Coasian Motion: Deforestation and the Central Tendency to Disperse

Dan Hammer, Robin Kraft, David Wheeler

January 23, 2013

Introduction

Deforestation and forest degradation account for 12% of annual carbon emissions, as much as the global transporation sector. An emissions source of this magnitude must be addressed in order to avert severe climate change. International efforts to curb the rate of deforestation have thus far been a series of bilateral agreements, mostly centered around Brazil and Indonesia, the two largest contributors to global deforestation. In 2007, the two countries accounted for approximately 40% of global deforestation. However, as international attention continues to focus on Brazil and Indonesia, forest clearing activity has become more disperesed, especially around the periphery of these regional hotspots. In this paper, we report the broad geographic trends in deforestation, using an original data set on forest clearing activity from satellite imagery. We highlight the increased dispersion of clearing activity and discuss the likely implications for global conservation efforts.

Data

We rely on bimonthly data from the Forest Monitoring for Action (FORMA) system, which is the basis for the Global Forest Watch initiative through the World Resources Institute. The FORMA system reports the likelihood of forest clearing activity at 16-day intervals for each 500-meter, forested pixel in the humid tropics. The output data set is derived from the time series analysis of remotely sensed data, primarily from the Moderate Resolution Image Spectroradiometer (MODIS) sensor aboard NASA's Terra satellite. We collect attributes from the time series on a number of spectral data, including the derived Normalized Difference Vegetation Index (NDVI) that reports reflected green and infrared

Definition of dispersion

The pixel-level alerts are primed for aggregation into political units. The uncertainty in the clearing alerts is, in fact, mitigated by aggregation if we assume that measurement error is independent and identically distributed, which is not beyond the realm of possibility. Let p_{it} indicate the probability of forest clearing activity between February 2000 through the interval indexed by t. Let C_j be a collection of pixel indices within the administrative unit j. Let D_{jt} be the aggregated and scaled probabilities of clearing for administrative unit C_j, such that

$$D_{jt} = \sum_{i \in C_j} \mathbb{I}(p_{it} \geq 0.5) \cdot p_{it} \tag{1}$$

We use the Shannon Entropy measure to report the level of dispersion across the n administrative units. For each t, we calculate the entropy:

$$E_t = -\sum_{j=1}^{n} \tilde{D}_{jt} \log_2 \tilde{D}_{jt}, \tag{2}$$

where $\tilde{D}_{jt}$ is the proportion of clearing signal in administrative unit $j \in 1, 2, \ldots, n$ through period t.

