Cease and Disperse: The spatial distribution of deforestation in response to Indonesia's moratorium

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Introduction

There is an urgent need for reliable and open information on deforestation. The dialogue on forest resources between government, industry, and environmental advocates is consistently characterized by defensive positioning, rather than productive collaboration. Much of the dissonance is a result of disparate and often conflicting data sources; each side claiming foul play in the reporting or monitoring of clearing activity. In the meantime, the deforestation rate is excessively high and accelerating: almost 15% of annual greenhouse gas emissions can be attributed to forest clearing activity. In addition, forest landscapes are becoming increasingly fragmented, threatening ecosystem reslience and biodiversity. Without viable oversight and enforcement, the rate and spatial distribution of deforestation will continue to be socially suboptimal. A *necessary*, though far from sufficient, condition for informed conservation policy is a common platform of information on forest clearing activity.

To date, a reliable monitoring system has not existed. Enforcement costs are relatively high.

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. Specifically,

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

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).

$$\max \int_0^T \left[pq(t) - c_1(R(t))q(t) - c_2(w(t))\right] e^{-rt} \, dt \tag{1}$$

Empirical strategy

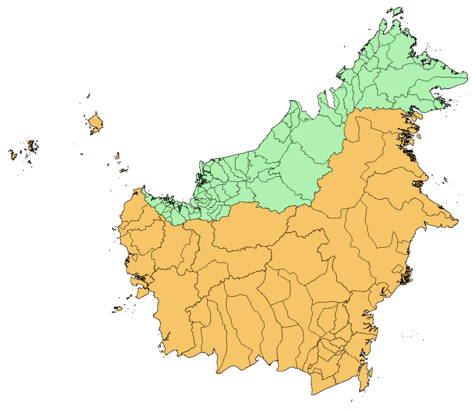
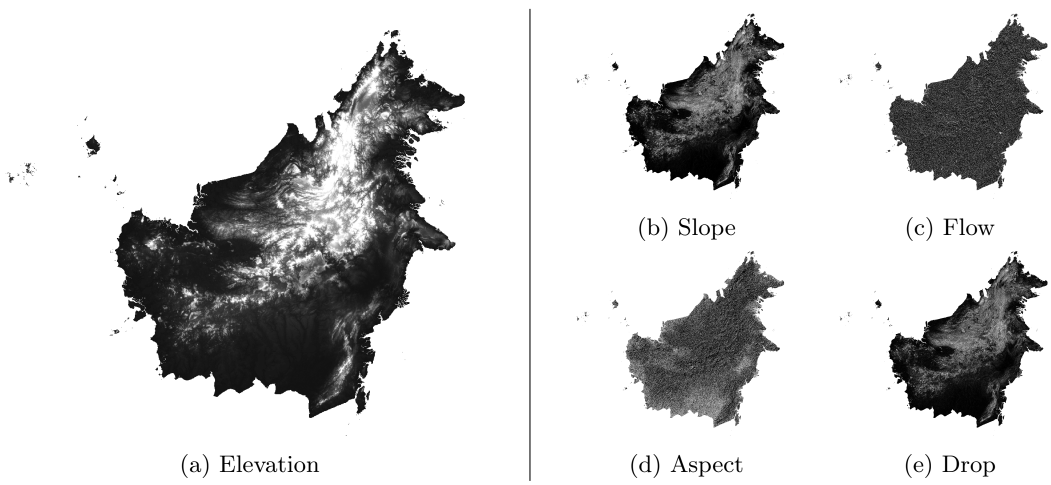


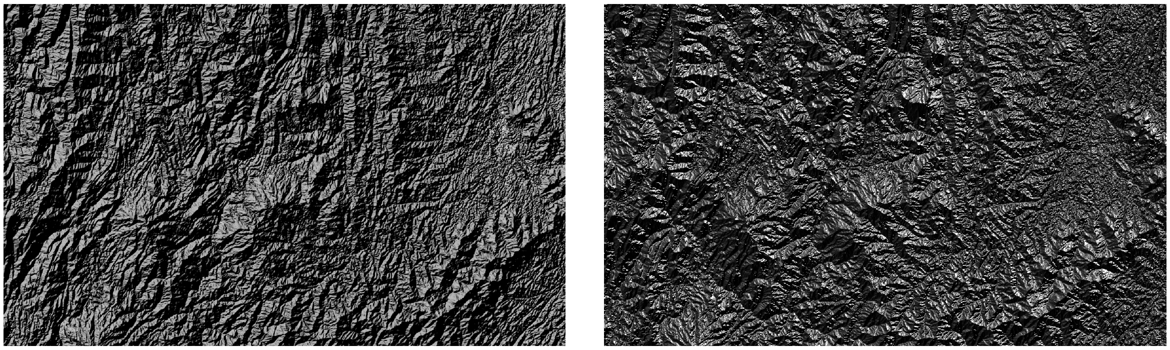
Figure 1: Sample area, Malaysia in green and Indonesia in orange. Borders indicate subprovinces.



(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.

Results



(a) Hillshade

(b) Flow direction

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

	Model 1
(Intercept)	5.48^{*}
	(2.88)
pd	0.00
	(0.04)
cid	13.50^{***}
	(4.07)
mora	2.80
	(6.88)
pd:cid	-0.10^{*}
	(0.05)
pd:mora	-0.02
	(0.06)
cid:mora	-37.27^{***}
	(9.73)
pd:cid:mora	0.33^{***}
	(0.09)
R^2	0.35
Adj. R^2	0.33
Num. obs.	202

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

Table 1: Statistical models