Spatial forecasting of tropical moist forest cover change over the 21 century

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# Abstract

Tropical forests are disappearing at an alarming rate because of human activities. Here we modelled spatially the anthropogenic deforestation process in 119 tropical territories (92 countries) including all the humid tropical forests in the world. We demonstrated the effectiveness of protected areas at deplacing deforestation and the negative impact of road infrastructures on forest conservation globally. We derived high resolution global maps of the deforestation risk and likely future forest cover for the 21 century under a “business-as-usual” scenario. If large areas of tropical forest will still remain in 2100 at the heart of the Amazon, in the Congo Basin, and in New-Guinea, many countries will entirely lose their tropical forests before the end of the 21 century. Remaining forests will be strongly fragmented and located in remote places.

**Keywords:** deforestation, forecasts, forest cover change, forest refuge areas, moist tropical forests, spatial modelling, scenarios.

**One sentence summary:** Tropical moist forests will still exist at the end of the 21 century, but not everywhere in the tropics.

# Introduction

Tropical forests are the “Jewels of the Earth”. They shelter 30 million species of plants and animals representing half of the Earth’s wildlife and at least two-thirds of its plant species (Gibson *et al.* [2011](#ref-Gibson2011); Wilson *et al.* [2012](#ref-Wilson2012)). They also play an important role in the global carbon cycle, and at regulating the global climate (Bonan [2008](#ref-Bonan2008); Pan *et al.* [2011](#ref-Pan2011); Baccini *et al.* [2017](#ref-Baccini2017)). At the local scale, they regulate the regional climate (Dickinson & Kennedy [1992](#ref-Dickinson1992)), cooling the atmosphere (Ellison *et al.* [2017](#ref-Ellison2017); De Frenne *et al.* [2019](#ref-DeFrenne2019)), and facilitating access to water (Ellison *et al.* [2017](#ref-Ellison2017)). They also provide protection against erosion and flooding (Bradshaw *et al.* [2007](#ref-Bradshaw2007)). Close to 1.6 billion people (a quarter of the world’s population) rely on forest resources for their livelihoods (FAO [2015](#ref-FAO2015)). Despite the many ecosystem services they provide, tropical forests are disappearing at an alarming rate (Hansen *et al.* [2013](#ref-Hansen2013); Achard *et al.* [2014](#ref-Achard2014); Keenan *et al.* [2015](#ref-Keenan2015); Vancutsem *et al.* [2020](#ref-Vancutsem2020)), mostly because of human activites (Geist & Lambin [2001](#ref-Geist2001); Curtis *et al.* [2018](#ref-Curtis2018)). Currently, around 8 Mha (twice the size of Switzerland) of tropical forest are disappearing each year (FAO [2015](#ref-FAO2015)). At this rate, will there still be tropical forests in 2100 and where will they be concentrated?

Statistical modelling of deforestation can help understand better the deforestation process, identifying the main drivers of deforestation and quantifying their relative effects. Regarding roads, modelling deforestation can help assess the impact of roads on the risk of deforestation and anticipate the changes in forest-cover associated to the potential development of road infrastructure.

Spatial forecast of tropical deforestation and inform policy makers on what’s going to happen if they do nothing versus what is likely to happen in response to decisions.

In this study, we present the first attempt to model and forecast tropical deforestation globally using high resolution data.

# Spatial model of deforestation

* Some methodological information

# Effectiveness of protected areas

# Road’s impact on deforestation

# Remaining forests in 2100

* Countries having lost their forest
* Residual fragmented forest
* Intact forest blocks

# Impact on ecosystem services

* Impact on carbon emissions
* Biodiversity loss (map of biodiversity)
* Risk of zoonose and pandemy associated to deforestation

# Priority areas for conservation

* Refuge areas
* Impact on policies
* Various scenarios: map of probability can be used with different scenarios regarding deforestation intensity.

