The opportunity costs of reducing carbon emissions in an Amazonian agro-industrial region: the Xingu headwaters

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Introduction

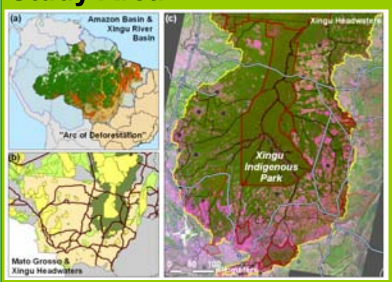
Tropical deforestation is the cause of 8 to 25% of world-wide, human-induced emissions of carbon to the atmosphere (Canadell et al. 2007). Despite this, the Kyoto Protocol provides no incentives for reducing deforestation (Schlamadinger et al 2007). In 2005, at the Montreal Conference of the Parties of the UN Framework Convention on Climate Change, a proposal was formally made to include deforestation in the post-2012 UNFCCC regime (Gullison et al. 2007). Negotiations of this important new component of climate change policy must be completed by December of 2009. One important challenge in developing the "Reductions in Emissions from Deforestation and forest Degradation" (REDD) regime is to determine the cost of deforestation reduction programs, and the possible flow of benefits to indigenous peoples (Griffiths 2007). In this paper, we present an analysis of the opportunity costs of reducing deforestation to zero in a large agroindustrial Amazon landscape with a large indigenous population.

Central Questions

How much would it cost to the soy and cattle industries, per ton of reduced carbon emission, to slow deforestation in this region?

What is the potential for the carbon market to provide incentives to stakeholders for forest conservation?

Study Area

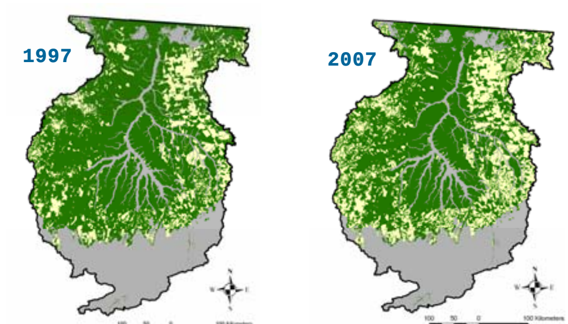


(a) The Amazon Basin region, showing areas of deforestation (red) within the Legal Amazon. The Xingu River basin is outlined in yellow; (b) The state of Mato Grosso (beige), with federal and state conservation areas (light green) and indigenous areas (yellow) and major federal and state roads (red) shown. The Xingu River headwaters region is shown in dark green; (c) The Xingu River headwaters region (~177,000 km^2), with indigenous lands and protected areas shown (red hatching). Indigenous territories cover approximately 42,200 km2 within the Xingu headwaters (24% of the total area). The Parque Indigena do Xingu (PIX) is the largest, with an area of 28,000 km2 (16% of the total area). The PIX is inhabited by approximately 4700 people (ca. 940 families), distributed among 14 different tribes (ISA 2007). (Land cover is shown for a 2007 Landsat 5 TM mosaic.) Private lands make up 50 % of total area of the Xingu headwaters region.

Methods & Results

Forest Cover Change, 1997 - 2007

Forest cover and deforestation in 1997 were calculated from a map developed by the Brazilian National Space Research Institute (INPE), which only identifies vegetation and clearing within the forest biome. To evaluate the current extent of deforestation in the region as a starting point for analyses of future policy options, we developed a land cover classification map for the year 2007 using image segmentation and object-oriented classification techniques on a 25m-resolution ALOS PALSAR image mosaic (116 scenes, June and July 2007) (J. Kellndorfer et al., unpublished data), a 30m-resolution (oversampled to 25 m) Landsat 5 ETM image mosaic (12 scenes, June to August 2007) (C. Stickler et al., unpublished data), and a 90m-resolution NASA Shuttle Radar Topography Mission (SRTM) digital elevation model (oversampled to 25 m). We distinguished 4 classes: (1) cleared areas; (2) vegetated forest areas; (3) wetlands; (4) open water (the latter two were later aggregated into a single "non-forest" class).



~25,000 km^2 deforested → ~43,000 km^2 deforested

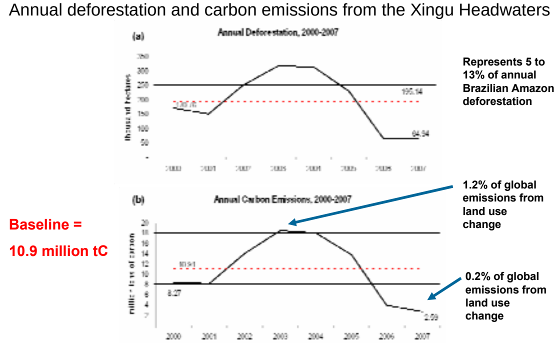
Annual Deforestation & Carbon Emissions, 2000 - 2007

Annual Deforestation: We estimated annual deforestation for 2000 to 2006 using maps developed by the Brazilian National Space Research Institute (INPE 2008). For deforestation between 2006 and 2007, we applied to our 2007 ALOS/Landsat-based classification a mask derived from the PRODES data to screen out areas classified as non-forest (including wetlands, *cerrado* woodlands, and other features) and as previously deforested.