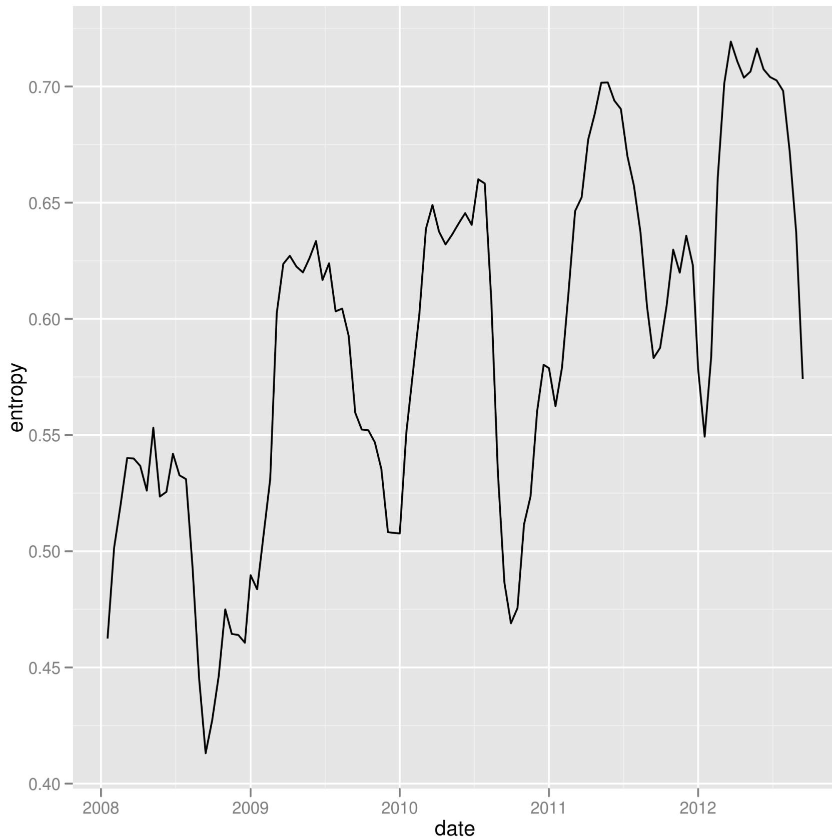

Figure 1: Normalized entropy at the country level between Dec 2005 and Sept 2012.

Geographic dispersion

Country

TODO: why seasonal?

Province level

Regional highlights

Implications for conservation

Conservation negotiations rely on a series of joint arrangements. Each arrangement takes a significant amount of time to specify. Even if the number of relevant players in the negotiation rises linearly, the number of joint arrangements will rise exponentially. The complexity and barriers to a common conservation agreement increase exponentially as tropical deforestation becomes more dispersed. The basis for this observation is founded in both operations research and contract theory [find citations].

Conclusion

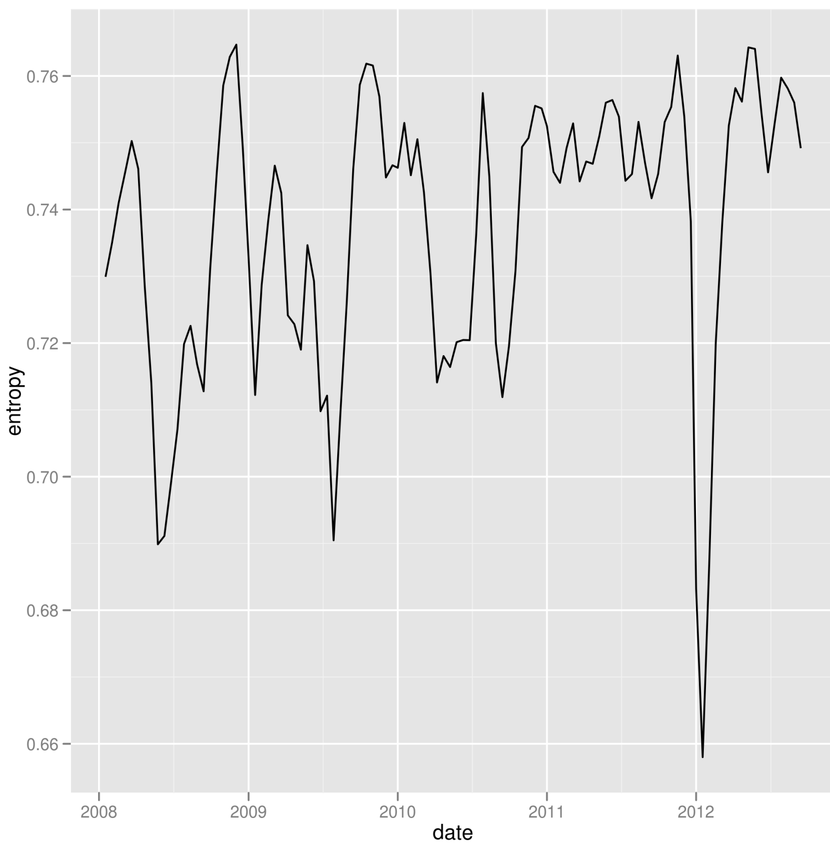

Figure 2: Normalized entropy at the country level between Dec 2005 and Sept 2012.