Cease and Disperse: The effect of Indonesia's moratorium on the spatial distribution of deforestation

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Introduction

Deforestation accounts for roughly 15% of global carbon emission each year. The current rate of deforestation is almost certainly above the socially optimal rate, as there are many environmental services that are not incorporated into the private cost of clearing. The release of stored carbon is perhaps the most apparent externality imposed by clearing forest. Another set of services that are disregarded by individual landowners is tied to the spatial distribution of standing forest. Forest landscapes are becoming increasingly fragmented, threatening ecosystem reslience and biodiversity. Contiguous forests that foster ranging mammals and birds are broken up for the relatively homogenous agricultural plots. The goods and services provided by biodiversity are invaluable, and often overlooked. In the frenzy to curb the overall deforestation *rate*, the spatial distribution may be suffering. This paper does not present an argument on the relative value of ecosystem services for habitat destruction versus fragmentation, only that there may be unintended consequences of an overall prohibition of new clearing.

This paper examines the effect of Indonesia's 2011 moratorium on new deforestation on the spatial dispersion of clearing activity. Specifically, it examines the choice of landowners to expand on previously cleared clusters or to move to new, untouched areas. We find that the moratorium with weak enforcement scattered deforestation, disproportionately increasing the creation rate of new clusters in Kalimantan, the Indonesian side of the island of Borneo. We also examine the character of those clusters over time, how the physical attributes of new clusters change, potentially indicating a push toward more marginal land.

The first section describes the socio-political context for the moratorium. The second section introduces a simple, dynamic programming model that illustrates the choice to clear new forests. The third section compares the rates of cluster formation in Indonesia and Malaysia, proposing that the observed difference indicates a dispersion effect in Indonesia. The final section offers analysis and limits of inference.

Background

In May 2010, Indonesia announced a moratorium on new deforestation, with an array of caveats. Industry has used the uncertainty in land use maps to find loopholes in the moratorium and the rate of deforestation has fallen only slightly [insert citation, time series graph]. Norway offered US$1 billion in aid contingent on a demonstrated reduction in the deforestation rate.

Model

Let A_i be the amount of the forested land in pixel i, and let a_{it} indicate the proportion of the land that has been cleared by time t. The profit $\pi(a_i) = r(a_i) - c(a_i)$, where $r''(a_i) < 0$ and $c''(a_i) = 0$. We assume a relatively high fixed cost of clearing, so that $c(a_i) = F + \gamma a_i$ with γ constant in land cleared. Consider two separate plots such that $i \in \{1, 2\}$. The probability of getting caught δ_i and immediately paying a fine is an increasing function of a_i, but a decreasing function of the size of the other plot. The rationale is that more condensed clearing is more likely to raise alarms with enforcement agents; and clearing activity in another pixel will divert attention. We want to study the decision point at which the agent decides to begin clearing in the new plot, and how that varies with the increased overall probability of paying a fine (the moratorium).

$$V(A) = \max_a \{\pi(A-a) + \beta \mathbb{E}[V(a)]\},$$

where we assume that, if caught, the land is taken from the landowner, such that $\mathbb{E}(x) = \delta x$. The δ parameter is plot-specific, and

$$\frac{\partial \delta_1(a_1, a_2)}{\partial a_1} < 0 \quad \text{and} \quad \frac{\partial \delta_1(a_1, a_2)}{\partial a_2} > 0,$$

which implies that the larger the proportion cleared within a plot (the more densely clustered), the greater the risk of expropriation by the government. It's more noticeable. Likewise, given the scarce resources and constant costs of enforcement, the likelihood of getting caught decreases in the size of *another* cluster. The clustering in another plot acts as a diversion, of sorts, and reduces the likelihood of enforcement agents noticing other activity.
The individual firm takes price $p(t)$ as given and, for $i \in \{1, 2\}$ attempts to

$$\max \int_0^T [p(t)q_i(t) - c(R(t))q_i(t)]\, e^{-rt}\, dt \tag{1}$$

The total reserves $R(t) = R_1(t) + R_2(t)$.