# Scenarios of deforestation

* Alternatives to “business-as-usual” scenarios of deforestation
* Which mean do we consider 2000–2010 or 2010–2020 or mean?
* No need to take into account diffusion of deforestation between countries and continents before 2100 (see linear change of perc with time per continent)

# Importance of assessing tropical forest resilience to climate change

(Vieilledent *et al.* [2016](#ref-Vieilledent2016); Esquivel-Muelbert *et al.* [2018](#ref-Esquivel-Muelbert2018); Zellweger *et al.* [2020](#ref-Zellweger2020))

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# Tables

# Figures

## Relative spatial probability of deforestation

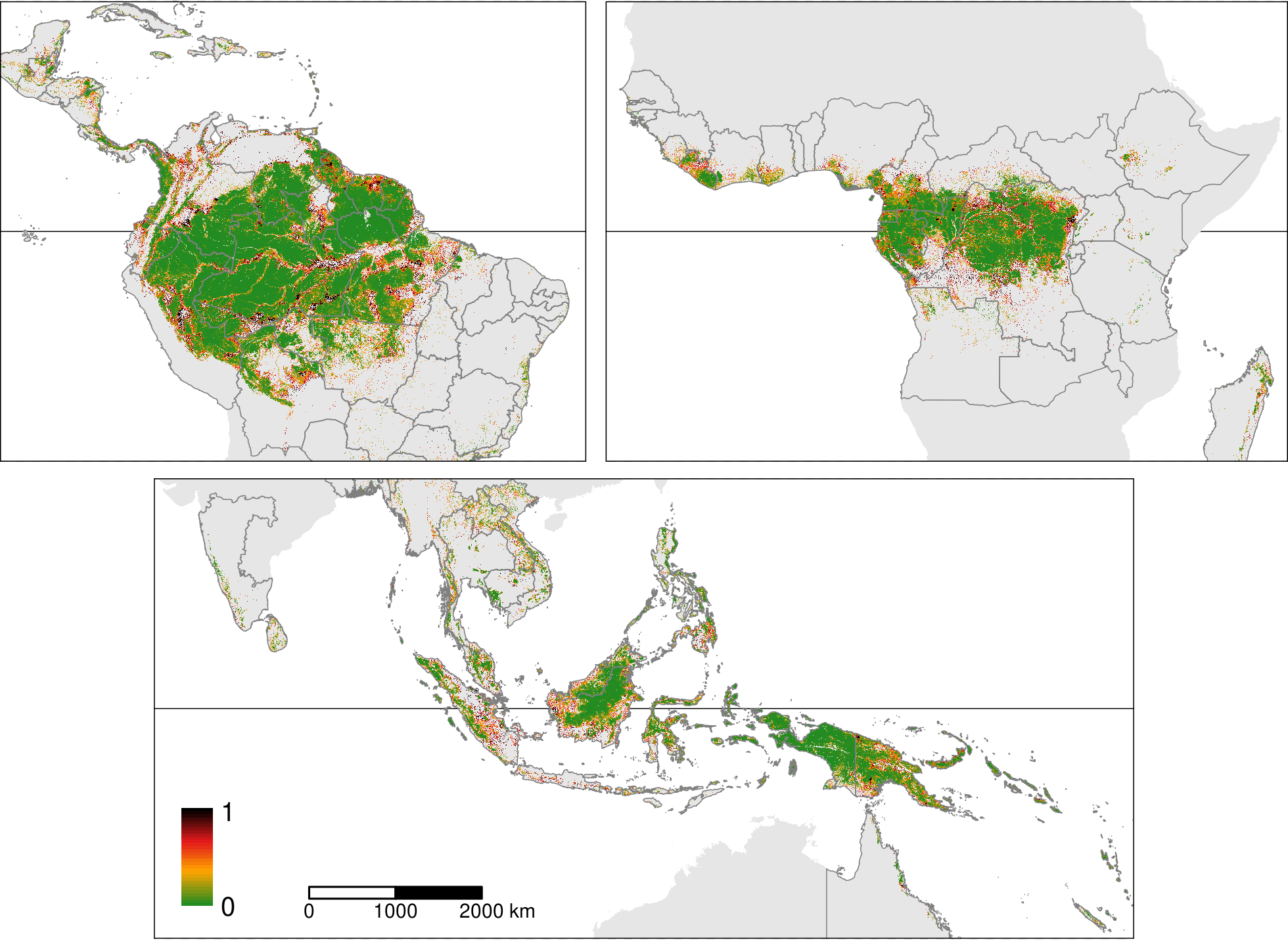


Figure 1: **Predicted relative spatial probability of deforestation**. Map of the spatial probability of deforestation computed for each forest pixel in 2020. On the map, we clearly see the effect of the distance to nearest town, road, and river, and the effect of the distance to forest edge on the spatial probability of deforestation.

