

Modelling and projecting deforestation and forest fragmentation in New-Caledonia



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- Explicative variables

3 Modelling

- Statistical model
- Software

4 Results

- Parameters
- Spatial probability

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- Forest cover change
- Perspectives

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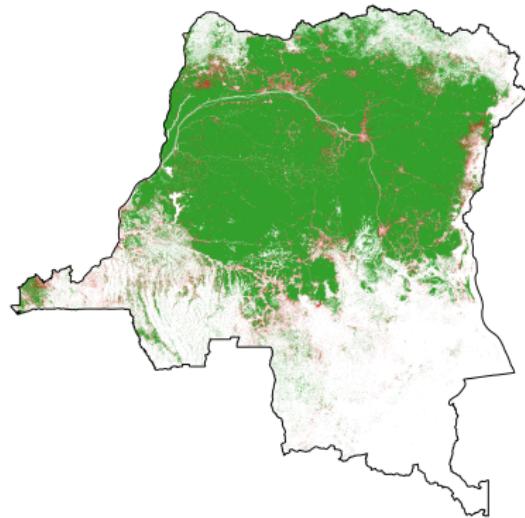
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Long term projections

- Tropical forests shelter most of the terrestrial biodiversity and carbon stocks
- They are currently being deforested at rates close to 1%/yr

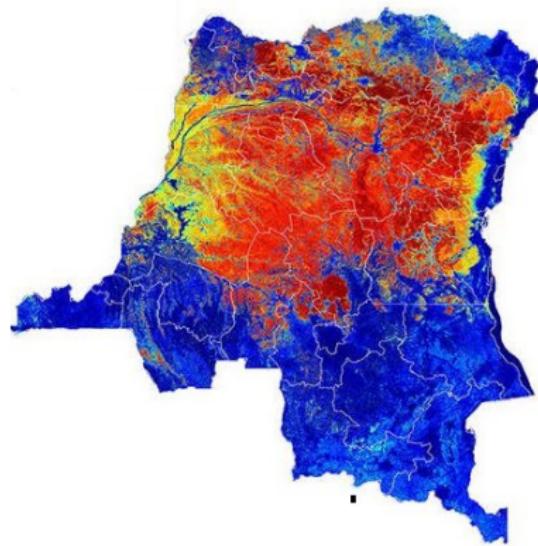


**2005-2015 deforestation in
Democratic Republic of the Congo**

What happens when you project annual deforestation on the medium or long term (2050-2100) ?

Spatial projections

- Not all forests are equally threatened
- And biodiversity and forest carbon stocks vary spatially

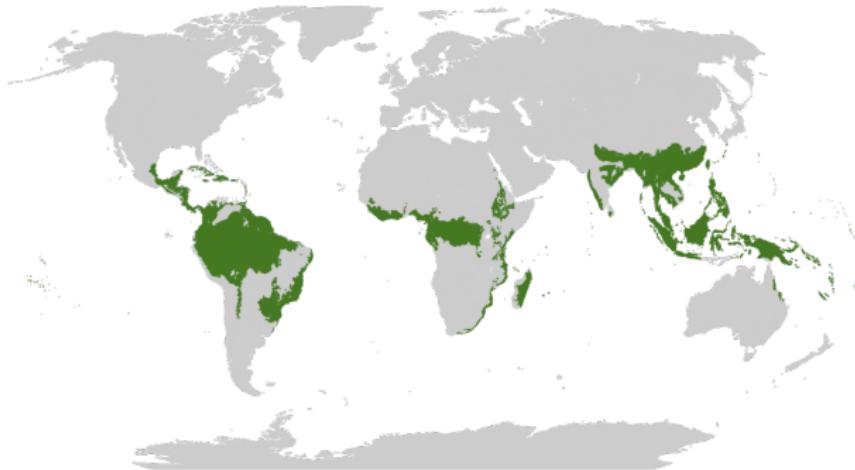


Aboveground biomass in Democratic Republic of the Congo

What are the consequences of long term deforestation for biodiversity and CO₂ emissions ?

