Forest cover on Gorongosa Mountain

Assessment of satellite imagery 2019

May 2020

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1. Background and approach

Two previous reports were compiled by the Gorongosa Project on the forest cover of Gorongosa Mountain: “Forest loss on Gorongosa Mountain - Historical assessment and analysis of high-resolution satellite imagery 2010 – 2015” and “Forest cover on Gorongosa Mountain - Assessment of satellite imagery 1977-2017”.

The current report continues with the monitoring of forest cover on Gorongosa Mountain using a newly commissioned high-resolution satellite image. The image collection for a DigitalGlobe, 30cm resolution satellite image was done on 31 May 2019 covering an extent of 507 km^2. The orthorectified image was received at the end of June 2019 (Fig. 1).

The following images were thus acquired by the Gorongosa Project (GP) over the past decade:

- 2010 IKONOS at 1 m resolution;
- 2013 GeoEye-1 at 50cm resolution;
- 2015 WorldView at 40cm resolution;
- 2017 DigitalGlobe at 30cm resolution;
- 2019 DigitalGlobe at 30cm resolution.

The historical extent of the forest was at first based on the vegetation map of Macedo (1970a). This map was scanned and georeferenced after which the outline of the forest was digitized. The Macedo map did not benefit from satellite imagery, GIS or GPS technology. This map is problematic to use as a baseline for the extent of the original forest.

A cloudless 5.5-m-resolution black-and-white satellite photograph that was originally captured on 6 July 1977 (early-mid-dry season) by the US intelligence services Hexagon satellite program (KH9) and declassified in 2011 was obtained courtesy of Dr Josh Daskin. The extent of forest was digitized on screen. This is now being used as the baseline figure for the forest cover although Macedo (1970b) already reports substantial anthropogenic pressure on the mountain above 750m that was in evidence during his first visit in 1964.

The extent of the forest in more recent years was determined through visual assessment of the successive high-resolution images within the ArcGIS environment. This extent was digitized on screen rather than using any automated classification.

This rather low-tech approach is preferred for two reasons:

- Firstly, due to the inability over the last few years to access most of the Mountain, ground truthing of any automatic image classification is not possible;
- Secondly, each of the successive images has a better resolution than the previous one (see page 9 of the 2016 report). The more recent images help to interpret the older ones.

In addition to assessing forest cover, the number of settlements within the boundary of the National Park was also determined. Previously, the settlements that were visible on the 2013/2015 images were digitized by Bridget Conneely. This same exercise was now repeated by Margarida Victor for the 2019 image .

