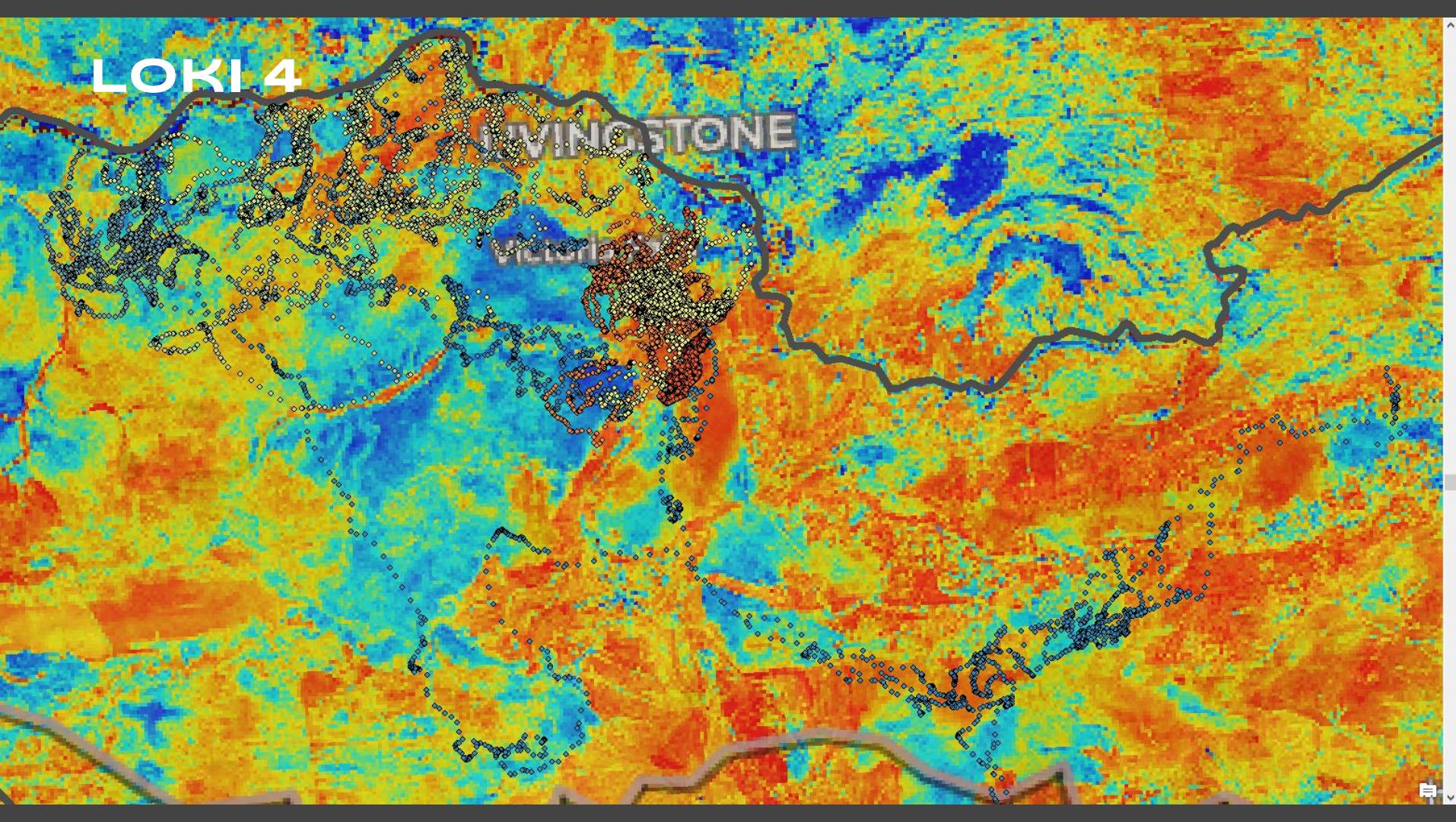
Victoria Falls

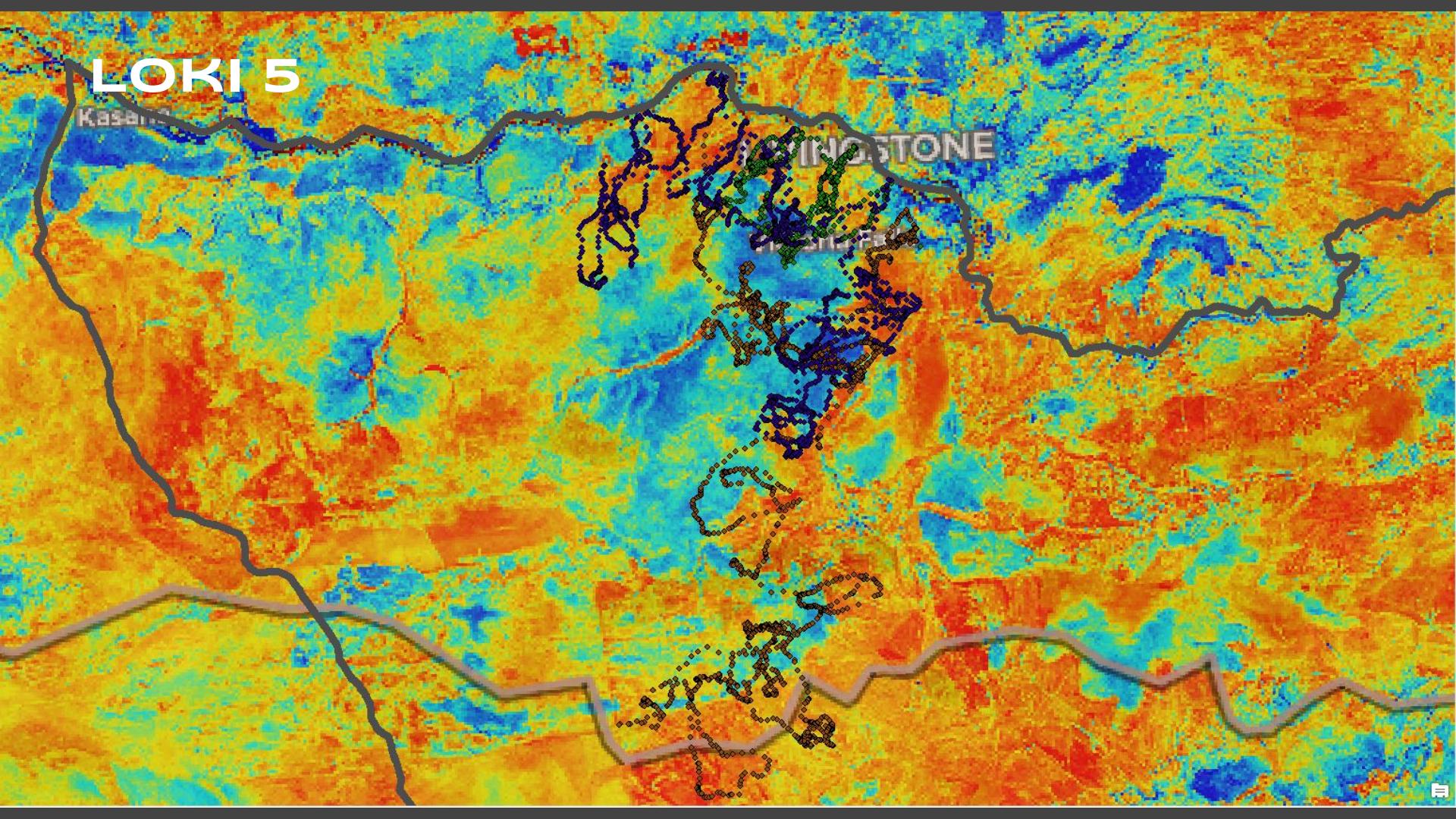


LOKI4

DRYING TONE

WELLSITE





LOKI 5

Kasam

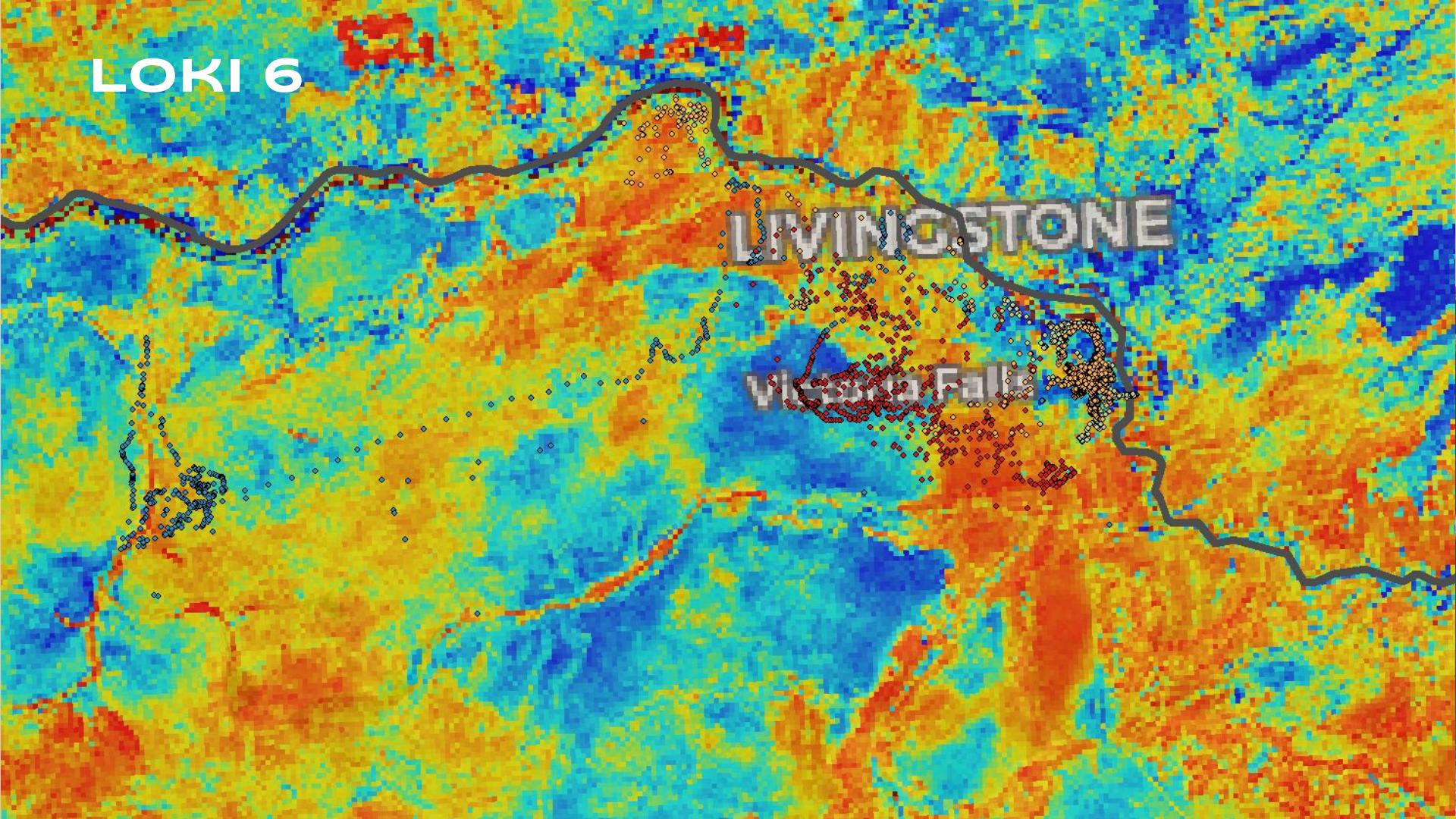
INDUSTONE



LOKI 6

LIVINGSTONE

Victoria Falls