Objectives

- Modelling the deforestation process spatially
- Deriving high-resolution maps of the spatial probability of deforestation
- Projecting forest cover change until 2050 under a business-as-usual scenario
- At the pantropical scale



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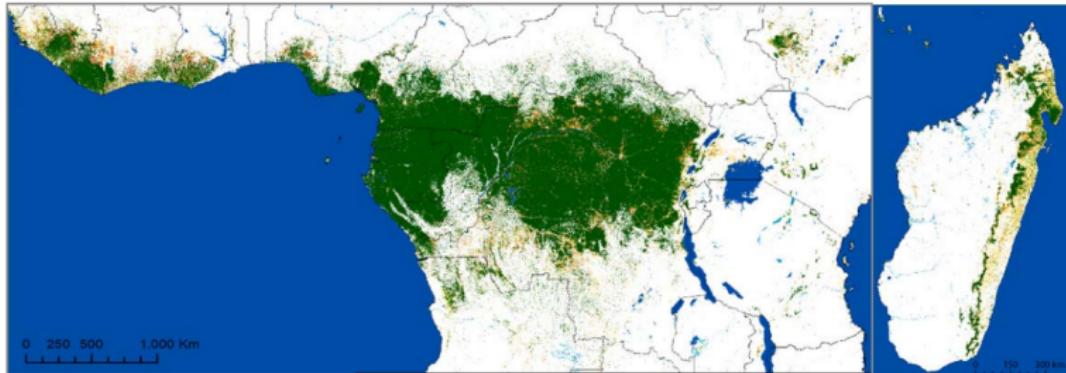
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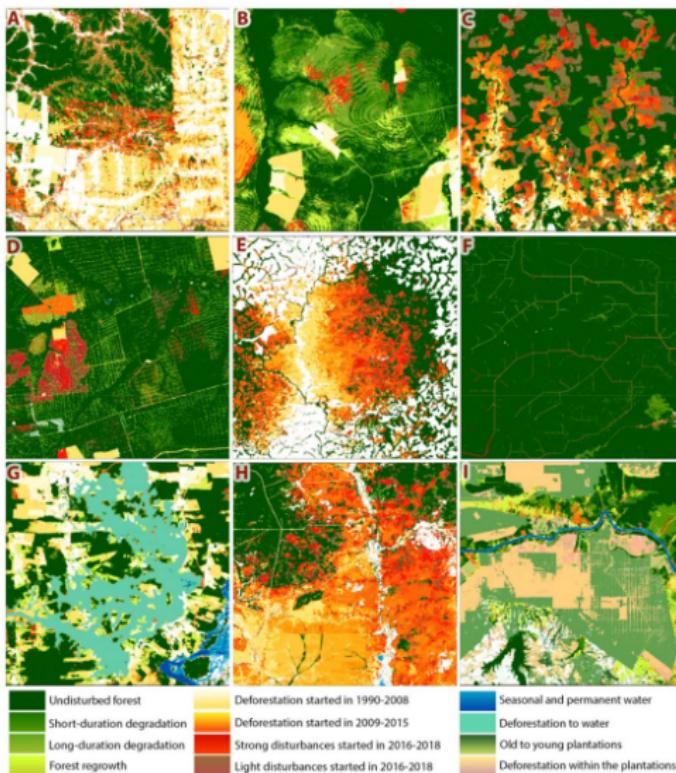
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Historical deforestation

- Wall-to-wall map of **tropical moist forest cover change** at 30 m resolution from 1990 to 2018
- Using the 37-years full Landsat satellite archive and Google Earth Engine
- Time-series analysis at the pixel scale using a complex decision tree based on expert knowledge



Historical deforestation



Historical deforestation

- **Vancutsem Ch., F. Achard , J.-F. Pekel , G. Vieilledent, S. Carboni , D. Simonetti , J. Gallego.** Long-term monitoring of the tropical moist forests dynamics reveals unprecedented deforestation rates. Submitted to *Nature Communications*.
- Hansen et al. 2013 : underestimated deforestation rates in Africa (small scale mosaic deforestation)
- Response variable : deforestation on 2005-2015