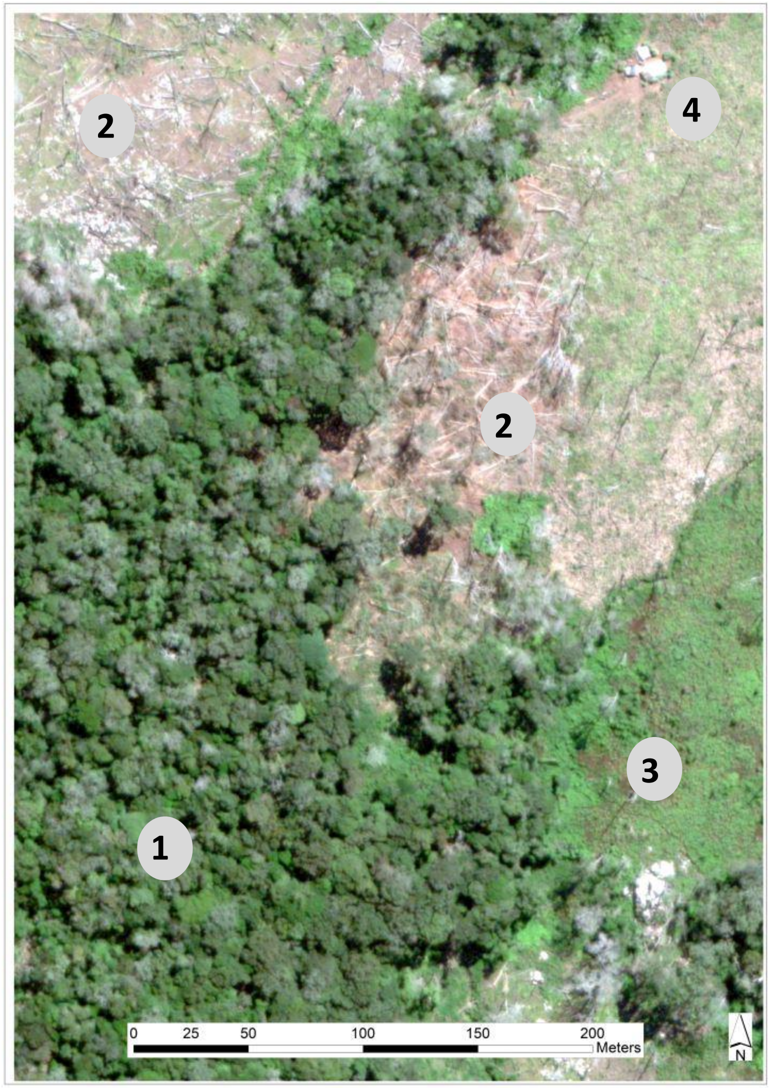

Fig. 1: Detail of the high-resolution satellite image of 2019.
1 = forest, 2 = forest cut 2017-2019 (see fallen tree trunks),
3 = forest cut before 2017, 4 = settlement.

2. Forest cover and forest loss

The assessment of the satellite imagery confirms the past and on-going loss of forest to slash-and-burn agriculture (Table 1 and Fig. 2).

Table 1: Extent of forest cover and forest loss since 1977.

Year	Forest (ha)	Forest cover in % of 1977	Forest loss (ha)	Annual forest loss (ha)
1977	13 500			
2010	11 642	86.2	1 858	81
2013	10 364	76.8	1 278	426
2015	9 702	71.9	662	331
2017	8 979	66.5	723	362
2019	8 279	61.3	700	350

There have been some small changes to the figures for the forest cover in 2010, 2013, 2015 and 2017 since the 2016 report. This is as a result of small refinements in forest outlines and forest cuts from the analysis of the successively higher-resolution images.

The pattern of forest loss has shifted over time (Fig. 3). Overall, the largest losses have been in the southern and south-western sectors of the Mountain (Fig. 4). The forest loss has also very obviously fragmented the landscape including some dramatic examples (Fig. 5).

3. Number of settlements

In 2013, a total of 1 032 settlements were counted with some 4452 individual structures. By 2019, the total number of settlements was 1 271 with 4 574 structures. Most of the settlements are found on the lower part of the mountain (Fig. 6).

Only 518 of the settlements from 2013 were still in exactly the same locality as in 2019. A significant expansion occurred in the higher-lying central part . A new, very dense concentration of structures is apparent on the eastern flank of the mountain (Fig. 6).

