

Forest cover in Madagascar: past, present, and future



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Plan

- 1 Historical deforestation
- 2 Current deforestation

- 3 Future forest cover
- 4 Perspectives

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Objective

- To obtain recent (2000-2017) and accurate deforestation rate estimates for Madagascar.

Method

- We combined :
 - Harper 2007 natural forest cover change map in 1953-2000
 - Hansen 2013 tree cover loss in 2000-2017

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Fifty years of deforestation and forest fragmentation in Madagascar

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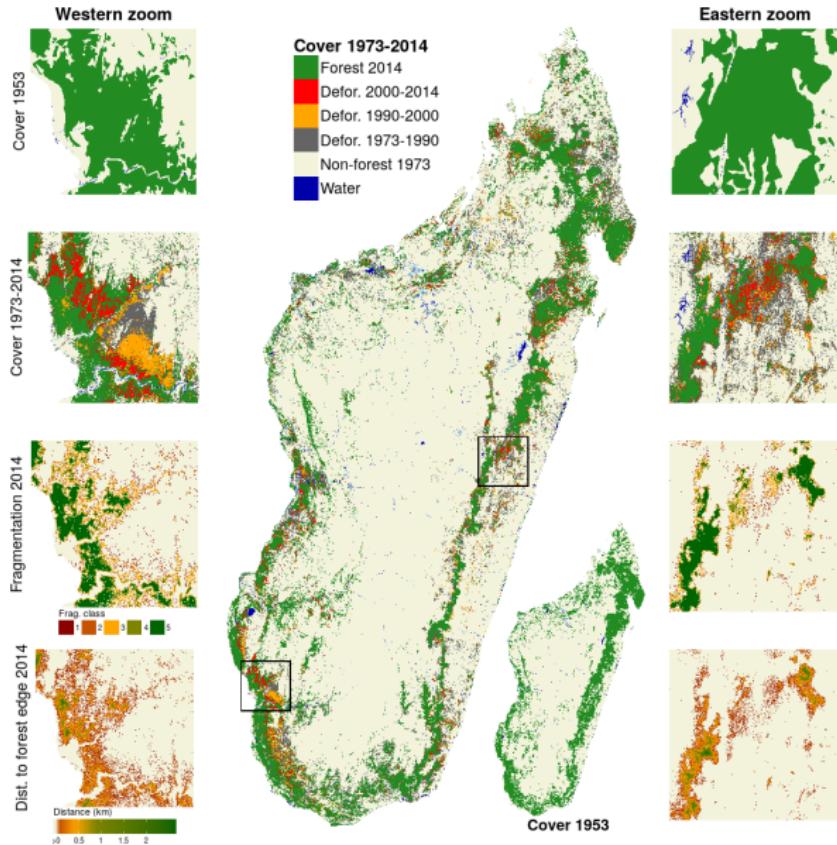
Date submitted: 29 June 2006 Date accepted: 26 September 2007