Explicative variables

- Variable types : **landscape, accessibility, protection status**

Product	Source	Variable derived	Unit	Resolution (m)
Deforestation maps (2005-2015)	Vancutsem et al. (1)	forest/non-forest	—	30
		distance to forest edge	m	30
		distance to previous deforestation	m	30
Digital Elevation Model	SRTM v4.1 CSI-CIAR (2)	altitude	m	90
Highways	OSM - Geofabrik (3)	slope	°	90
Places		distance to roads	m	150
Waterways	WDPA (4)	distance to towns	m	150
Protected areas		distance to river	m	150
		presence of protected area	—	30

- (1) Vancutsem et al., (2) <http://srtm.csi.cgiar.org>,
(3) <http://www.geofabrik.de>, (4) <http://protectedplanet.net>

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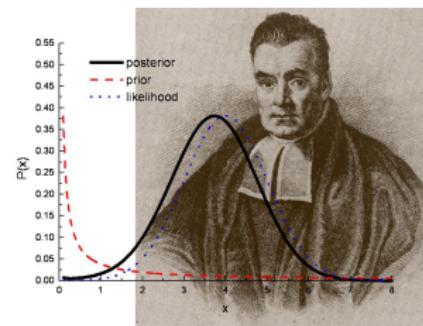
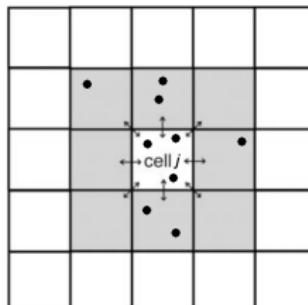


European
Commission



Statistical model

- $Y_{ij} \in \{0, 1\} \sim \text{Bernoulli}(\theta_{ij})$
- $\text{logit}(\theta_{ij}) = X_i \beta + \rho_j$
- Autocorrelated spatial random effects ρ_j (10 km) to account for **unmeasured** or **unmeasurable** factors : population density, soil type, geographical barriers, law enforcement locally
- Structure spatially the **residual variability** that is not explained by the model's variables
- Hierarchical Bayesian framework



Statistical model

- One model per country
- 40,000 sample points (balanced sampling deforested/non-deforested areas)
- Variable selection (statistical significance + process coherence)

Software

The screenshot shows the GitHub repository page for 'forestatrisk'. The repository has 257 commits, 1 branch, 1 release, 1 environment, 1 contributor, and is licensed under GPL-3.0. The last commit was made 7 days ago. The repository has 8 issues, 0 pull requests, 0 projects, and a wiki.

forestatrisk' Python package to model and forecast tropical deforestation

Code Issues 8 Pull requests 0 Projects 0 Wiki Security Insights Settings

257 commits 1 branch 1 release 1 environment 1 contributor GPL-3.0

Branch: master New pull request Create new file Upload files Find File Clone or download

ghislainv	New tuto	Latest commit cd54275 7 days ago
C	Update	last month
docs	New tuto	7 days ago
forestatrisk	urllib for Python3	last month

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

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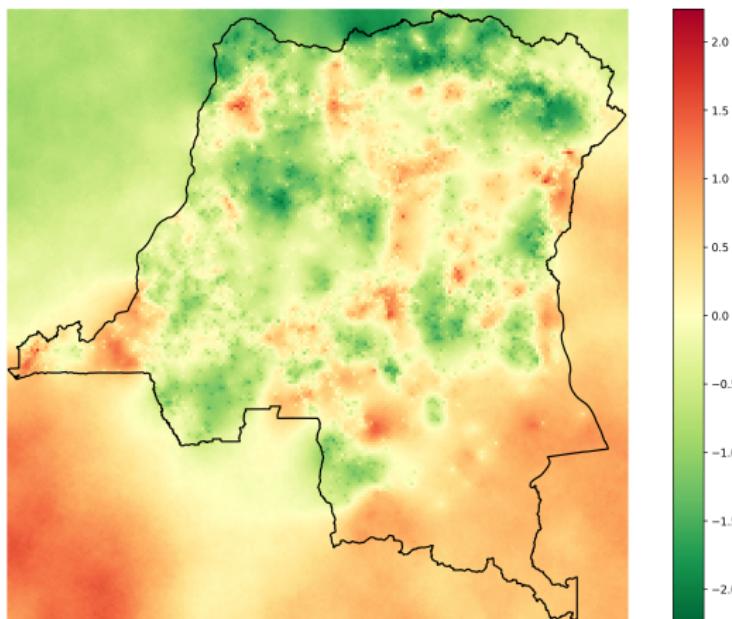
Parameters