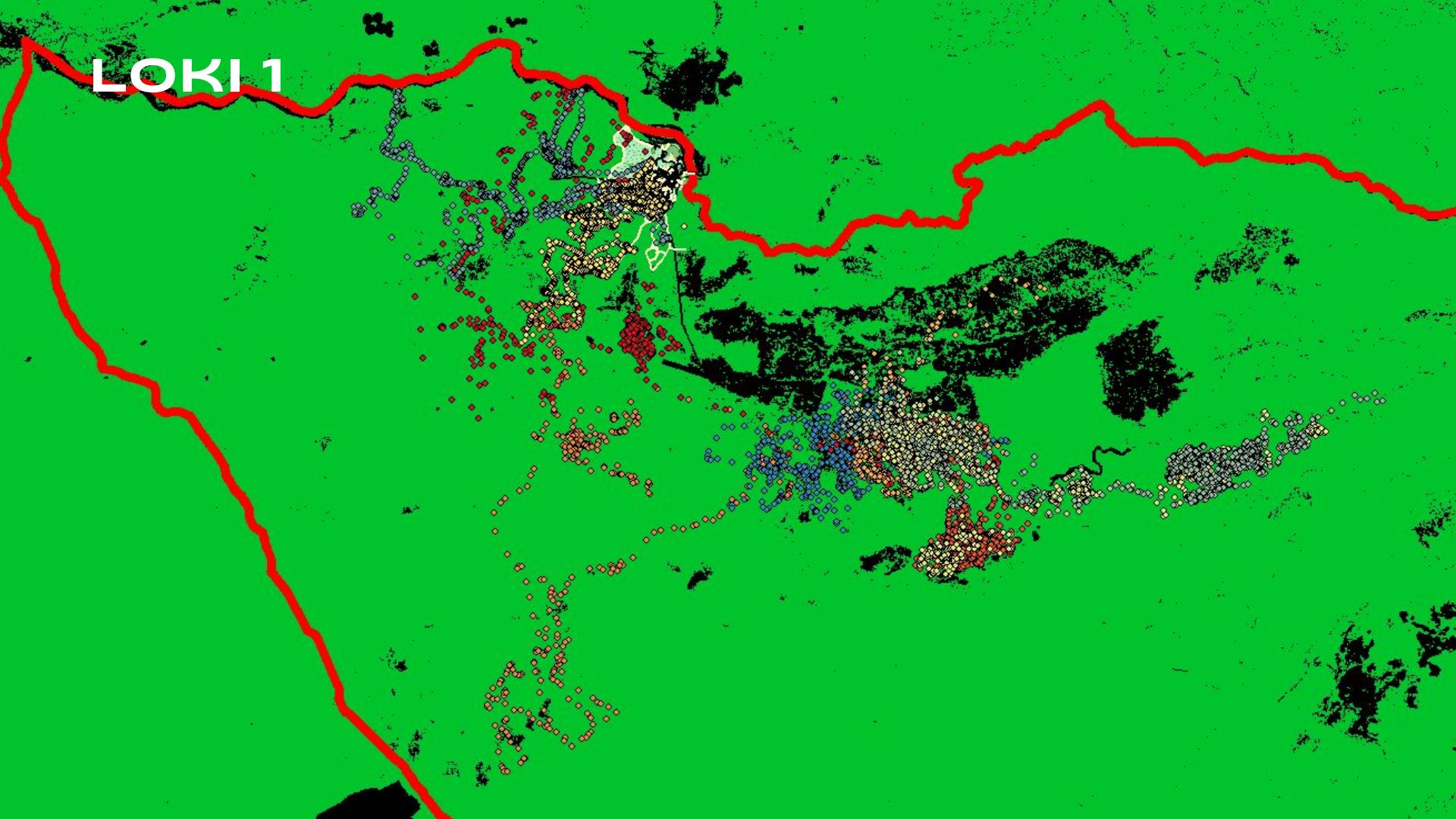


Reclassified KAZA Raster

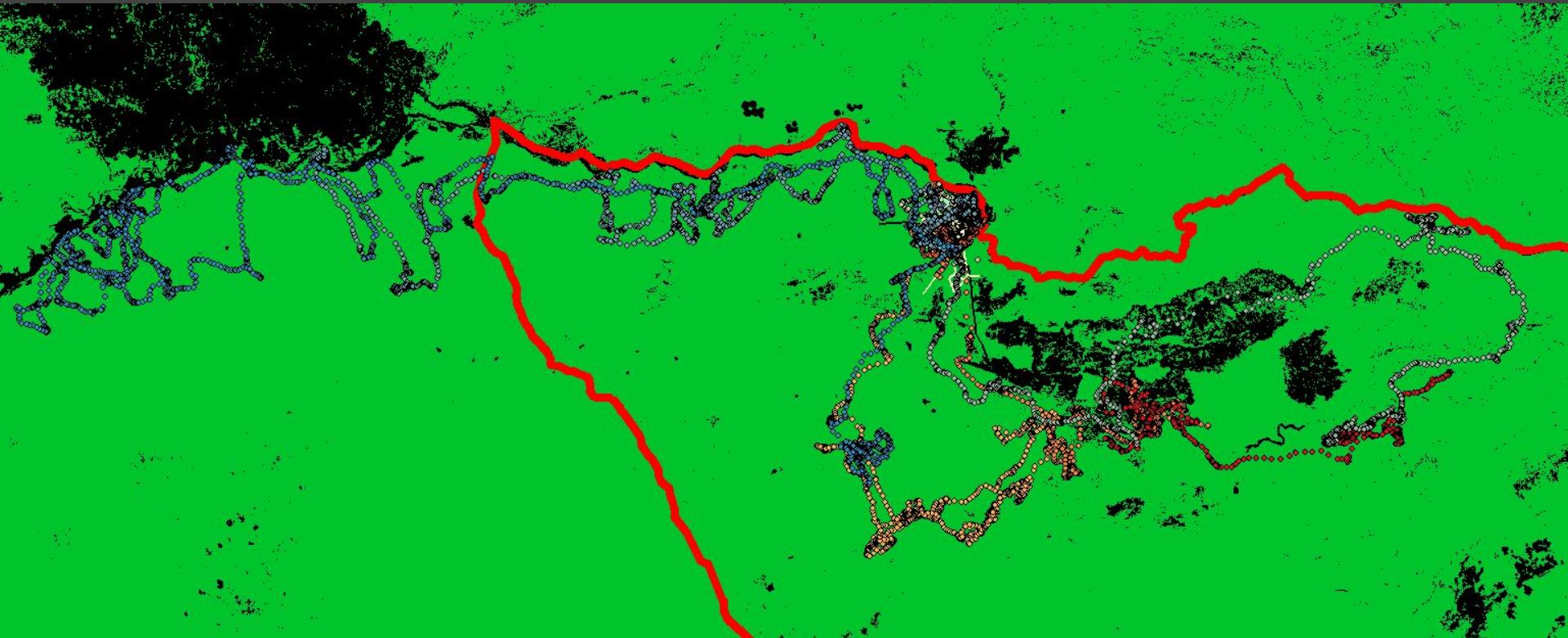
KAZA Raster layer reclassified based on what can be objectively classified as traversable or untraversable land for elephants