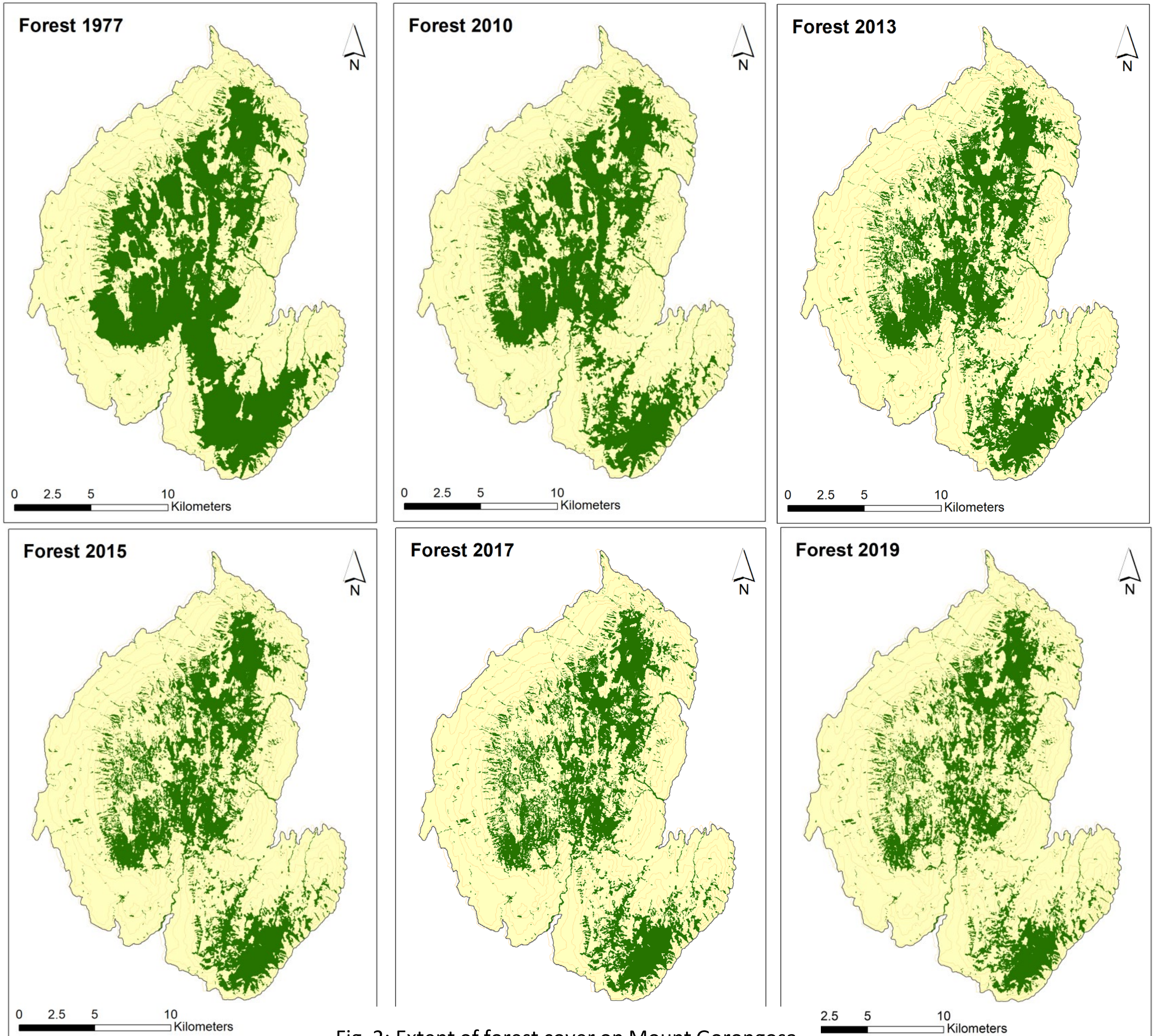

Fig. 2: Extent of forest cover on Mount Gorongosa.