High-Resolution Global Maps of 21st-Century Forest Cover Change

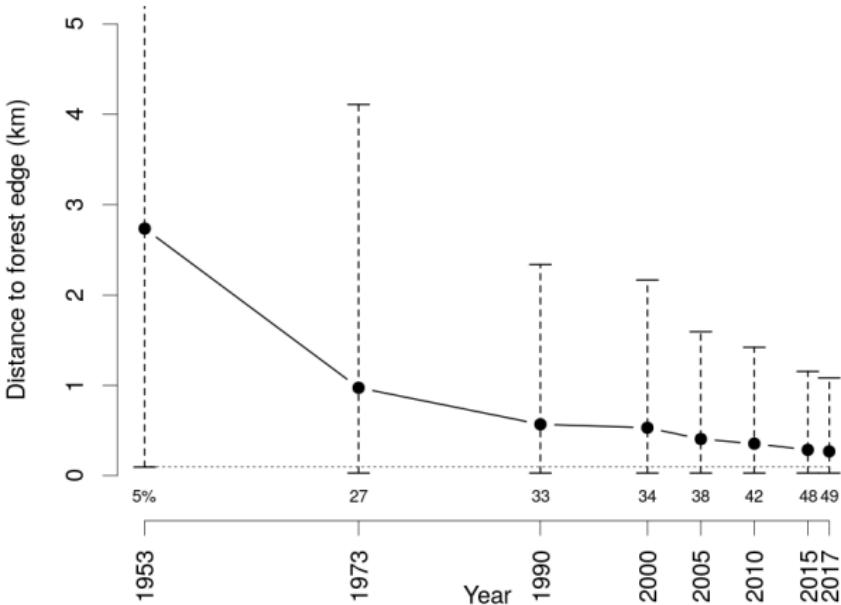
M. C. Hansen,^{1,*} P. V. Potapov,¹ R. Moore,² M. Hancher,² S. A. Turubanova,³ A. Tyukavina,³
D. Thau,² S. V. Stehman,³ S. J. Goetz,⁴ T. R. Loveland,⁵ A. Kommareddy,⁶ A. Egorov,⁶ L. Chini,¹
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- We obtained : an updated natural forest cover change map from 2000 to 2017. Free of clouds. At 30 m resolution.

Historical deforestation



Fragmentation



In 2017, about 50% of the forest is located within a distance of 100 m from a forest edge or open area.

Deforestation rates

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

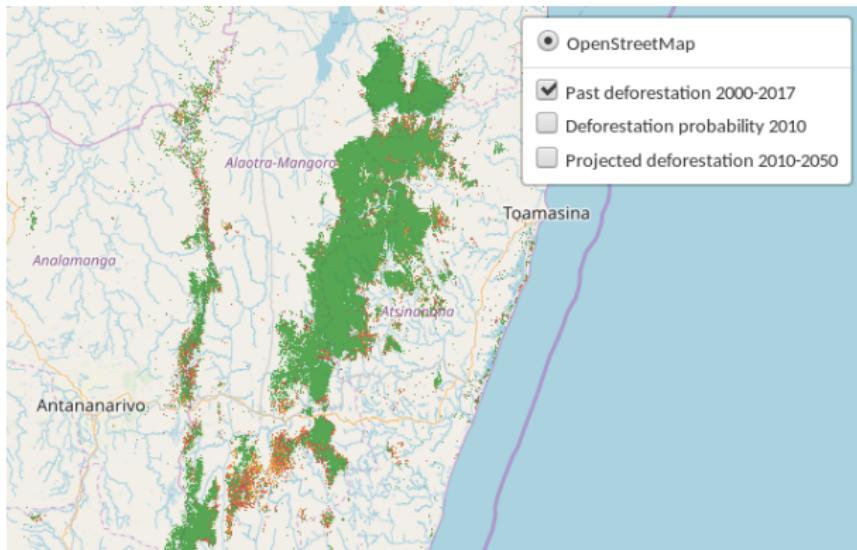
Increase in deforestation rates since 2005.

Publication

Vieilledent G., C. Grinand, F. A. Rakotomalala, R. Ranaivosoa, J.-R. Rakotoarijaona, T. F. Allnutt, and F. Achard. 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.
[[doi:10.1016/j.biocon.2018.04.008](https://doi.org/10.1016/j.biocon.2018.04.008)].

Maps

- Interactive map at <https://forestatrisk.cirad.fr/mada/>
- GIS files on Cirad Dataverse :
<http://dx.doi.org/10.18167/DVN1/AUBRRC>