Parameter values : β and variance V_p of the spatial random effects.

Binomial logistic regression with iCAR process				
Model: I(1 - fcc23) + trial ~ 1 + C(pa) + scale(slope) + scale(dist_defor) + scale(dist_edge) + scale(dist_road) + scale(dist_town) + scale(dist_river) + cell				
Posterior:				
	Mean	Std	CI_low	CI_high
Intercept	-4.64	0.155	-4.92	-4.37
C(pa)[T.1.0]	-0.206	0.101	-0.402	-0.00777
scale(slope)	-0.0505	0.028	-0.113	0.00411
scale(dist_defor)	-5.64	0.304	-6.21	-5.08
scale(dist_edge)	-7.19	0.315	-7.76	-6.54
scale(dist_road)	-0.22	0.0416	-0.303	-0.14
scale(dist_town)	-0.171	0.042	-0.258	-0.0922
scale(dist_river)	-0.0664	0.0311	-0.124	0.00367
Vrho	2.7	0.304	2.32	3.39
Deviance	1.25e+04	89.6	1.23e+04	1.27e+04

- Set of parameters for each country.
- Each effect can be easily interpreted.
- Effects can be compared between countries (efficiency of the protected areas, effect of road infrastructures).

Spatial random effects



Then interpolated at 1km.

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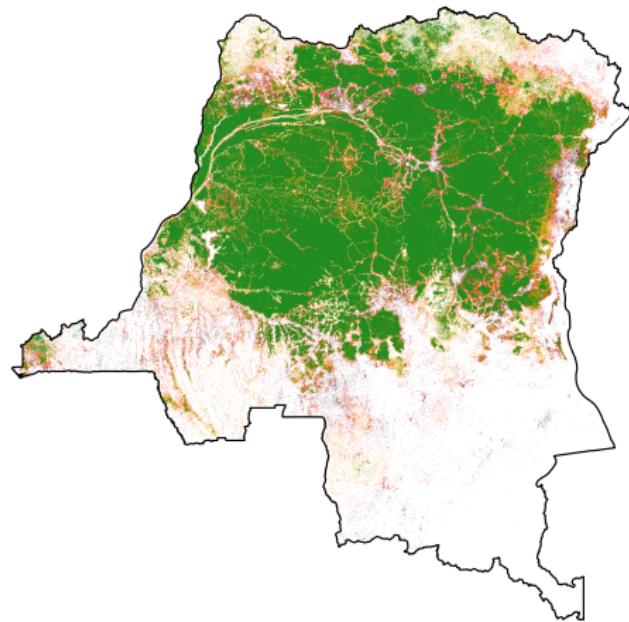
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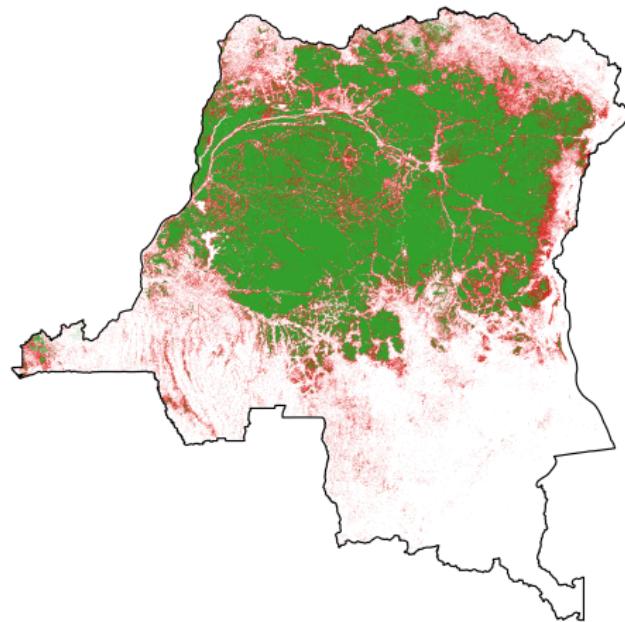
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Spatial probability of deforestation



