

Update to: Combining global tree cover loss data with historical national forest cover maps to look at six decades of deforestation and forest fragmentation in Madagascar[§]

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1 Summary

In a recent paper (Vieilledent *et al.*, 2018), we have published estimates of deforestation and forest fragmentation in Madagascar for the period 1953-2014. We had used a method combining historical forest cover maps (1953-2000) with annual tree cover loss data (2000-2014) to derive new forest cover maps for the period 2000-2014. We had shown that deforestation rate had increased since 2005 to reach about 100,000 ha/yr (1%/yr) for the period 2010-2014 and that remaining forest was highly fragmented, 46% of the remaining forest in 2014 (covering 8.9 Mha) being at less than 100 m from forest edge or a forest clearing.

In this follow-up study, we have used version 1.5 of the Global Forest Change data (Hansen *et al.*, 2013), providing updated tree cover loss data for the period 2014-2017 (<http://earthenginepartners.appspot.com/science-2013-global-forest>), to provide updated estimates of deforestation and forest fragmentation in Madagascar on the periods 2010-2015 and 2015-2017. To do so, we used the exact same methodology as the one described in Vieilledent *et al.* (2018).

We provide new forest cover and forest fragmentation maps for Madagascar for the years 2015 and 2017 (Fig. 1). We estimate that tropical forests cover 8.4 Mha in 2017 in Madagascar. We show that the deforestation trend observed on the period 2005-2014 in Vieilledent *et al.* (2018) has been accelerating on the period 2015-2017. During these two years, 324,000 hectares have been deforested at the national scale in Madagascar (Tab. 1). This corresponds to a 56% increase in the annual deforestation rate compared to the period 2010-2015 (Tab. 1). Associated to deforestation, remaining forest keeps on being highly fragmented (Tab. 2). At the end of the year 2017, almost half (49%) of the forest in Madagascar was located at a distance lower than 100 m from forest edge or a forest clearing (Fig. 2).

Some limitations about using version 1.5 of the tree cover loss data to analyze the deforestation trend on the full period 2000-2017 are discussed on the Global Forest Change website. Only the satellite data from 2011 onward have been reprocessed in this new version, so that comparing deforestation on the period 2000-2012 with deforestation on the period 2011-2017 should be performed with caution. In our case, we can confidently compare deforestation on the period 2010-2015 with deforestation on the period 2015-2017.

Increase in the deforestation rates in Madagascar is most likely associated to demographic growth and poor environmental law enforcement. These news results are alarming. If nothing is done to rapidly curb deforestation in the country, Madagascar risks losing almost all its tropical forest and associated biodiversity in the next 50 years.

2 Data accessibility

Results of this study are entirely reproducible. Data and code used in the analysis have been archived on the CIRAD Dataverse repository:

- Input data: <http://dx.doi.org/10.18167/DVN1/2FP7LR>
- Code: <http://dx.doi.org/10.18167/DVN1/275TDF>
- Output data: <http://dx.doi.org/10.18167/DVN1/AUBRRC>

3 References

- Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O. & Townshend, J.R.G. (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* **342**, 850–853.
- Pekel, J.F., Cottam, A., Gorelick, N. & Belward, A.S. (2016) High-resolution mapping of global surface water and its long-term changes. *Nature* **540**, 418–422.
- Vieilledent, G., Grinand, C., Rakotomalala, F.A., Ranaivosoa, R., Rakotoarijaona, J.R., Allnut, T.F. & Achard, F. (2018) Combining global tree cover loss data with historical national forest cover maps to look at six decades of deforestation and forest fragmentation in madagascar. *Biological Conservation* **222**, 189 – 197.

4 Tables

Table 1: **Change in natural forest cover and deforestation rates from 1953 to 2017 in Madagascar.** Areas are provided in thousands of hectares (Kha). Forest map for the year 1973 has 3.3 Mha of unclassified areas due to the presence of clouds on satellite images. As a consequence, partial deforestation rates for the periods 1953-1973 and 1973-1990 are computed based on the available forest extent. The last two columns indicate the annual deforested areas and annual deforestation rates on the previous time-period (e.g. 1953-1973 for year 1973, 1973-1990 for year 1990, etc.).