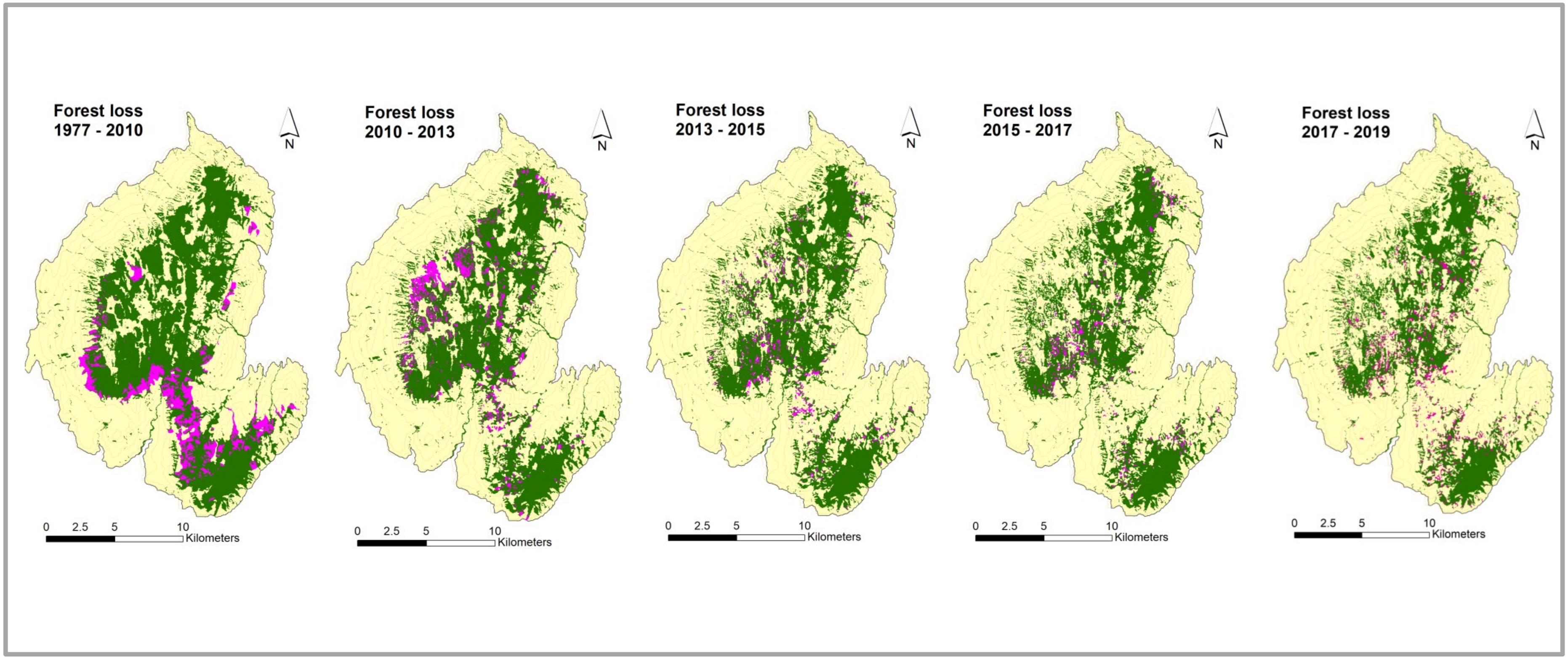

Fig. 3: Pattern of forest loss (in purple) on Mount Gorongosa from 1977 to 2019.

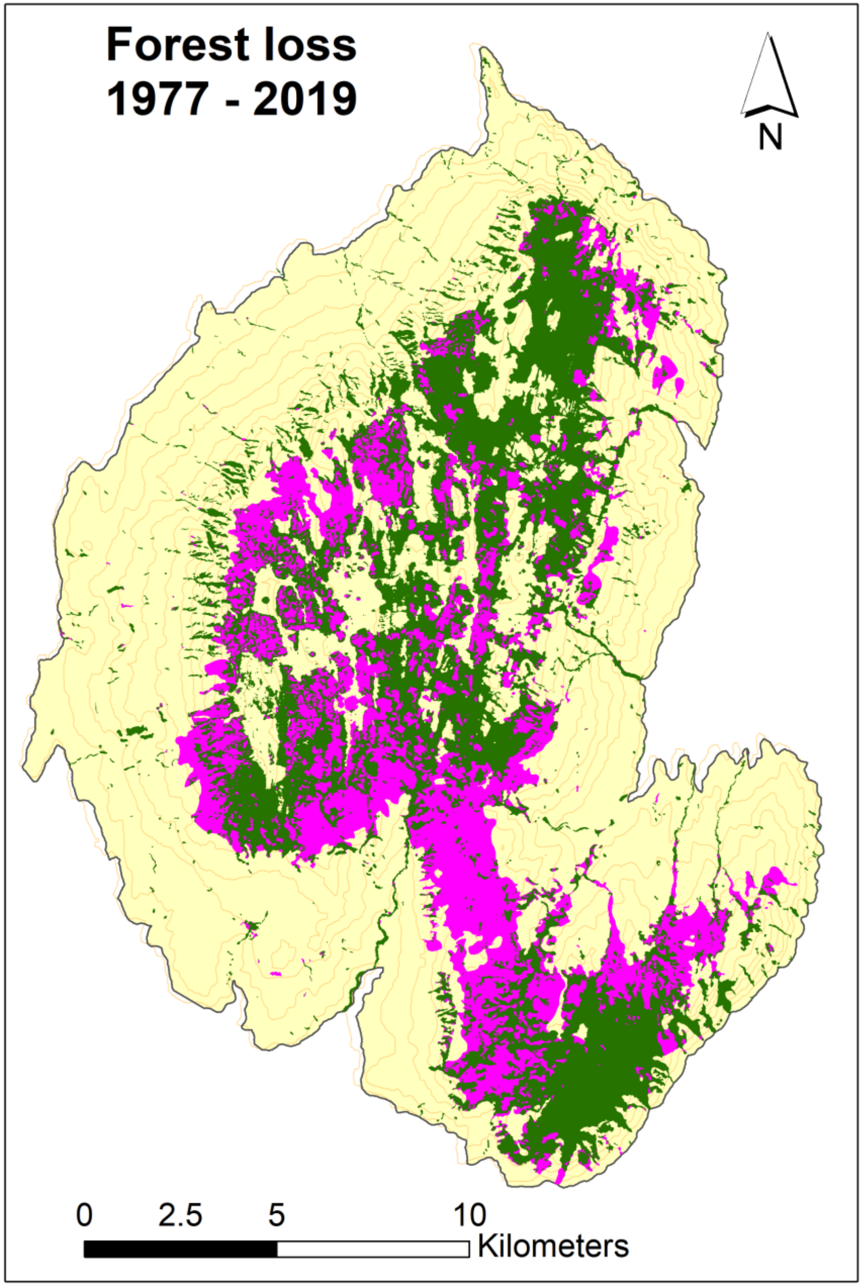

Fig. 4: Overall pattern of forest loss (in purple) on Mount Gorongosa from 1977 to 2019.