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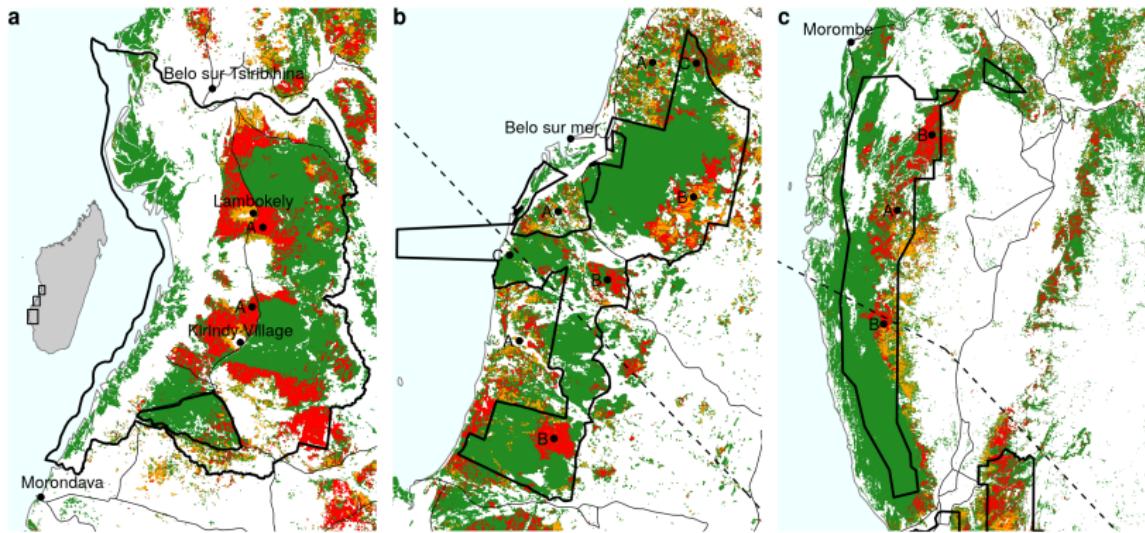
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Objective

- To understand the proximate and underlying causes of current deforestation in Madagascar

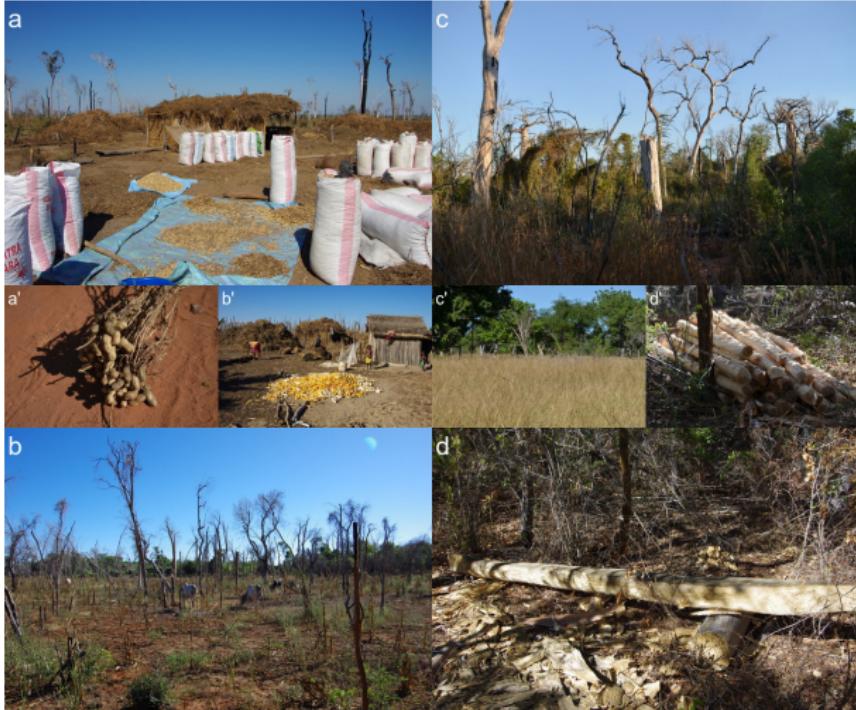
Methods

- Focus on Western Madagascar around 3 protected areas :
Menabe-Antimena, Kirindy-Mite, and Mikea