Future forest cover



Projected forest cover change in **2015-2050** under a business-as-usual scenario.

BAU : historical deforestation (ha/yr) observed on **2005-2015**.

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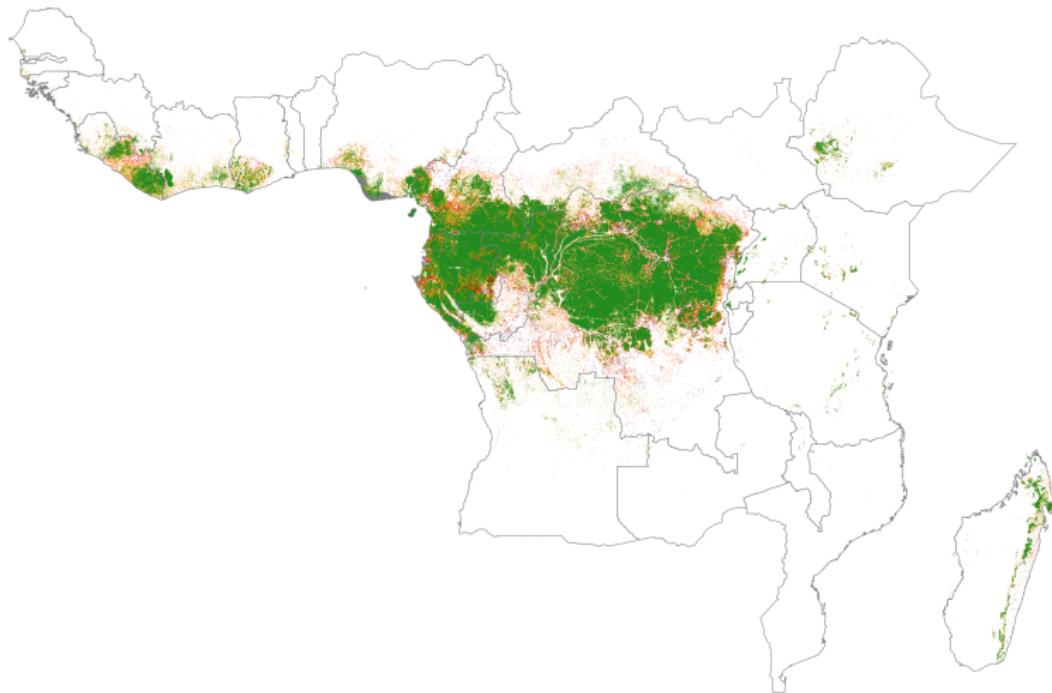
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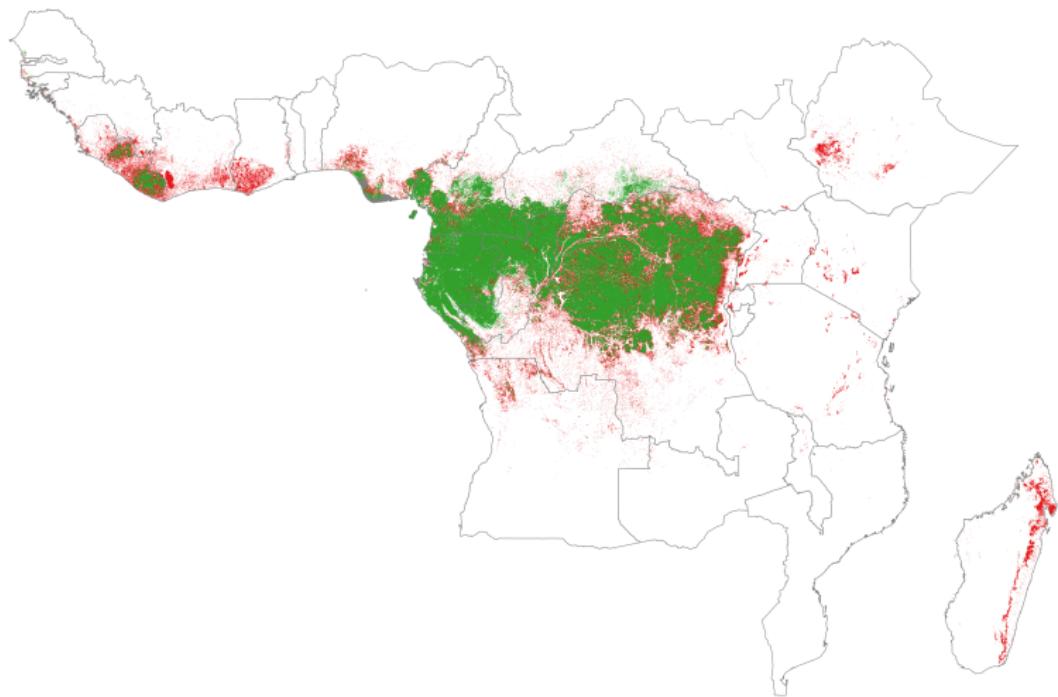
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African continent