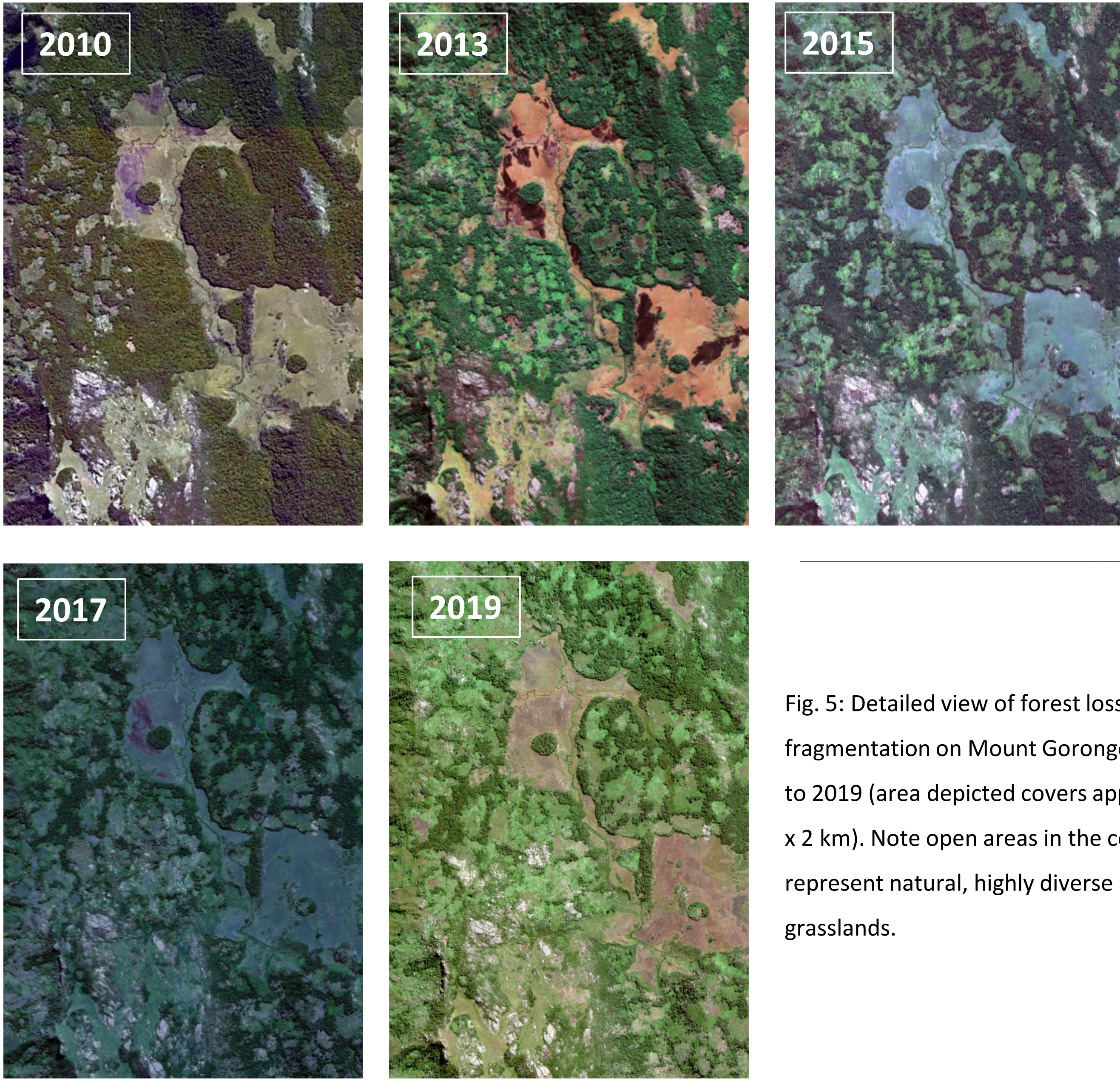

Fig. 5: Detailed view of forest loss and fragmentation on Mount Gorongosa from 1977 to 2019 (area depicted covers approximately 2 x 2 km). Note open areas in the centre that represent natural, highly diverse ancient grasslands.