Year	Forest (Kha)	Unmap (Kha)	Annual defor. (Kha/yr)	Rate (%/yr)
1953	15,968	0	-	-
1973	14,241	3,317	86	0.6
1990	10,762	0	205	1.6
2000	9,879	0	88	0.8
2005	9,673	0	41	0.4
2010	9,320	0	71	0.7
2015	8,770	0	110	1.2
2017	8,446	0	162	1.9

Table 2: **Change in forest fragmentation from 1953 to 2017 in Madagascar.** Five forest fragmentation classes, based on the percentage of forest in the neighborhood, are defined: 0-20% (highly fragmented), 21-40%, 41-60%, 61-80% and 81-100% (lowly fragmented). The percentage of forest falling in each forest fragmentation class is reported for each year. Forest areas are provided in thousands of hectares (Kha).

Year	Forest (Kha)	0-20	21-40	41-60	61-80	81-100
1953	15,968	0	1	8	12	78
1973	14,242	6	9	12	16	57
1990	10,762	7	10	13	17	53
2000	9,879	7	11	14	17	51
2005	9,673	8	11	14	18	49
2010	9,320	8	12	15	18	47
2015	8,770	9	14	16	19	43
2017	8,446	10	14	16	18	41

5 Figures

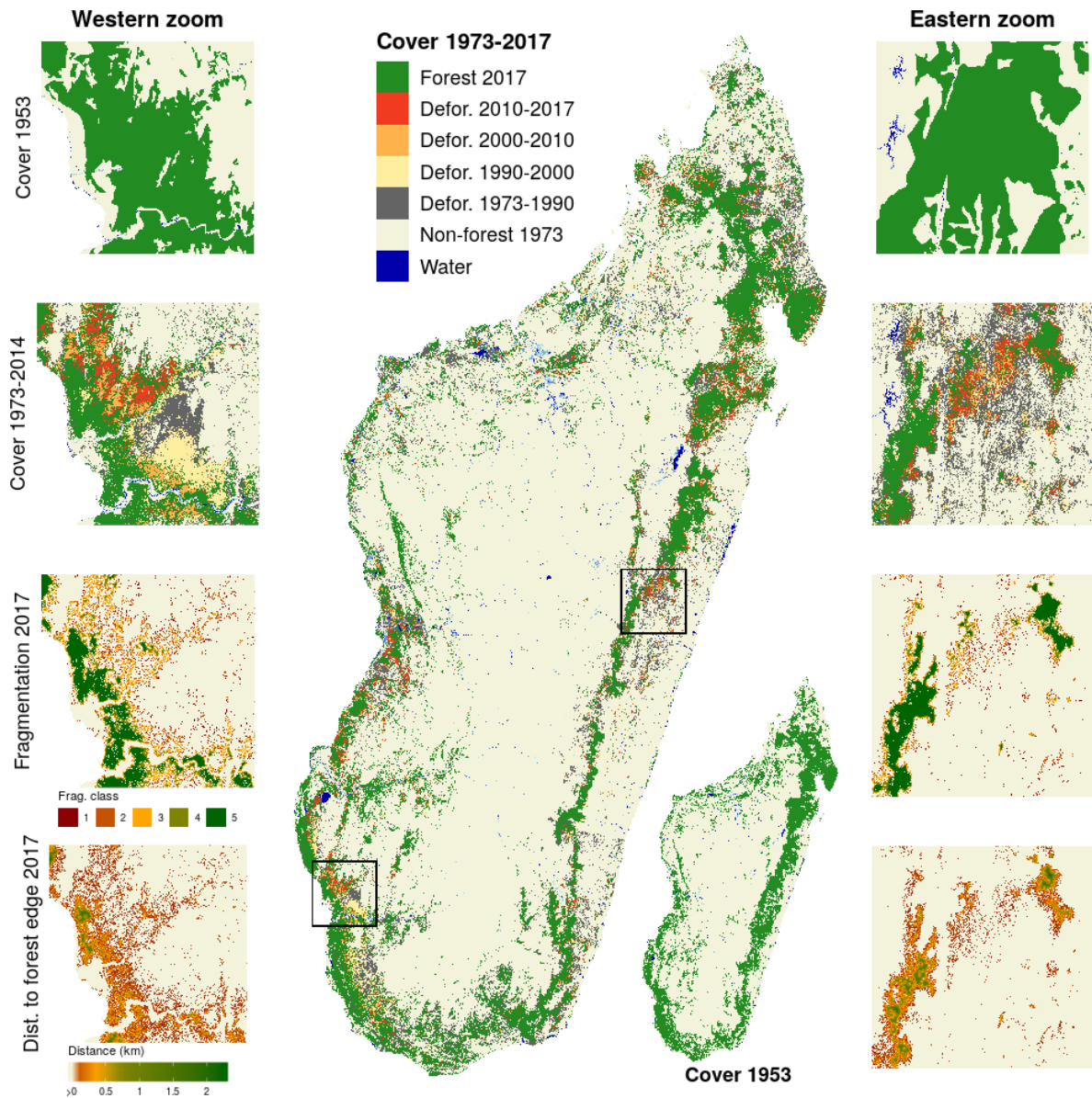