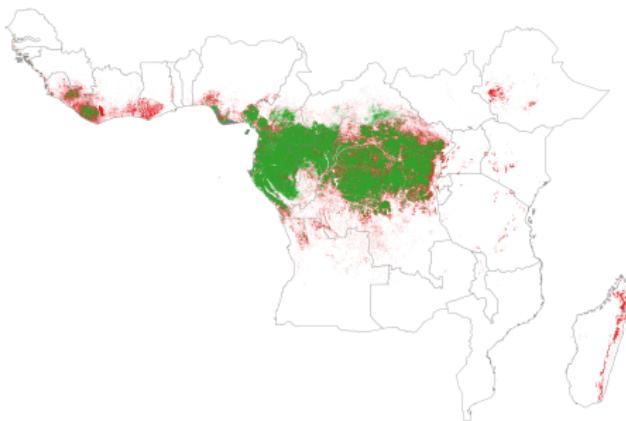
Spatial probability of deforestation.

African continent



Forest cover change in **2015-2050**, BAU scenario **2005-2015**.

African continent



- **No more moist forests in 2050** : West-African countries except Liberia, East-African countries including Madagascar
- **Remaining forest block** : Congo, Gabon, Equatorial-Guinea, Cameroon
- **Highly fragmented forest** : Democratic Republic of the Congo
- **Two blocks of forest on both sides of the Congo River**

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Historical forest cover change

- Forest cover change 2000-2010-2019
- Map : <https://forestatrisk.cirad.fr/newcal>
- Forest cover AND annual deforestation



Comparison

Forest cover :

- FAO statistics (825,000 ha)
- CORIFOR : Digitized map at 1/3000 from 2008 aerial photos

Deforestation :

- FAO statistics (0 ha/yr)
- OEIL : fires, in 2017 24,145 ha, 1/3 in forest

Causes of deforestation

- Effects of mines and ultramafic soils
- Deforestation causes : mines vs. fires

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Fragmentation

- Fragmentation : past, future
- Distance to forest edge
- Amount of forest habitat in the neighborhood

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Forest gain

- Forest regeneration



... Thank you for your attention ...
<https://ecology.ghislainv.fr/presentations>
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