Empirical strategy

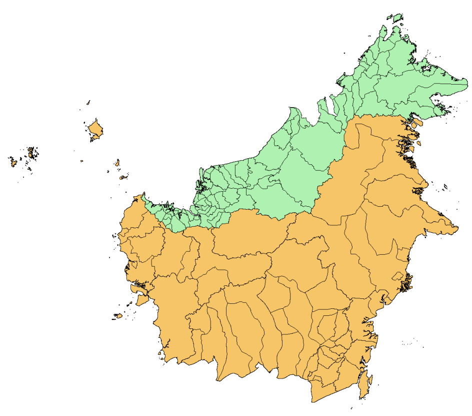
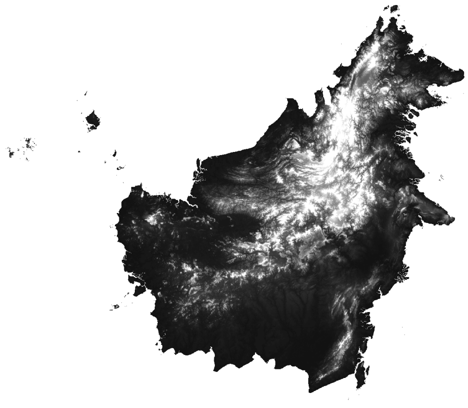


Figure 1: Sample area, Malaysia in green and Indonesia in orange. Borders indicate subprovinces.

Results

Discussion

Policy acts on people with incentives, not on inanimate objects. You cannot simply legislate a reduction of deforestation. The paper indicates that there is some *leakage* associated with local (not just in space like a protected area, but in scope of policy) conservation policy. This paper suggests that measures should be taken to dampen the incentives of both plots, reduce the incentive to clear at all. Maybe that would push people to the black market, though, just as deforestation was pushed to new areas in this study. The scope is not wide enough. This also offers an argument for an overhead and comprehensive monitoring system.



(a) Elevation

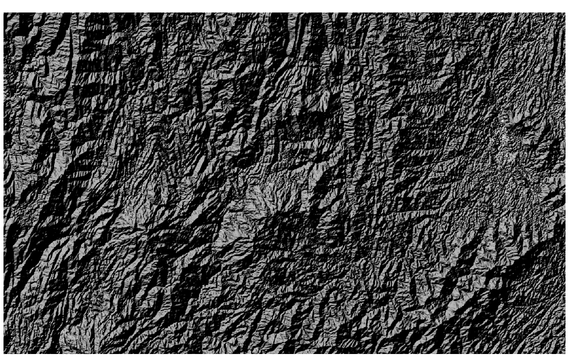
(b) Slope

(c) Flow

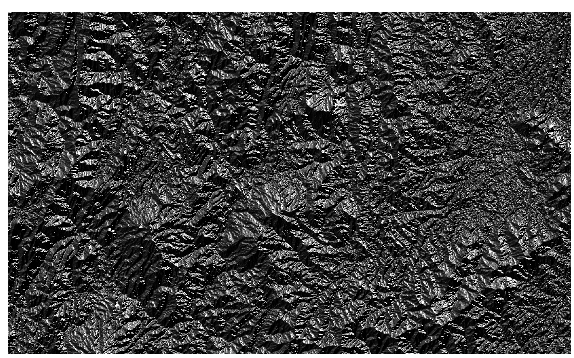
(d) Aspect

(e) Drop

Figure 2: Map of the digital elevation model (left) with derived data sets (right) indicating slope, hydrology, and terrain roughness, 90m resolution.



(a) Hillshade



(b) Flow direction

Figure 3: Detailed images of two derived data sets for the same area.

	Model 1
(Intercept)	44.23^{***}
	(6.39)
pd	0.05
	(0.20)
cid	50.84^{***}
	(9.04)
mora	-2.67
	(20.73)
pd:cid	-0.47
	(0.29)
pd:mora	0.10
	(0.32)
cid:mora	-139.65^{***}
	(29.31)
pd:cid:mora	1.85^{***}
	(0.45)
R^2	0.40
Adj. R^2	0.38
Num. obs.	202

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 1: Statistical models