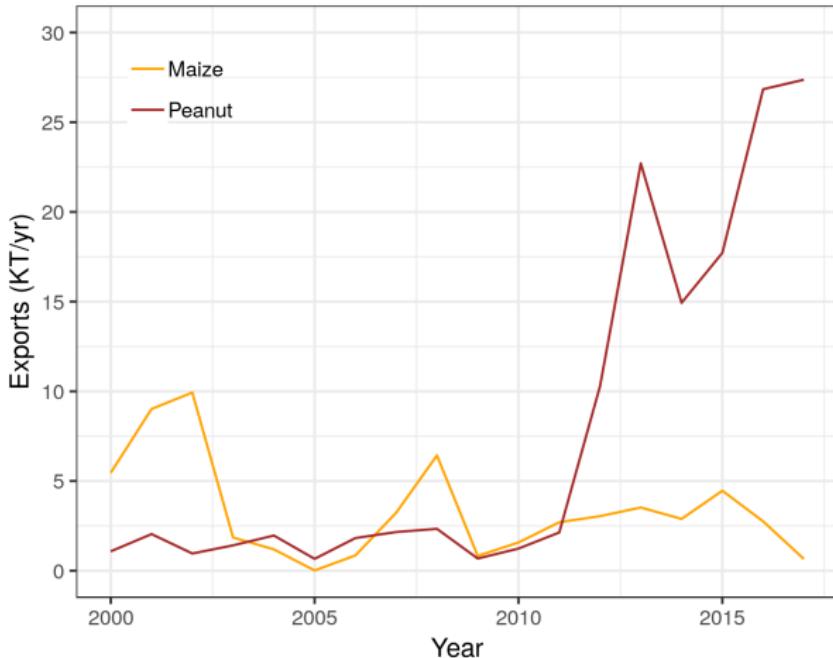
- Field observations (date and causes of deforestation)
- Surveys : local farmers, administration and environmental stakeholders
- Bibliographic study : reports, articles, FAOSTATS, UN Comtrade

Proximate causes



- Slash-and-burn agriculture for maize and peanuts
- Cash crops (small part for subsistence)
- Fires after cyclones to open grasslands for zebu grazing

Exports



- Since 2011 : peanut boom
- High global demand for vegetable oil
- Many intermediaries : buyers, resellers, export companies

Ultimate causes



- It's not only poverty that explains deforestation
- Unregulated global market (no zero imported deforestation policy)
- Weak enforcement of the environmental law

Publication

Vieilledent G., C. Grinand, M. Pedrono, T. Rabetrano, J.-R. Rakotoarijaona, B. Rakotoarivelo, F. A. Rakotomalala, L. Rakotomalala, A. Razafimpahanana and F. Achard. It's not only poverty : global trade and bad governance are responsible for the unceasing deforestation in western Madagascar. In prep.

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Objective

Deriving future forest cover maps for Madagascar (2050, 2100) under a business-as-usual scenario (100,000 ha/yr).



Modelling

Data

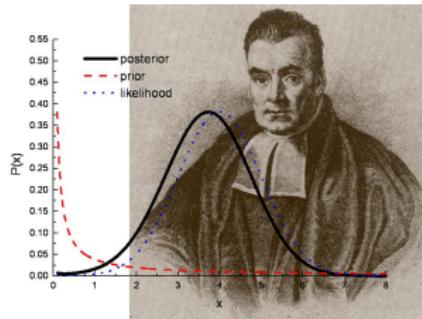
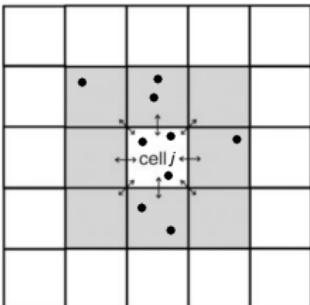
- Historical deforestation data : 2000-2010
- Explicative variables : **landscape, accessibility, land-tenure**
- 40,000 sample points (balanced sampling deforested/non-deforested areas)

Product	Source	Variable derived	Unit	Resolution (m)
Deforestation maps (1990-2000-2010)	Vlieliedent et al. 2018	distance to forest edge	m	30
		distance to past deforestation	m	30
Digital Elevation Model	SRTM v4.1 CSI-CGIAR	altitude	m	90
		slope	°	90
Highways	OSM - Geofabrik	distance to roads	m	150
Places		distance to towns	m	150
Waterways		distance to river	m	150
Protected areas	Rebloma	presence of protected area	-	30