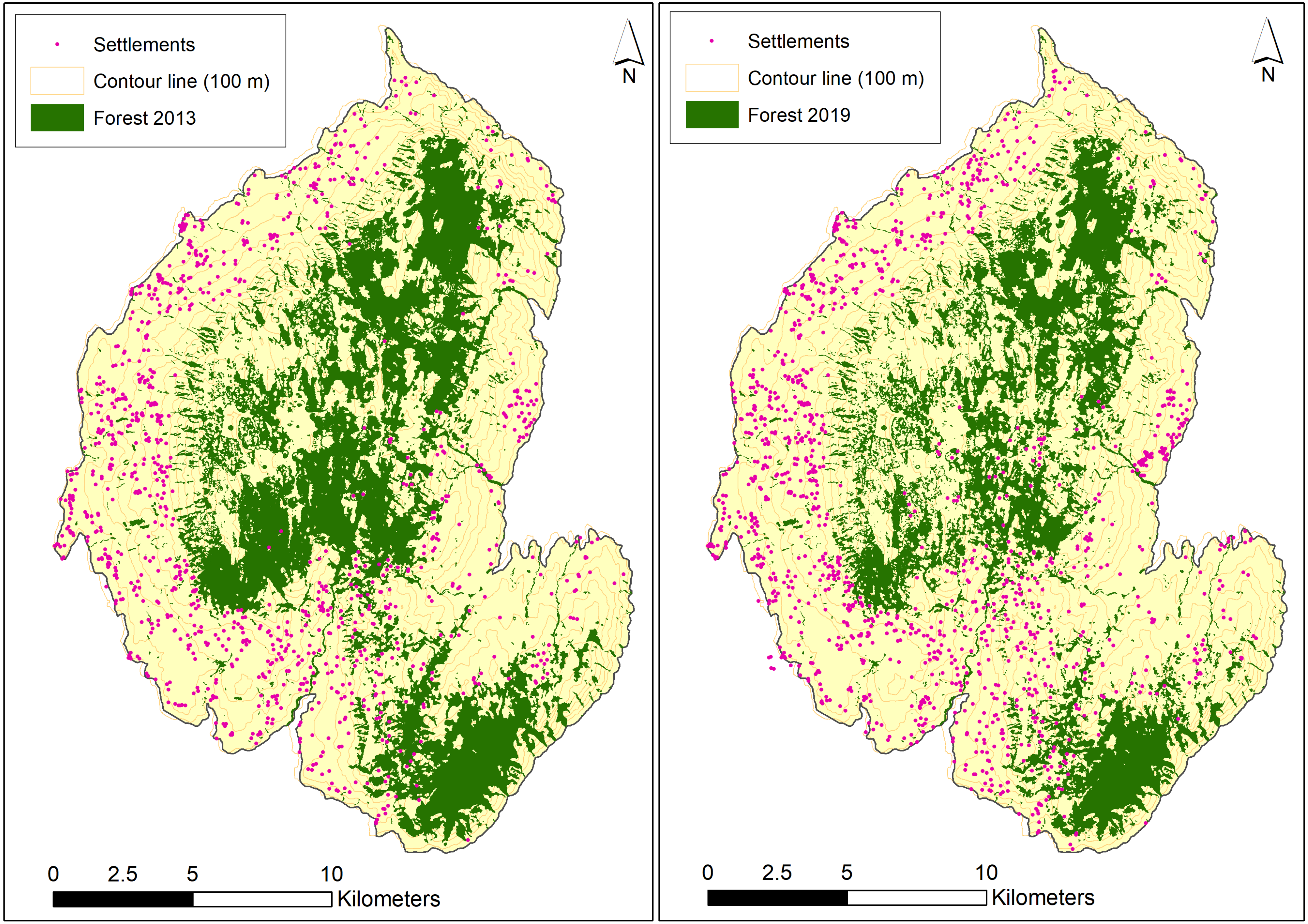

Fig. 6: Distribution of settlements in 2013 and 2019 on Mount Gorongosa. Note expansion in the central areas and new cluster on the eastern flank of the mountain.

4. Discussion

In the absence of any ground truthing or low-level overflights, the analysis of the high-resolution satellite imagery confirms the on-going loss of forest to slash-and-burn agriculture. The rate of loss has stabilised over the last few years to around 350 ha annually (Table 1). On average, every single day, one hectare of forest disappears. This stabilisation on the extent of forest being cut is cold comfort as it impacts on an ever-shrinking remainder of the original forest.

The extensive loss of forest in the central parts also affects certain types of forest more than others. It would appear that those forests on deeper soils and more gentle slopes are most targeted. These forests probably belong to the “Mixed Sub-montane Forest” community described by Müller et al. (2012).