## Projected forest cover change

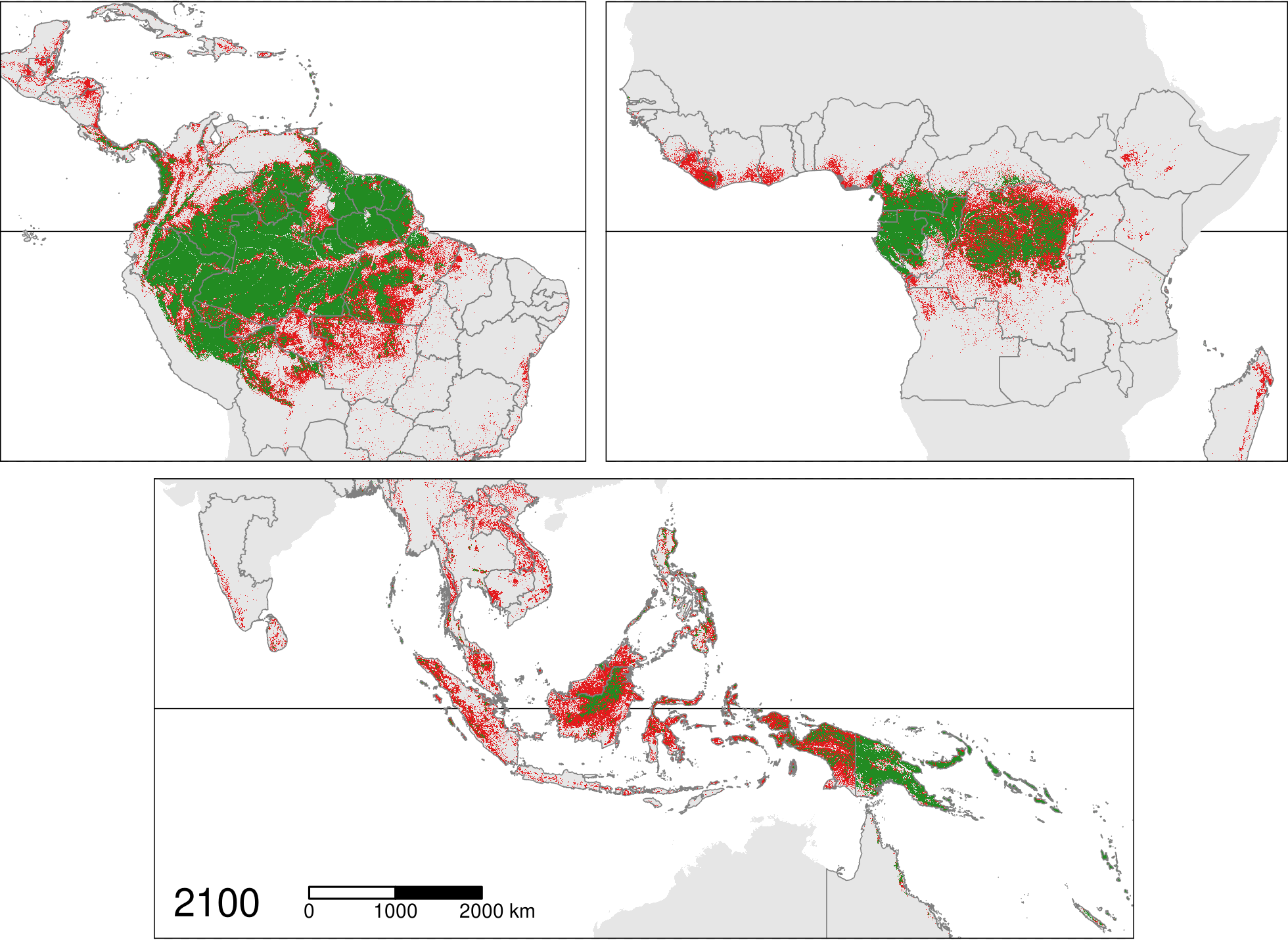


Figure 2: **Projected forest cover change**. Maps of the projected forest cover change (2020–2100). : projected deforestation, : remaining forest cover. Besides the loss of forest cover, we show a progressive fragmentation of the forest in the future, with an increasing number of forest patchs of smaller size.

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