Modelling

Model

- $Y_{ij} \in \{0, 1\} \sim \text{Bernoulli}(\theta_{ij})$
- $\text{logit}(\theta_{ij}) = f(\text{spatial factors}_i) + \rho_j$
- Autocorrelated spatial random effects ρ_j (10 km) to account for **unmeasured** or **unmeasurable** factors : population density, soil type, geographical barriers, law enforcement locally
- Hierarchical Bayesian framework



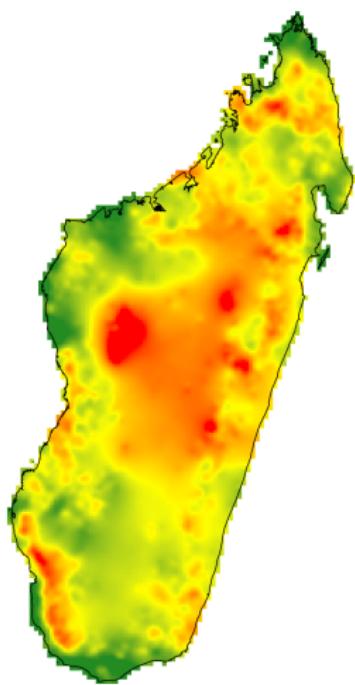
Results

Variable effects

```
## Binomial logistic regression with iCAR process
## Model: I(1 - fordefor) + trials ~ 1 + C(sapm) + scale(altitude) + scale(slope) +
scale(dist_defor) + scale(dist_edge) + scale(dist_road) + scale(dist_town) + cell
## Posteriors:
##                                Mean      Std    CI_low   CI_high
## Intercept        -0.217  0.0535  -0.328  -0.117
## C(sapm)[T.1.0]  -0.549  0.0846  -0.719  -0.39
## scale(altitude) -0.493  0.0732  -0.619  -0.344
## scale(slope)     -0.14   0.0359  -0.209  -0.0626
## scale(dist_defor) -0.429  0.0452  -0.512  -0.349
## scale(dist_edge)  -0.66   0.0571  -0.782  -0.554
## scale(dist_road)  -0.0425  0.0587  -0.155  0.0714
## scale(dist_town)  -0.15   0.0531  -0.261  -0.0532
## Vrho             7.55    0.616    6.23    8.63
## Deviance       9.72e+03    66.4  9.59e+03  9.85e+03
```