The loss of Mount Gorongosa’s forest is literally “death through a thousand cuts”. Rather than large clear cuts, the forest gets nibbled at from the edges whilst new openings are also being created. Existing openings are gradually expanded. A total of 1205 individual new cuts were mapped on the 2019 satellite image compared to the 2017 coverage.

The result is a continuous further fragmentation of the forest. The number of individuals forest patches has almost doubled since 1977. The average patch size has decreased from 15.4 ha in 1977 to only 4.8 ha in 2019. Whereas the largest continuous patch of forest covered 11 349 ha in 1977 this has decreased to only 2 8209 ha in 2019 (Table 2).

Table 2: Increasing fragmentation of the forest over time.

Year	Number of patches	Average patch size (ha)	Largest continuous extent (ha)
1977	876	15.4	11 349
2010	995	11.7	7 305
2013	1 167	8.9	6 463
2015	1 356	7.2	5 929
2017	1 599	5.6	2 960
2019	1 732	4.8	2 820

The number of individual cuts can be expressed in the form of a "heat map" to illustrate those areas with the highest relative deforestation pressure. There is on-going heavy pressure on the central-western area (Fig. 7) that is leading to extreme fragmentation (see Fig. 5). Pressure in the south-east and north-east may have eased a little.

The pattern of settlement has broadly remained the same (Fig. 8), but a significant new settlement has emerged in the east at around 900 m elevation with over 120 structures where in the past there were none.

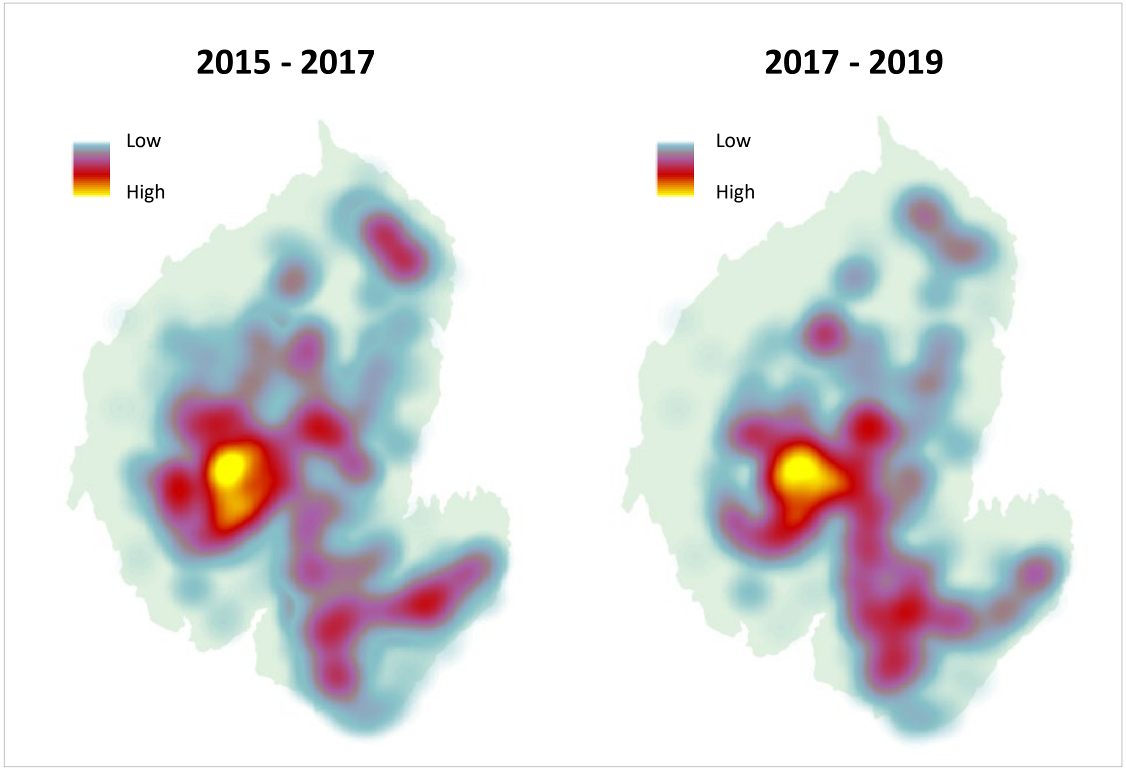

Fig. 7: Relative deforestation rate in terms of the number of new individual forest cuts.

