TITLE:

Enforcement evasion highlights need for independent satellite monitoring for forest governance

RUNNING TITLE:

Forest monitoring and enforcement evasion

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Abstract:

Our recent article, "Are Brazil's Deforesters Avoiding Detection?" demonstrated that focusing illegal deforestation enforcement on the subset of forest monitored by the flagship PRODES system has caused PRODES to capture a declining share of deforestation in the Brazilian Amazon. Deforesters may be purposively seeking out forests not monitored for enforcement. Addressing the problem would help Brazil maintain a cutting-edge forest governance model worthy of transfer to other nations. The two commentaries questioned our decision to investigate solely PRODES and not additional government monitoring systems. We focused on PRODES because it is the most salient deforestation monitoring system. Other key deforestation monitoring systems are all either limited to the same monitoring footprint as PRODES, not used for enforcement, or are rarely used for measuring forest loss in the Brazilian Amazon. We do agree with the commentaries that Brazil's new satellite monitoring protocol for greenhouse gas emissions estimation is critical progress of the type we were advocating in our original article.

Enforcement evasion highlights need for better satellite monitoring for forest governance

Brazil has earned praise for reducing the PRODES deforestation rate in the Amazon Biome. However, we (Richards, Arima, VanWey, Cohn, & Bhattarai, 2016) demonstrated that two systems monitoring more of the region's forests do not mirror the PRODES rate reduction. A recent study corroborated our finding, estimating a similar amount of cryptic-to-PRODES forest disturbance using a wholly distinct approach (Barlow et al., 2016).

We suspect that awareness that enforcement primarily targets forests monitored by PRODES prompts enforcement evasion via forest degradation and deforestation of forests that PRODES does not monitor. The commentaries (Rajão et al; Bustamante et al.) found our methods "useful," but questioned our findings because we focused on solely PRODES and not other government satellite forest monitoring systems deployed in Brazil.

However, these systems all either monitor the same forest subset as PRODES, aren't used for enforcement, or aren't publicly known (Table 1). Many monitoring systems are not used for enforcement (INPE, 2015; INPE & Embrapa, 2011) and therefore have no bearing on our enforcement evasion argument. With one possible exception[1], those that are used for enforcement monitor no greater a subset of Amazon forest than PRODES (Diniz et al., 2015; INPE, 2008). The one exception had never been publicly referenced prior to the Bustamante et al. comment and thus may not trigger (much) enforcement evasion.

We also justify our PRODES focus by the continued unrivaled, but unwarranted salience of its deforestation rate. It: was the basis for Norway's billion dollar deforestation performance payment to Brazil, is annual announced to widespread international publicity, and is oft-used to characterize Brazil as a model for successful forest governance (Nepstad et al., 2014). Official deforestation rates

must be reasonably certain, more coverage may reduce certainty, and some forest disturbance will always be cryptic to satellites (Bustamante et al., 2016). But technological advances now allow for more comprehensive deforestation monitoring than PRODES. Dividing forest disturbance into PRODES-monitored vs cryptic to PRODES is antiquated and incomplete. Moreover, enforcement evasion would prevent straightforward time series analysis of the PRODES deforestation rate.

We do join the commentaries in heralding improvements to the comprehensiveness of forest monitoring for terrestrial GHG accounting in Brazil. After publication of our article, Brazil adopted a policy mandating an approach (McT of Brazil, 2016) including degradation emissions and extending a PRODES-like deforestation monitoring approach to other biomes and over a larger subset of the forests of the Brazilian Amazon. The results, however, are not publicly available, the methods divulged are insufficient for replicability, and estimates are not annual (McT of Brazil, 2016). Thus the system is of limited use including for vital functions such as tracking the annual deforestation rate.

Maintaining the earth's forest cover is a wickedly difficult problem that Brazil may be the first nation to meaningfully tackle at scale. We do not intend to disparage the activities of the Brazilian government in facing the challenge. Brazil's commitment to multiple open and transparent deforestation monitoring systems is exemplary, vital for improved forest governance, and enabled our analysis itself.

Table 1.

Data Product	Coverage	Public	Enforcement	Deforestation	GHG

				Estimates	Accounting
PRODES	Primary Forest in Amazon Biome	X	X	X	
DETER	Same extent as PRODES	X	X		
DEGRAD	Same extent as PRODES	X	X		
DETER-B	Same extent as PRODES	X	X		
System X[1]	Same extent as PRODES, higher res		X		
TerraClass Amaz.	PRODES deforestation	X			
TerraClass Cerrado	Entire Cerrado Biome	X			
3rd National Com.	Brazil				X

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