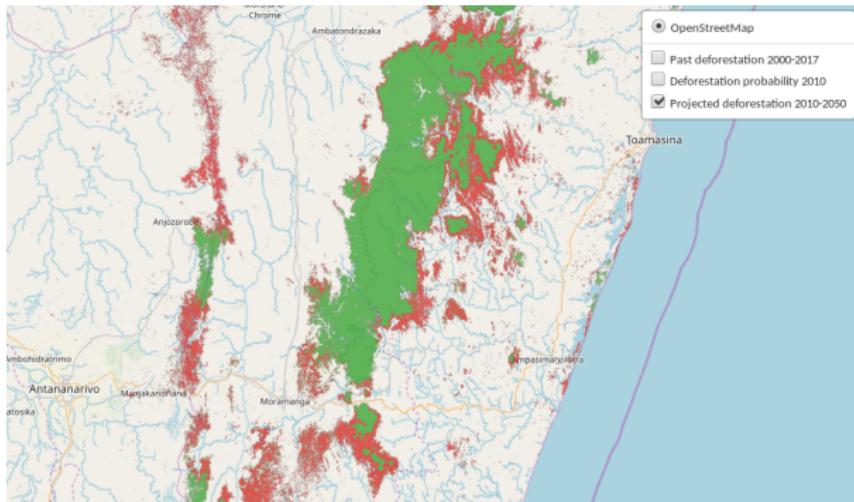
Results

Spatial random effects interpolated at 1 km



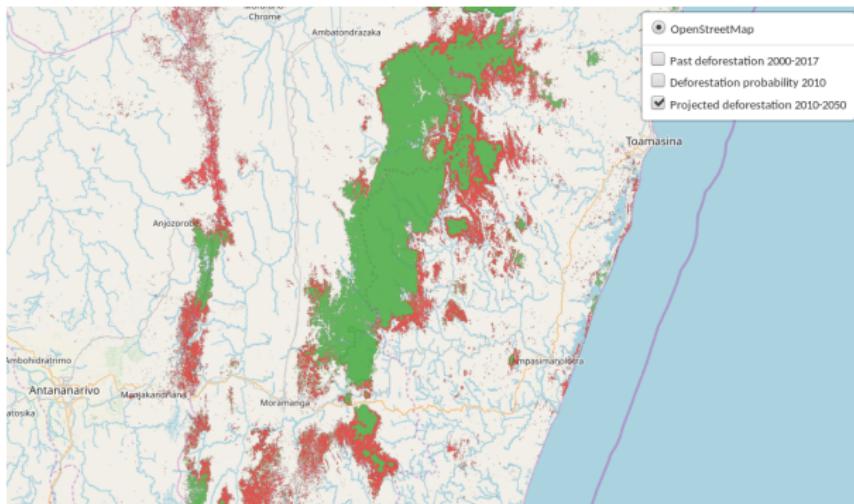
Results

- Spatial probability of deforestation at 30 m in 2010
- Projected forest cover change over the period 2010-2050 assuming a deforestation of 100,000 ha/yr
- Interactive map at <https://forestatrisk.cirad.fr/mada/>



Results

- High regional variability of the deforestation process
- Deforestation should occur preferentially outside protected areas (on the short term)
- Remaining forest in 2050 (~4 Mha) concentrated in areas at **high elevation**, and with **low accessibility**



Software

The screenshot shows a GitHub repository page for 'ghislainv/forestatrisk'. The top navigation bar includes links for Code, Issues (8), Pull requests (0), Projects (0), Wiki, Security, Insights, and Settings. The repository name 'ghislainv / forestatrisk' is at the top left, with options to Unwatch (3), Star (6), Fork (3), and Edit. Below the header, a description reads "'forestatrisk' Python package to model and forecast tropical deforestation". The repository has 257 commits, 1 branch, 1 release, 1 environment, 1 contributor, and is licensed under GPL-3.0. A dropdown menu shows the current branch is 'master'. Buttons for 'New pull request', 'Create new file', 'Upload files', 'Find File', and 'Clone or download' are visible. A list of recent commits by 'ghislainv' shows updates to 'C', 'docs', and the 'forestatrisk' package itself, with the latest commit being 7 days ago.

- **forestatrisk** Python package :
<https://github.com/ghislainv/forestatrisk>
- Rasters processed by chunks : high resolution (30 m, large spatial scale)
- Fast, without memory issues

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Impact on policy

Malagasy President's communication to council of ministers on 27/02/2019 untitled "**“Recouvrir Madagascar de forêt”**". One Planet Summit Nairobi.



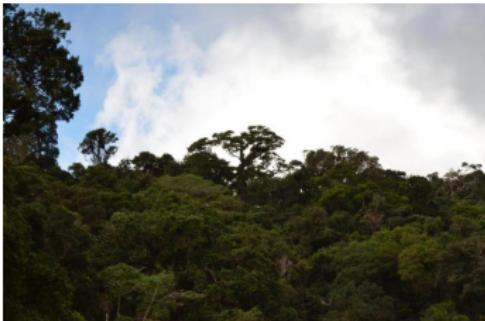
Restauration

Urgent action is needed to

- ① Protect remaining natural forests and stop deforestation
- ② Restore forest ecosystems (reforestation)

Reforestation :

- ① Tropical forests with native tree species (ecological corridors)
- ② Plantations to lower human pressure on natural forests (charcoal)





... Thank you for attention ...
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