LOKI 1



LOKI 2



LOKI 3



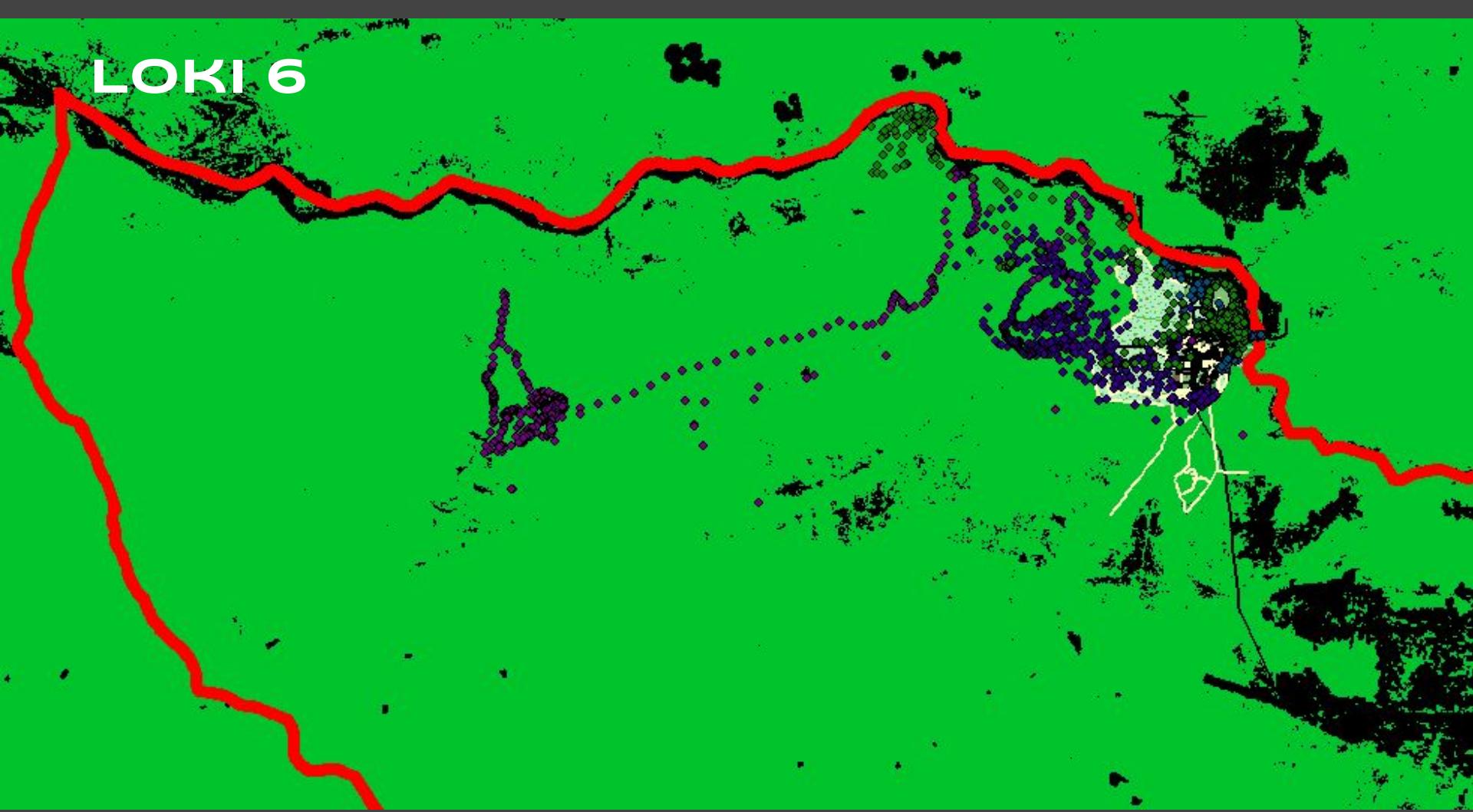
LOKI 4



LOKI 5



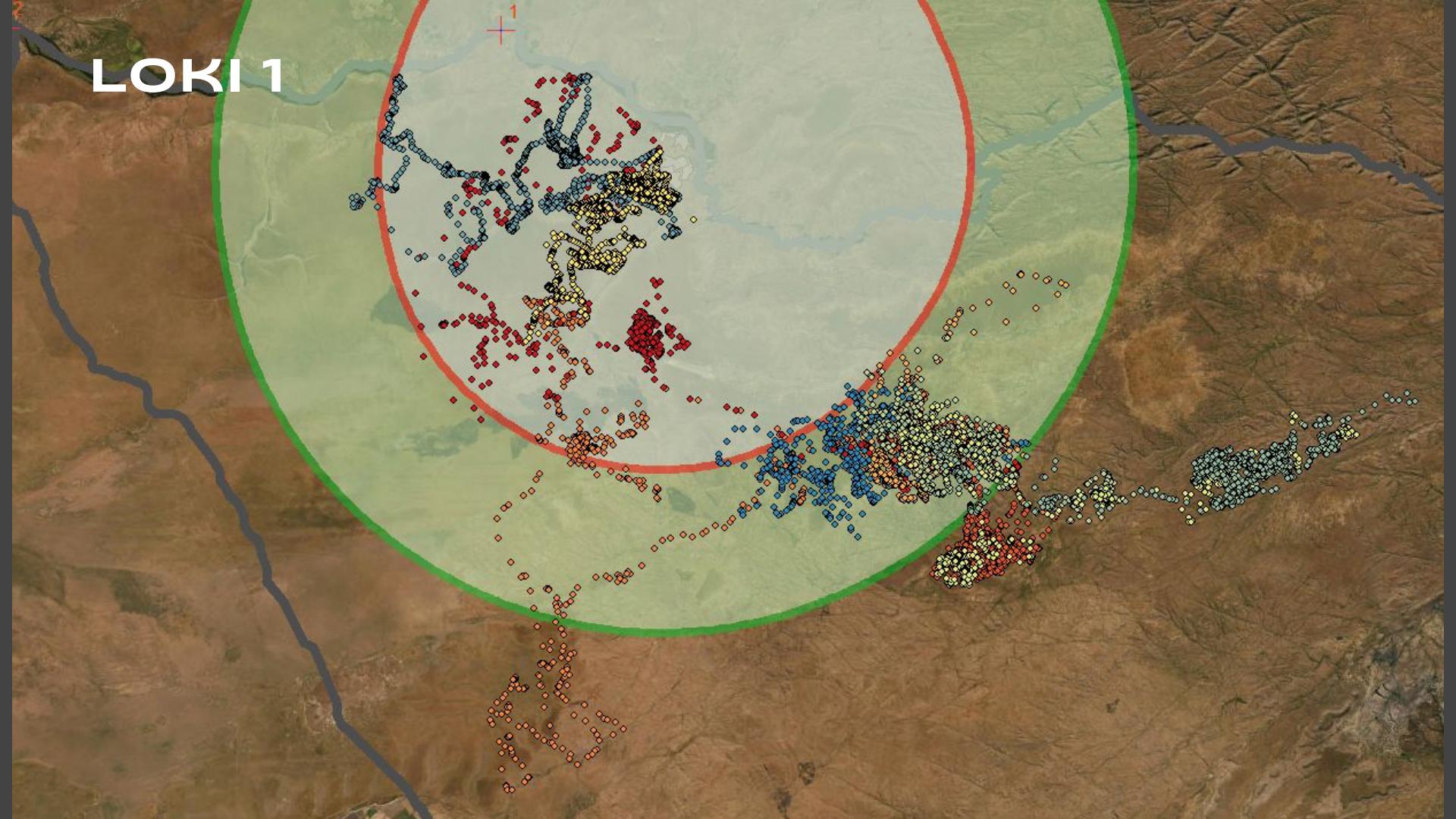
LOKI 6



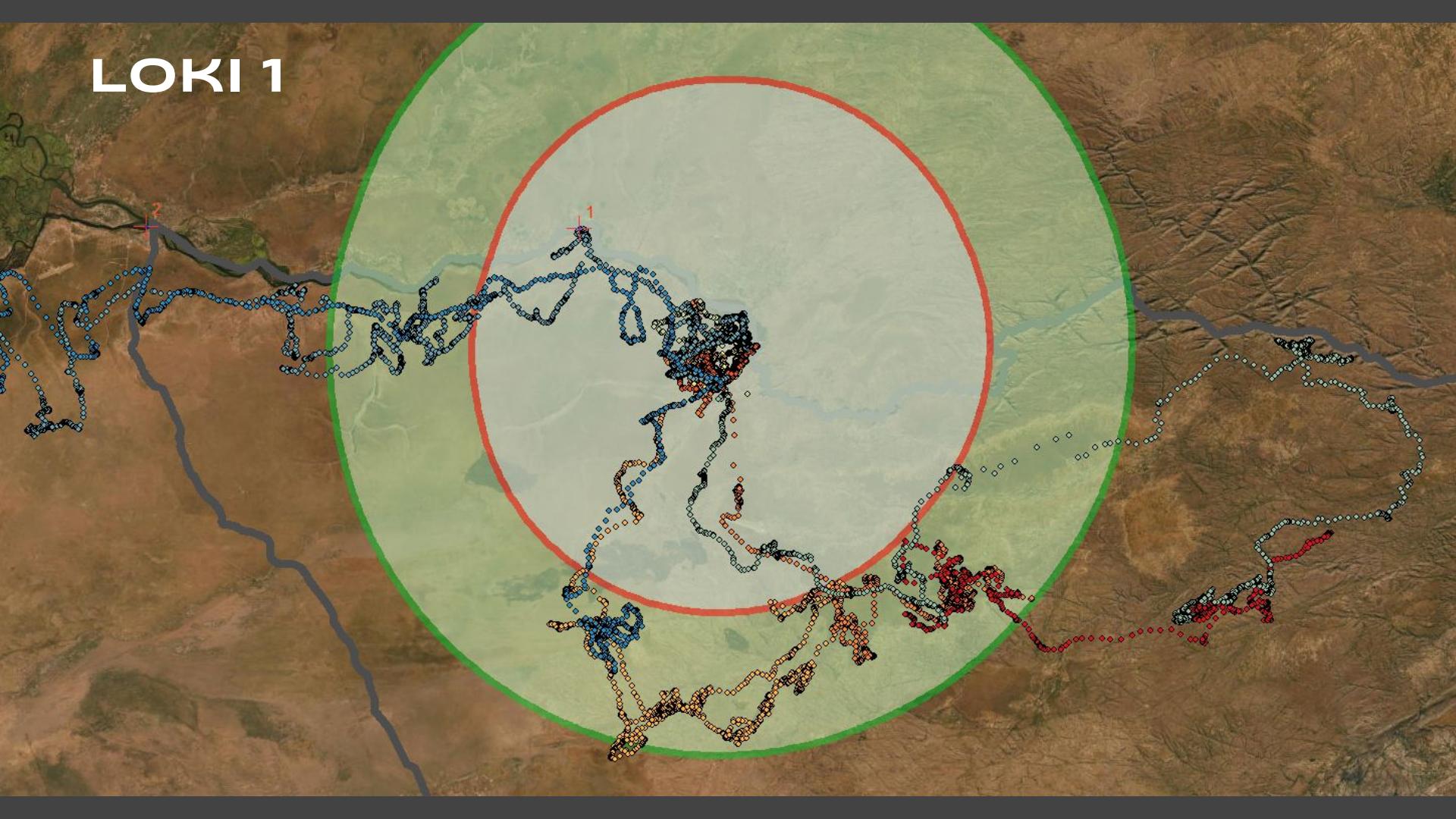
LOKI 1

1

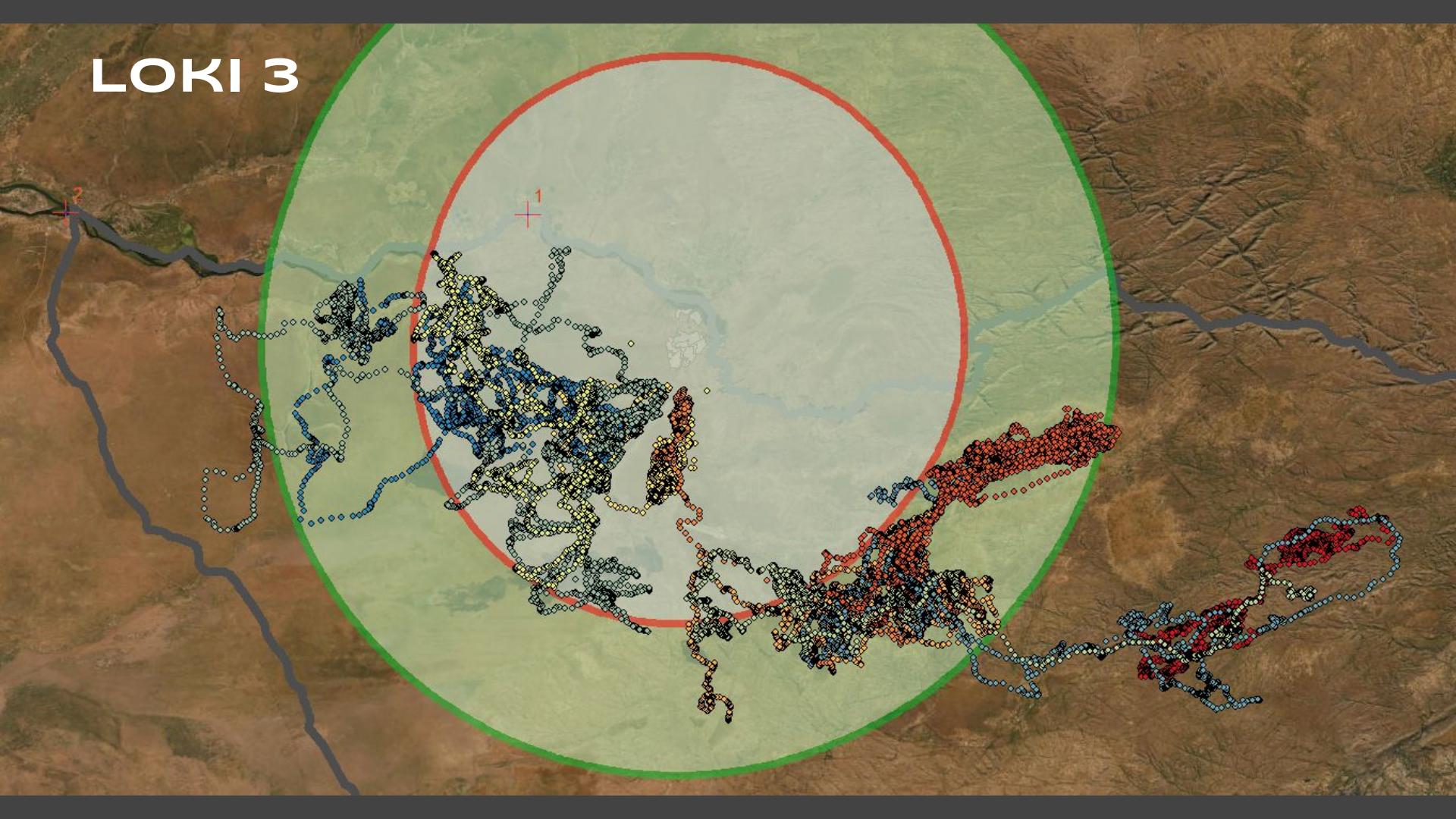
2



LOKI 1



LOKI 3



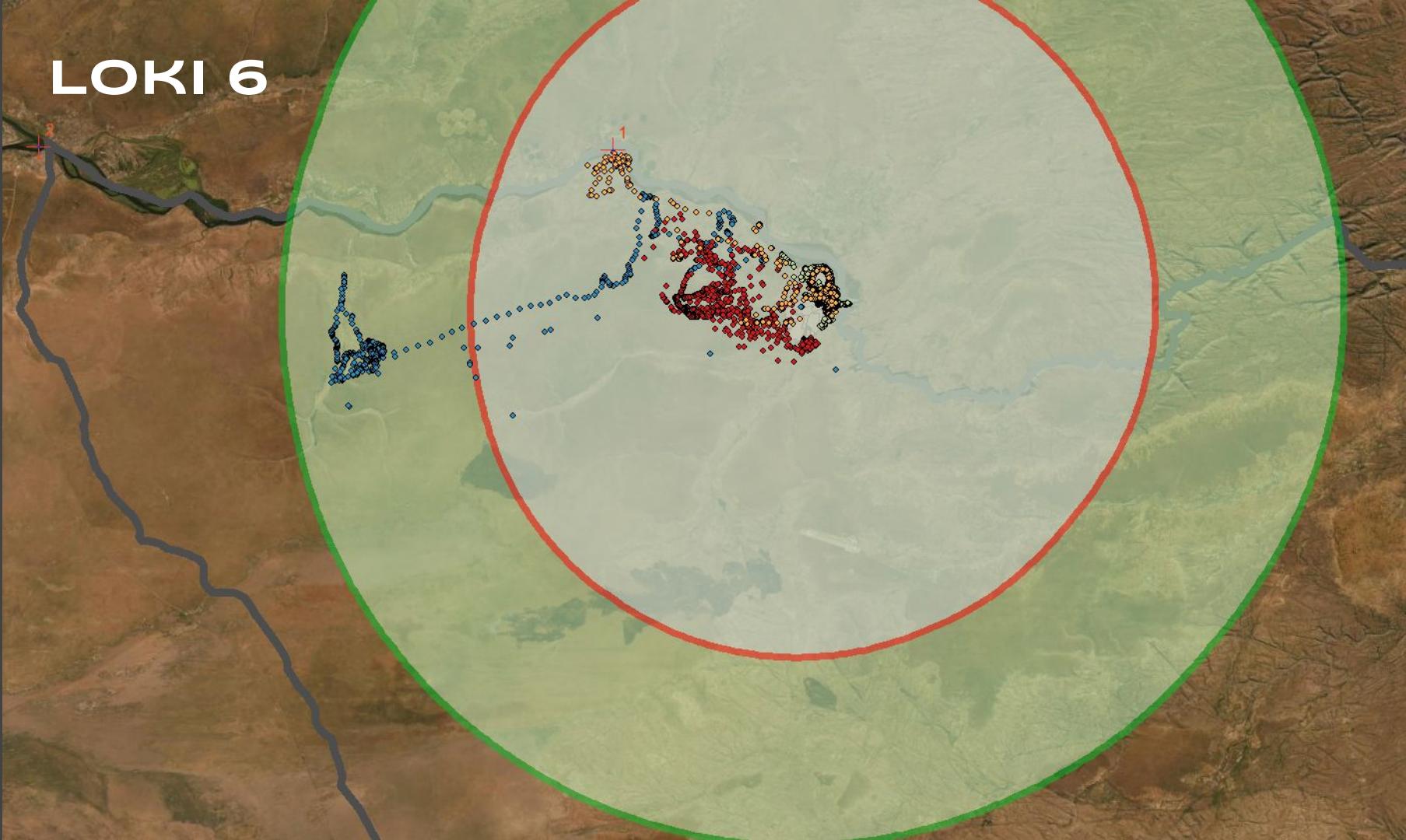
LOKI 4



LOKI 5



LOKI 6



LOKI 1



LOKI 2



LOKI 3



LOKI 4

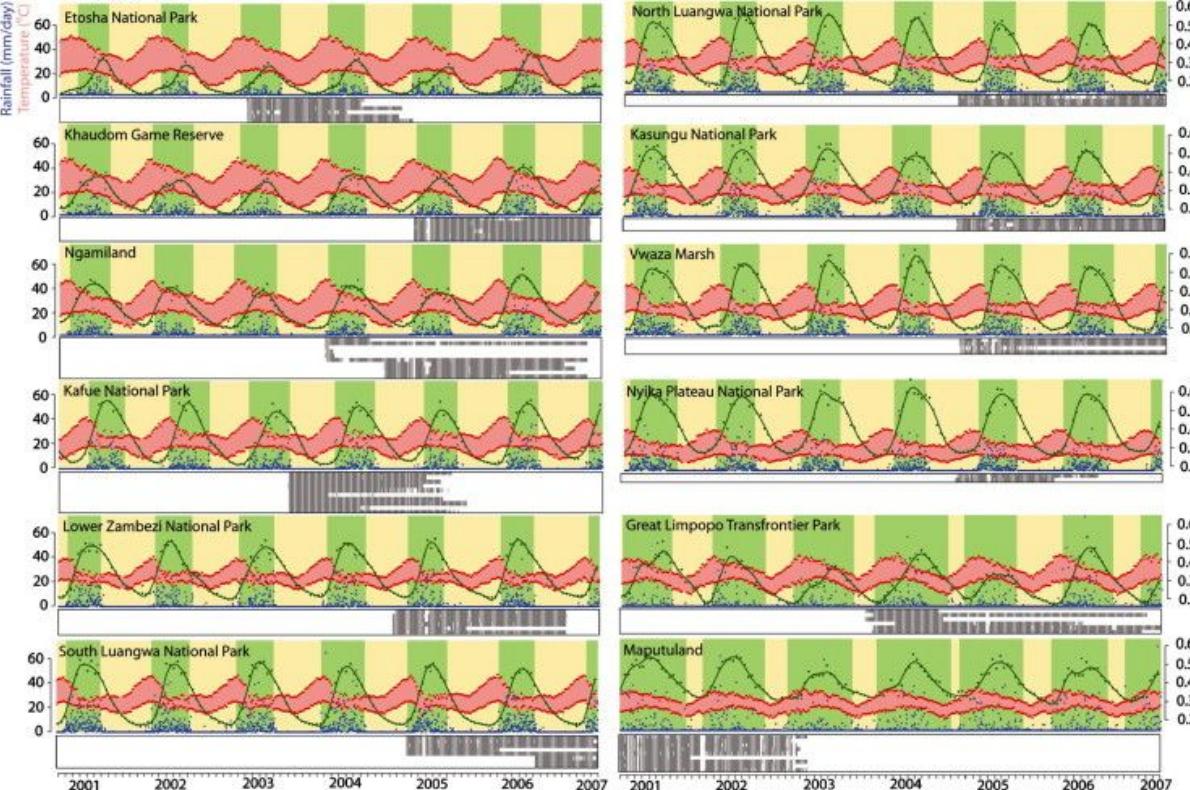


LOKI 5



LOKI 6

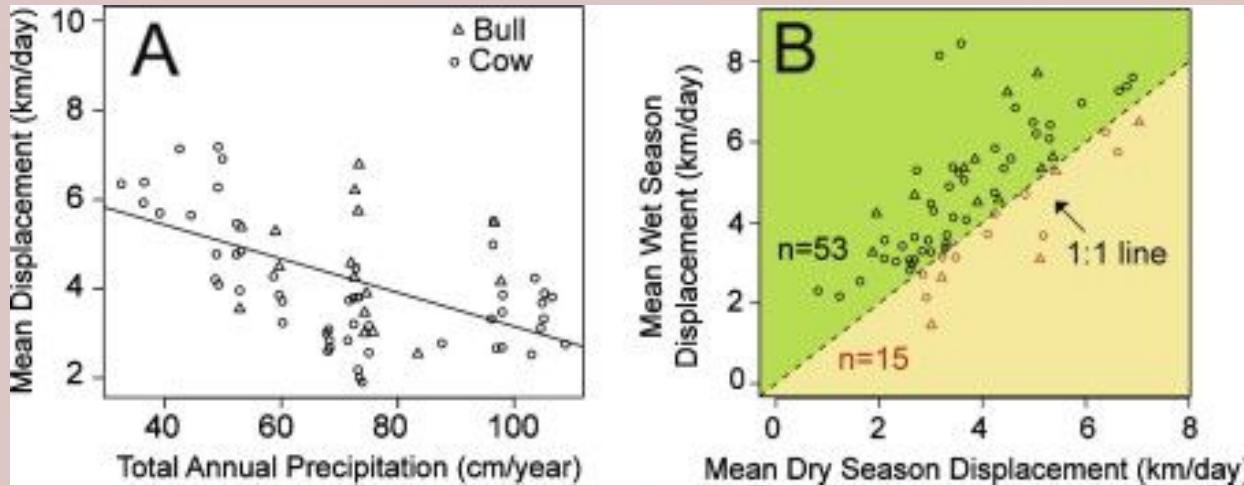




Temporal trends in temperature, rainfall, and greenness across the study sites. The top graph of each panel has three features, temperature range (red band), EVI (green line), and rainfall (blue points). The green and orange rectangles delineate wet and dry seasons. The bottom graph of each panel shows the elephant fixes at each site where each row represents an elephant.



Summary of Overall Movement Patterns



A shows mean displacements (km/day) for 68 elephants tracked for an average of 691 days plotted against total annual precipitation. The five elephants with insufficient data are not shown. Elephants in drier places move more on average than those in wetter areas ($R^2 = 0.67, p < 0.001$).

The provided image shows mean displacement for the 68 elephants with sufficient data (>250 days tracked and >250 fixes) plotted against total annual precipitation ($R^2 = 0.67$). (B) Wet season mean annual displacement plotted against dry season mean annual displacement. The 53 elephants with larger wet season displacements are in black, the 15 with larger dry season displacements are in red. Triangles indicate bull elephants.

Final Maps



2019 LULC

Projection :Arc_1950_UTM_Zone_36S

Classification System: Modified

GS Anderson Classification System – Adapted for Zimbabwe

Level 1:

1: Urban

Level 2

11: Residential
12: Commercial
13: Mixed
17: Garbage dump

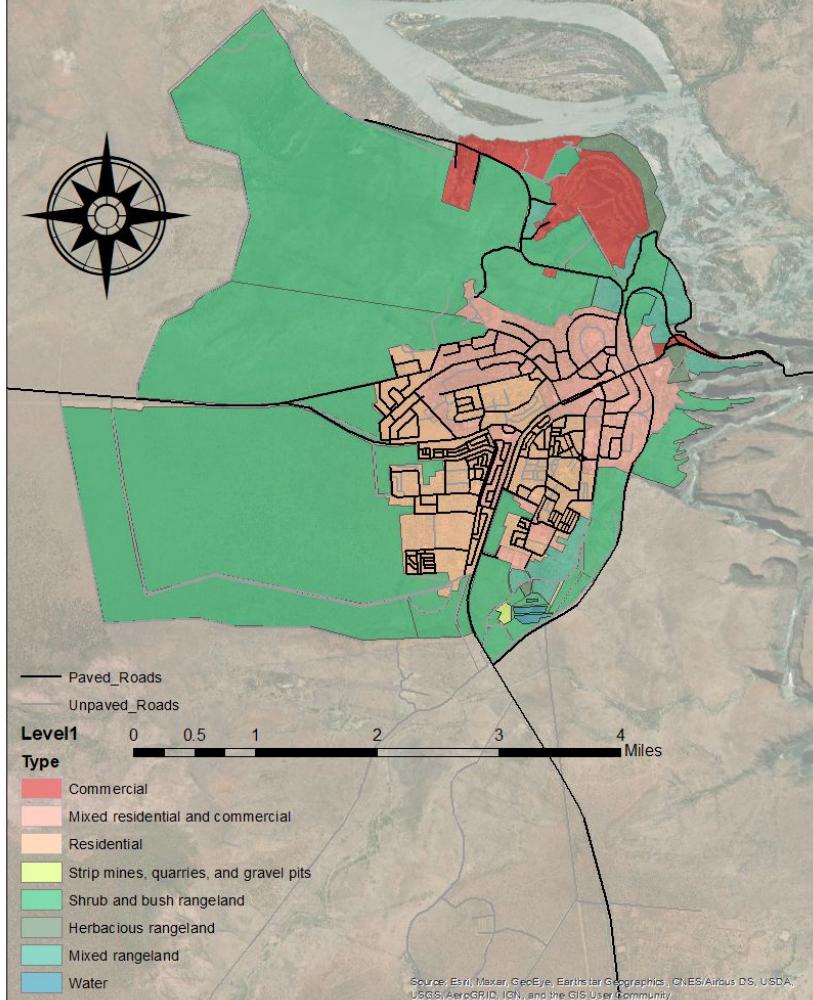
3: Rangeland

31: Herbaceous rangeland
32: Shrub and Bush rangeland
33: Mixed rangeland

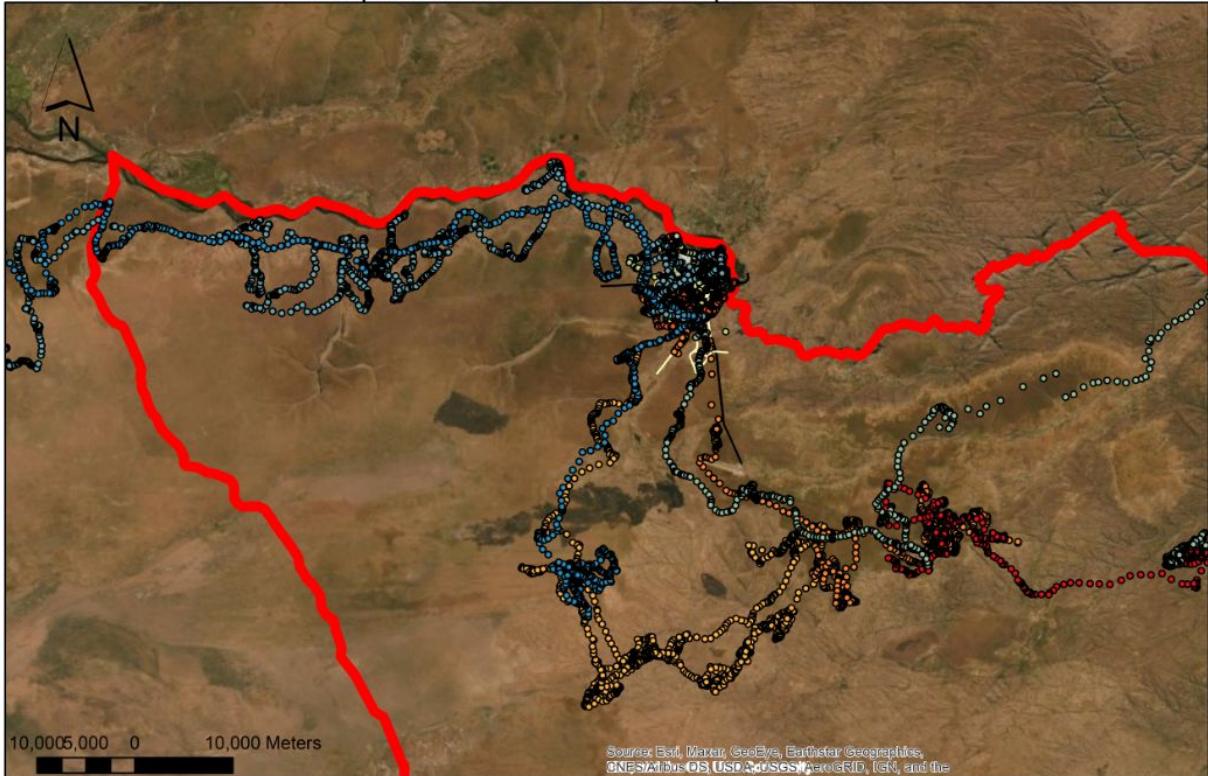
5: Water

5.53: Water treatment facility

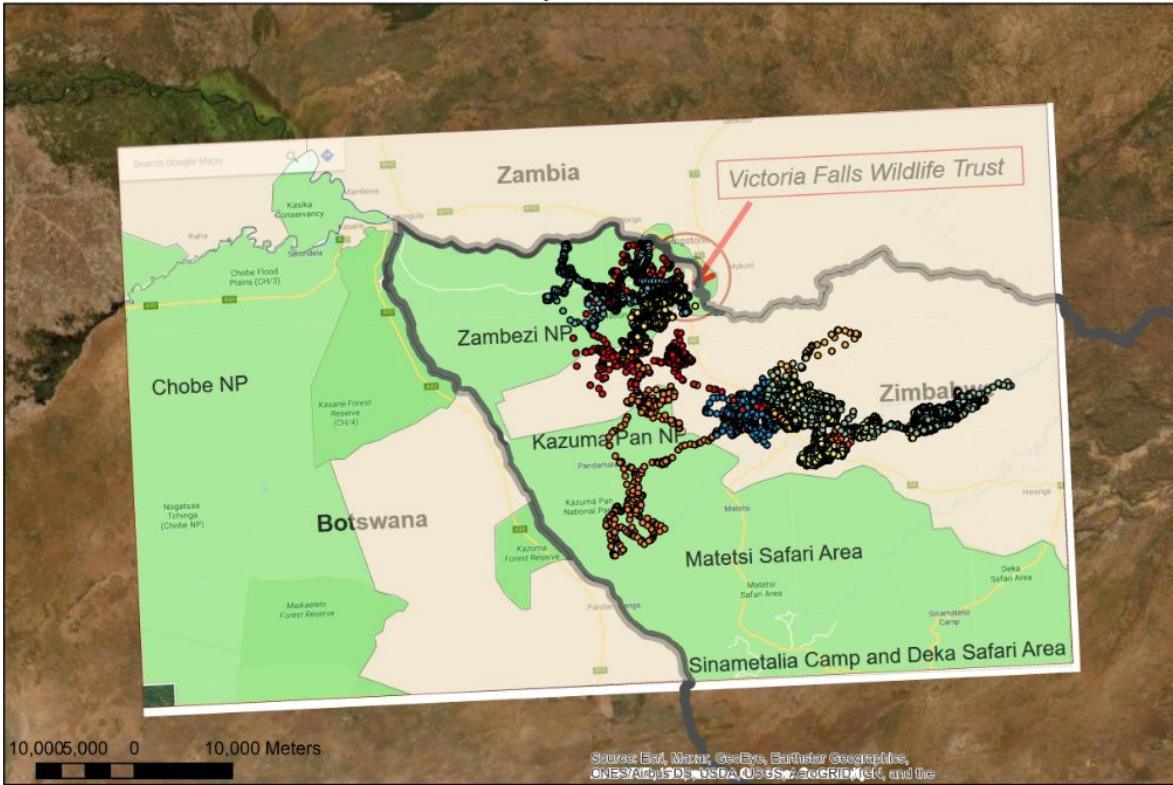
Land use and land cover around Victoria Falls, Zimbabwe