Figure 1: **Forest cover change on six decades from 1953 to 2017 in Madagascar.** forest cover changes from 1973 to 2017 are shown in the main figure, and forest cover in 1953 is shown in the bottom-right inset. Two zooms in the western dry (left part) and eastern moist (right part) ecoregions present more detailed views of (from top to bottom): forest cover in 1953, forest cover change from 1973 to 2017, forest fragmentation in 2017 and distance to forest edge in 2017. Data on water bodies (blue) and water seasonality (light blue for seasonal water to dark blue for permanent water) has been extracted from Pekel *et al.* (2016).

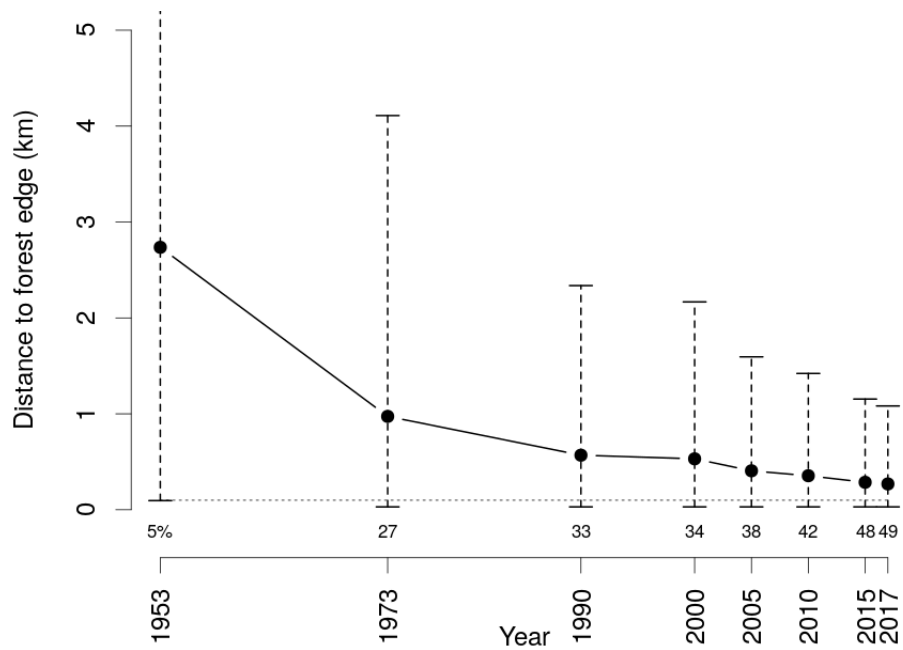


Figure 2: **Change in distance to forest edge from 1953 to 2017 in Madagascar.** Black dots represent the mean distance to forest edge for each year. Vertical dashed segments represent the 90% quantiles (5% and 95%) of the distance to forest edge. Horizontal dashed grey line indicates a distance to forest edge of 100 m. Numbers at the bottom of each vertical segments are the percentage of forest at a distance to forest edge lower than 100 m for each year.