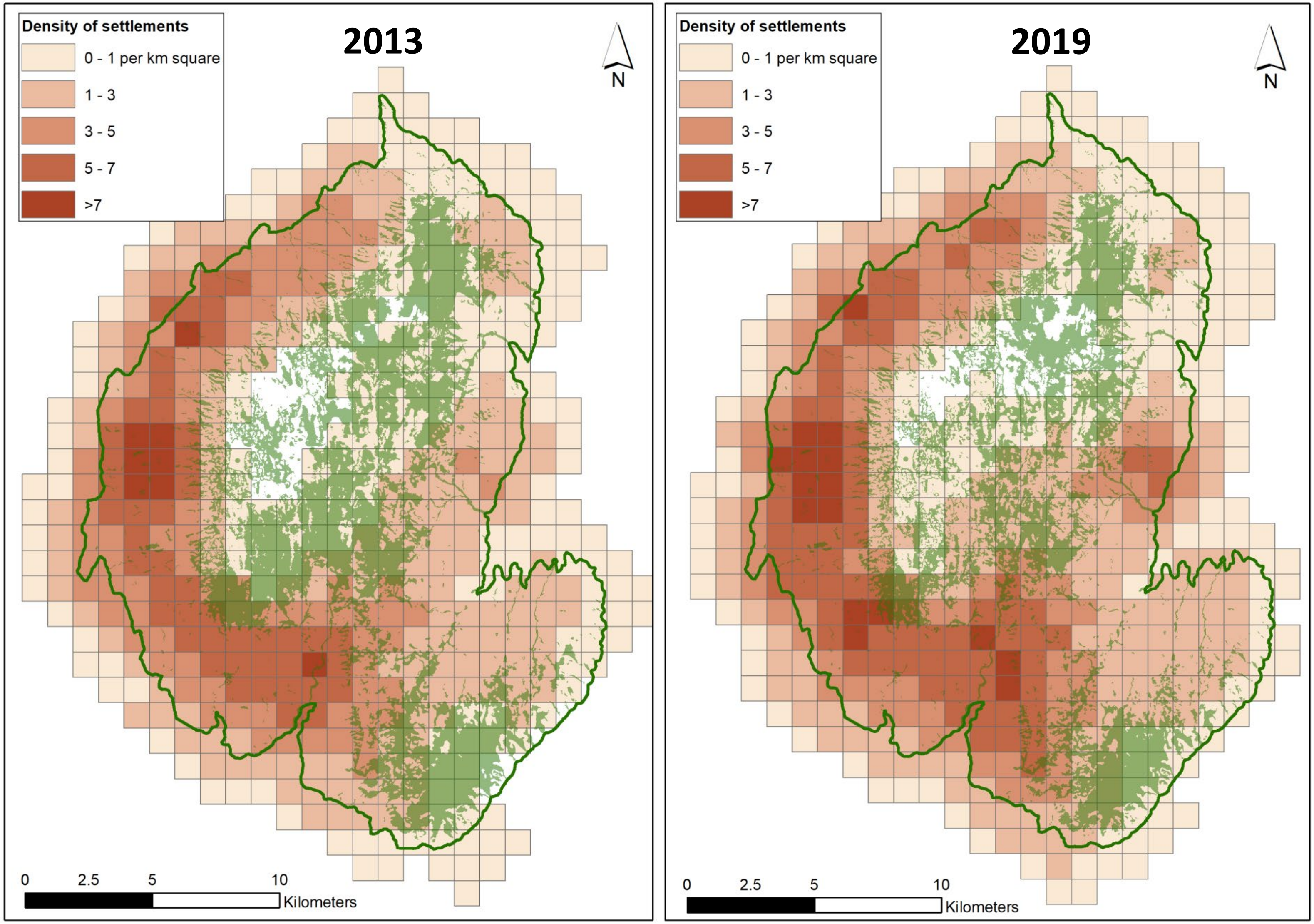

Fig. 8: Densities of settlements (per square km) in 2013 and 2019.

The scale of forest loss is far exceeding that what can be reclaimed through the coffee project. It will be necessary in future, once the mountain can be freely accessed, to have a significant restoration program put in place. A substantial reforestation effort will be required through active plantings and through the protection from fires.

The coffee project is providing an extremely useful platform and working environment for research on reforestation. The research project in 2019 by António Ngovene Júnior, one of our Masters students, was titled “Can shade coffee cultivation help restore Mount Gorongosa’s threatened forest biodiversity?”.

We are also planning to establish a long-term experiment in the area of the coffee project to assist in developing the most appropriate techniques for reforestation on Gorongosa mountain.

5. References

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