Sample Movement Data for Elephants in KAZA

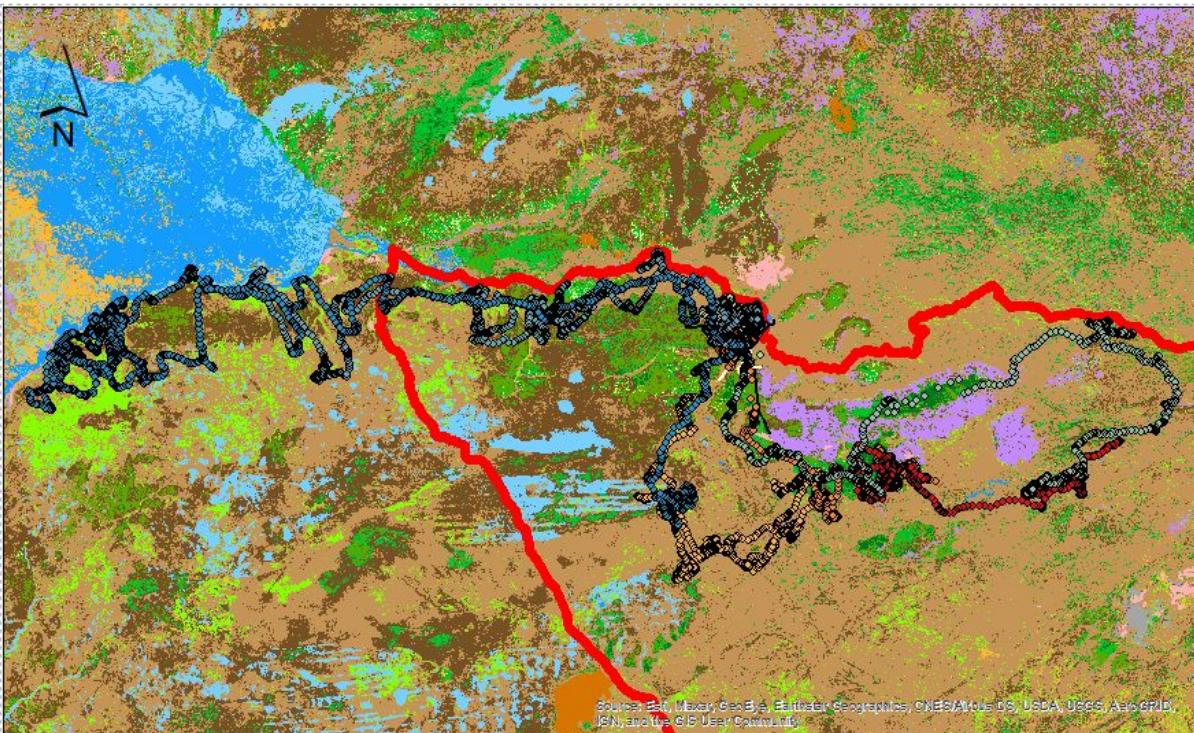


KAZA Study Area w/ Loki 1 data



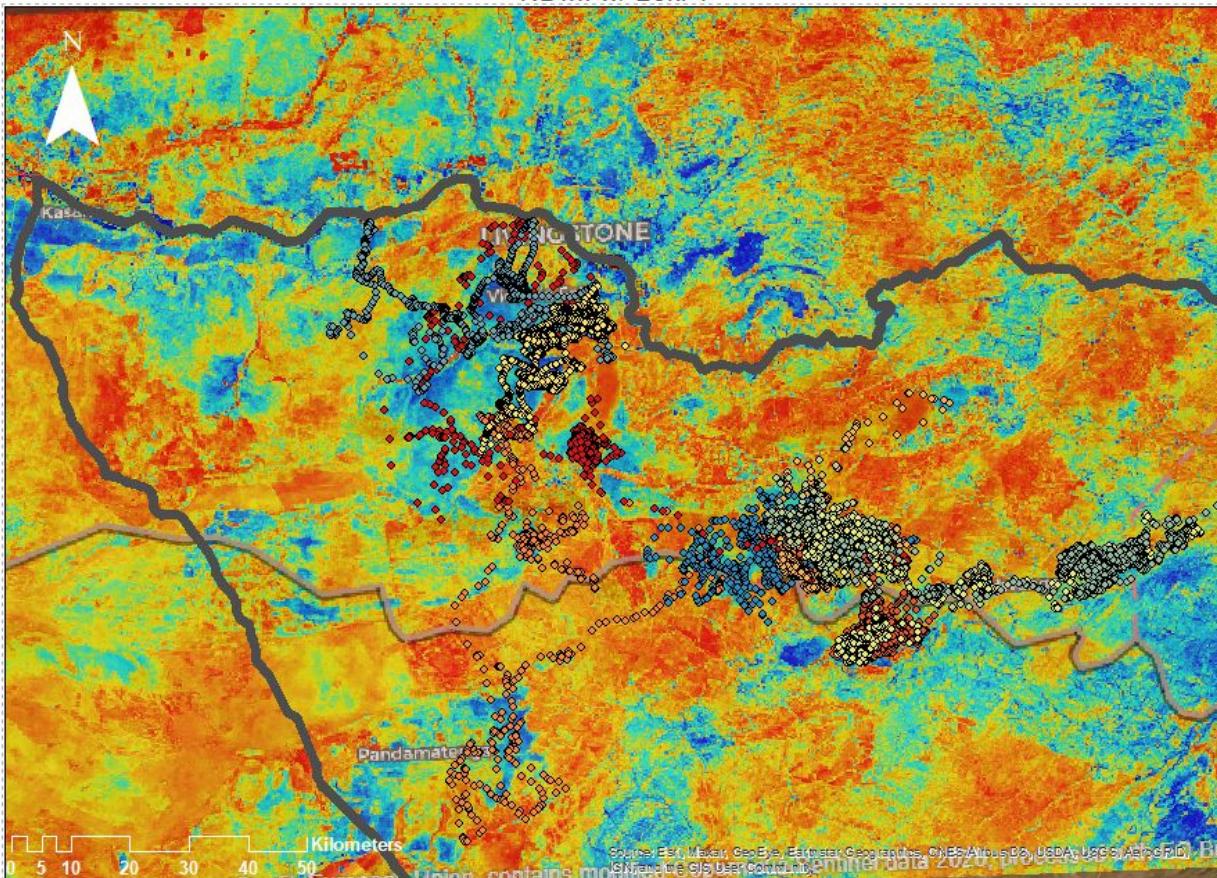
KAZA Raster w/ Loki 2 data

Sam Shuster
GEOG 4370
12/14/2020
Dr. Madden



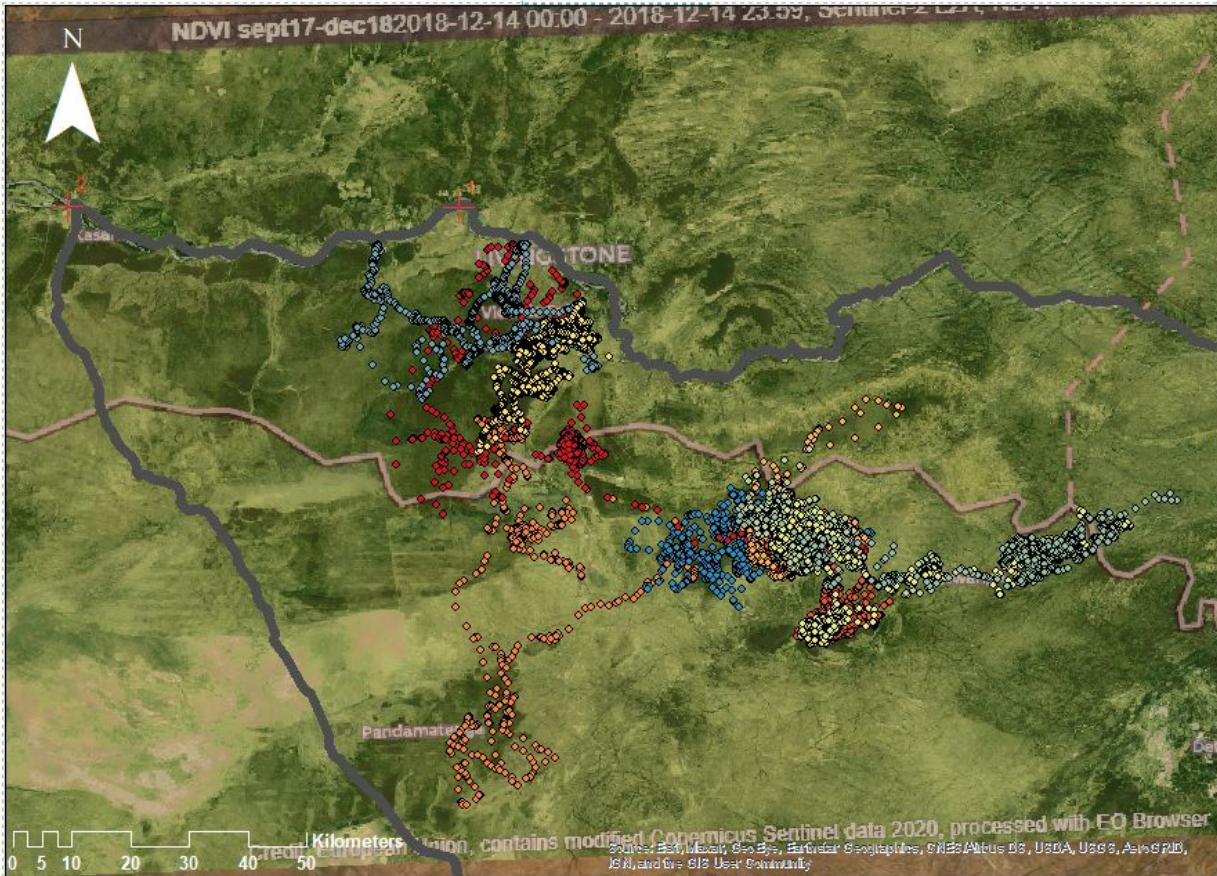
NDMI w/ Loki 1

Sam Shuster
GEOG 4370
12/14/2020
Dr. Madden



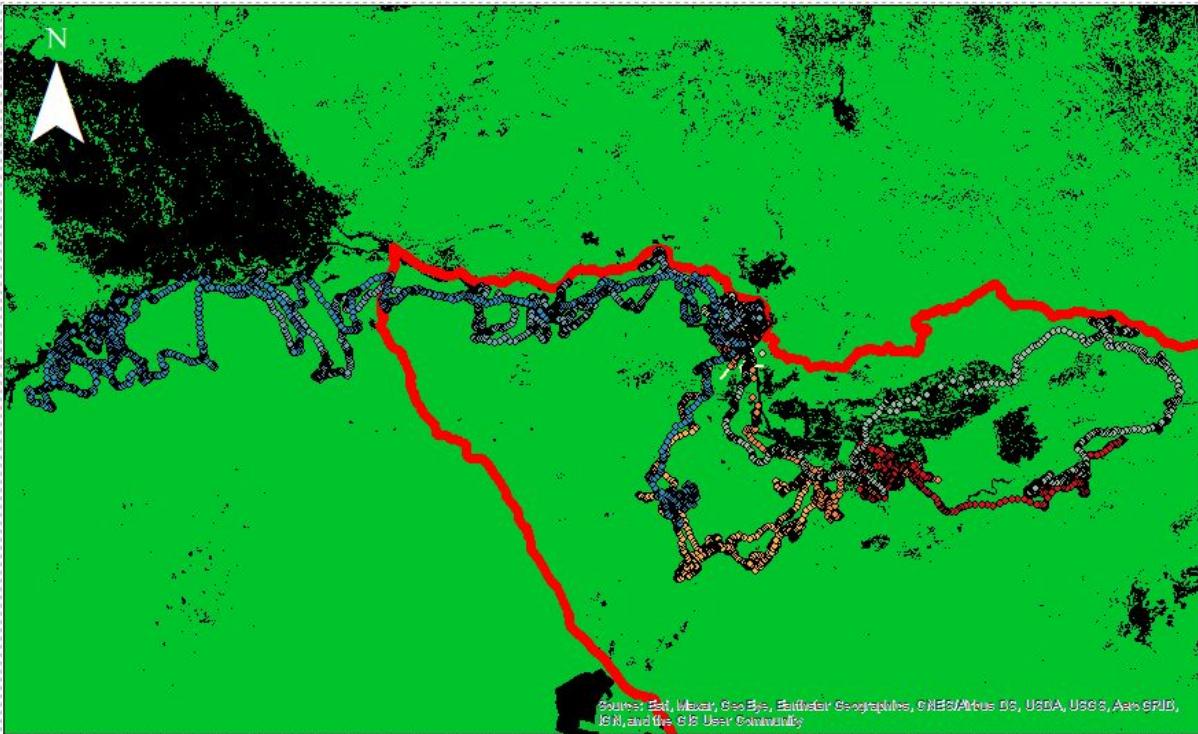
Sam Shuster
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Dr. Madden

NDVI w/ Loki 1



KAZA Traversable Land Raster w/ Loki 2 data

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Dr. Madden



Legend

Admin_Borders

landcover_2005_fixed.tif

Value

0

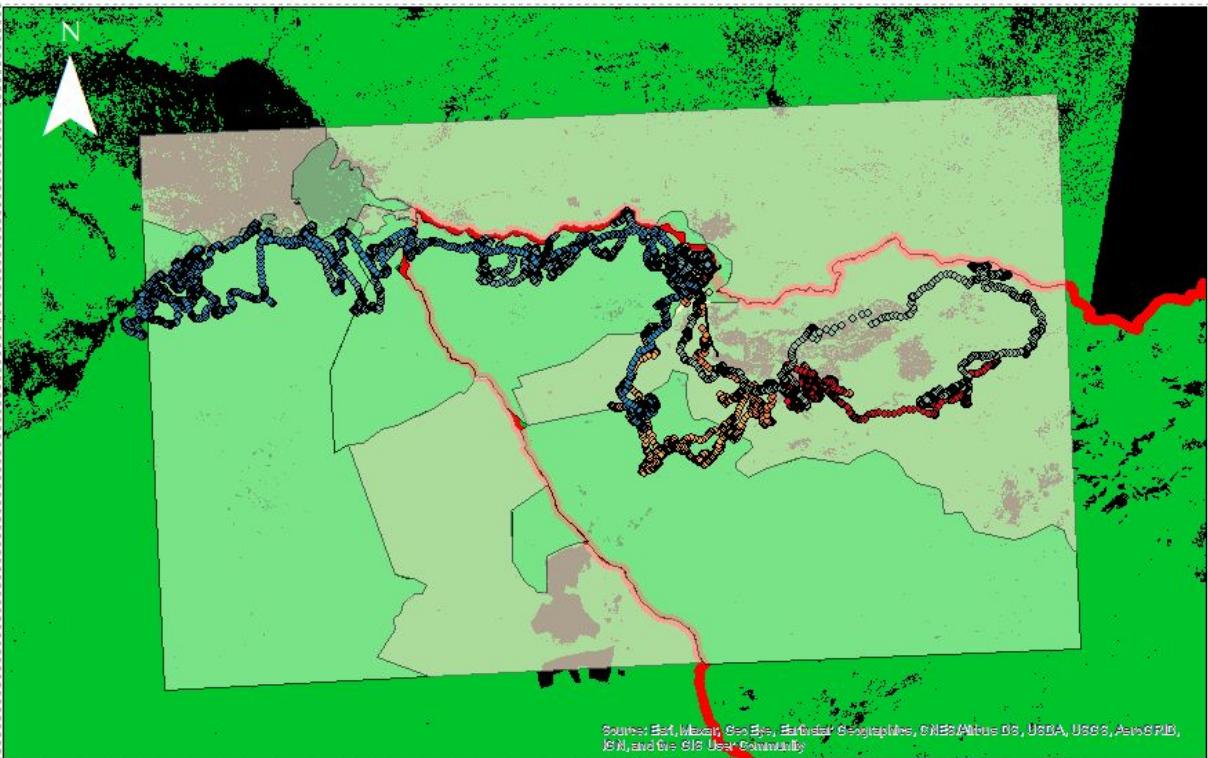
1

2	8	13	18	25
3	9	14	19	26
5	10	15	20	28
6	11	16	21	29
7	12	17	24	World Imagery



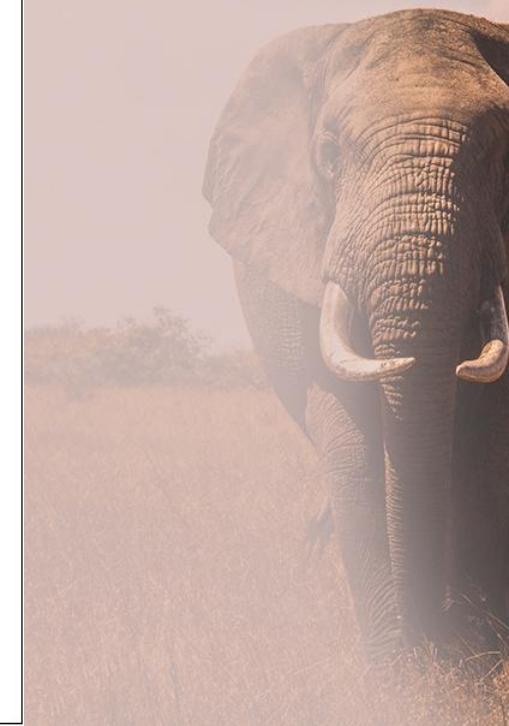
Traversable Land w/ Designated Conservation Areas w/ Loki 2

Sam Shuster
GEOG 4370
12/14/2020
Dr. Madden



Legend

- Not_Designated_Conservation
- Conservation_Areas
- Admin_Borders





Conclusions

- Based on overlay of GPS data over NDMI image, the elephants stay within the most moisture rich regions as they develop from season to season
 - Appears to be the most influential factor of analysis
- Vegetation growth according to NDVI analysis does not yield any real meaningful result
- Elephants remain within an approximately 25-40 km area from the urban settlement of Victoria Falls during the wet season
 - Dependent on the elephant
- The elephants in this data set do sometimes travel together but do not appear be part of the same herds
- Elephants split time spent on designated conservation land and undesignated land not according to land type but by personality temperament



Potential remediation/harm reduction techniques

1. Be extra mindful when considering the creation of fences in future building projects
