## Law enforcement and economic incentives for conservation in the Brazilian Amazon: modeling spatial complementarities

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## Abstract

Annual forest loss in the Brazilian Amazon was down to less than 5 thousand square kilometers in 2012, from almost 30 thousand in 2004. Overwhelming empirical evidence suggests that changes in the Brazilian law enforcement practice and the related governance system account for a large share of the overall success in curbing deforestation rates. At the same time, Brazil's government is discussing and experimenting with alternative approaches to compensate farmers for conservation actions through economic incentives, such as payments for environmental services (PES), at various administrative levels. A mixed carrot and sticks approach to conserve the world's largest continuous tropical rainforest poses various challenges to policy design. First, the lion's share of historical deforestation has been illegal, i.e. full compensation of opportunity costs by incentive schemes could result in perverse incentives for traditionally compliant land users. Partial compensation, however, is likely to be ineffective if not reinforced by a complementary disincentive or regulatory threat. Second, both incentives and regulatory disincentives tend to become less effective wherever liability for illegal deforestation cannot readily be established on the basis of formal land use rights. Conflicting and poorly delimited tenure claims are still common in a large part of the region. In this paper we develop a spatially explicit model that simulates deforestation decisions in response to policy incentives and disincentives at the regional scale. The model builds on elements of optimal enforcement theory and introduces the notion of imperfect PES contract enforcement in the context of avoided deforestation. We implement the simulations using official deforestation statistics and data collected from field-based forest law enforcement operations in the Amazon region. We show that a large-scale integration of PES with the existing regulatory enforcement strategy involves a tradeoff between the overall efficiency and equity effects of the policy mix. Introducing PES as a complementary policy measure increases policy implementation costs, but tends to reduce welfare losses for those hit hardest by law enforcement. Yet, this tradeoff is heterogeneous in space and depends on spatially variable deforestation patterns and enforcement costs. Moreover, we find that enforcement effectiveness can become a key determinant of efficiency in the overall policy mix, depending on how conditionality of the PES component is imposed.