2. Shield artificially created water sources from wildlife access in order to limit interaction with humans and prevent unintended influences
 - a. *Note* - the creation of artificial water sources at all may affect water distribution so this should be taken into account
3. Shield areas like waste disposal sights from wildlife access to limit anthropogenic issues

A vertical photograph of a large African elephant standing in a dry, golden-brown grassland. The elephant is facing towards the left of the frame. The background shows a hazy, overcast sky.

Challenges & Future Considerations

- Most challenging task was successfully reclassifying the KAZA raster layer in order to generalize the terrain features
- In future, I will try to find out how to transform the GPS point data into line features and then use those to perform quantitative analyses
- Learning how to add the tracking data for the other elephants not included in my analysis would provide more refined insight into movement patterns
- Include more robust statistical analysis (constrained by time)
- Implement more remote sensing indices to answer more questions



Data Sources

- Connected Conservation and the Victoria Falls Wildlife Trust
- Image Basemap in ArcGIS ArcMap = Image(s),
 - Esri World Imagery (e.g., 15-m USGS Landsat and 2.5-m ESA SPOT, 1-m GeoEye, 0.3-m and 0.6-m DigitalGlobe IKONOS satellite imagery) – Include a figure(s) showing the image(s) you us
- Sentinel Hub EO Browser
 - Landsat Imagery
 - Copernicus Imagery
- Google Earth & Google Maps
 - True color image

Data Sources

Scott R. Loarie, Rudi J. Van Aarde, Stuart L. Pimm,
Fences and artificial water affect African savannah elephant movement patterns,
Biological Conservation,
Volume 142, Issue 12,
2009,
Pages 3086-3098,
ISSN 0006-3207,
<https://doi.org/10.1016/j.biocon.2009.08.008>.
(<http://www.sciencedirect.com/science/article/pii/S0006320709003759>)