Carbon Emissions: To estimate the annual deforestation-driven carbon emissions from 2000 to 2007, we used a map of aboveground forest biomass developed for the region using remotely sensed and field-based data from or before 2000 (Saatchi et al. 2007). We estimated carbon stocks as one half of biomass and assigned carbon values to each pixel of deforestation. For each year, we summed the tons of carbon emitted from the cleared areas using published estimates of the carbon content of the pastures and farm plots that replace forests following clearing (Houghton et al. 2000).

Historical Baseline: We estimated the historical baseline for deforestation and for carbon emissions by averaging annual deforestation and emissions, respectively, from 2000 to 2007.

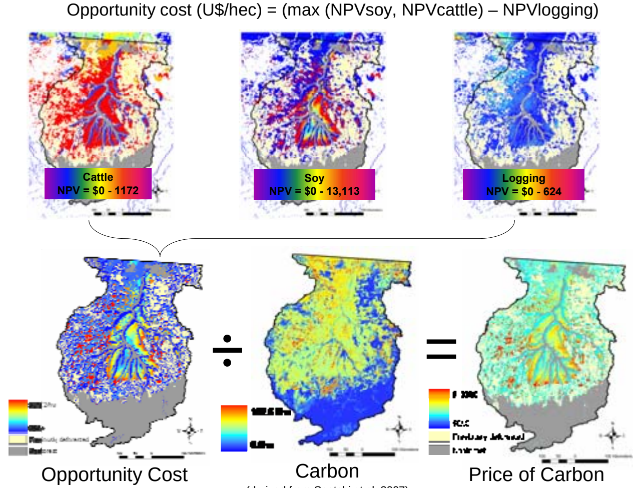
Annual deforestation and carbon emissions from the Xingu Headwaters



Estimate of opportunity cost

The opportunity cost of avoided deforestation was calculated using spatially-explicit rent models for soy production (Vera Diaz et al. 2007, Nepstad et al. 2007), cattle ranching (Merry et al., unpublished data), and sustainable timber harvest (Merry et al., submitted)—the three major economic activities in the region. These models estimate the potential rent of each economic activity based upon analyses of the costs of production, yields, and prices. For each of the three economic activities, the net present value was estimated for 30 years into the future assuming a 5% annual discount rate and a plausible schedule of highway paving (Soares et al.2006).

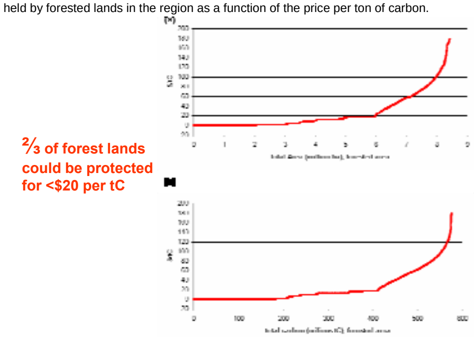
Opportunity cost (U$/hec) = (max (NPVsoy, NPVcattle) – NPVlogging)



Estimate of opportunity cost
The net present value of deforestation-dependent economic activities (soy production, cattle) for forested lands in the region ranged from $0 per ha to $2762 per ha. This translated to a price per ton of C of $0 to $180.

Cost of Reducing Emissions from Deforestation: carbon supply curves

We developed carbon supply curves to describe both the change in area of forest and the change in tons of carbon currently held by forested lands in the region as a function of the price per ton of carbon.



We estimate that approximately 71% of the forests in the region could be maintained for an opportunity cost of less than $20 per ton of carbon. This analysis suggests that the reduction of approximately eleven million tons of carbon emissions per year could be achieved through opportunity costs of $230M, or $23 per ton of carbon.

Over 5 years, ~ **55 million tons** of carbon emissions reductions could be achieved for a total opportunity cost of **$1.2 billion (~$22/tC)**

But… private landholders are not allowed to clear more than **20% of forests** in the forest biome or **65% of *cerrado*** savanna vegetation (Brazilian Forest Code)

Private Forest Stewardship Fund: Partial Compensation of Landholders

If maintenance of legally required forests compensated at rate of **50% of opportunity costs** as an incentive to keep forests standing, the 5-year cost of reducing deforestation to zero declines to **$600 million** and **$12 per ton** of reduced carbon emissions.

Forest Peoples' Fund: A Carbon-Based Subsidy for Indians

The indigenous tribes of the Xingu headwaters region have acted as forest guardians, defending forests from incursions by ranchers and soy farmers. If each indigenous family were provided with a "forest carbon subsidy" of one minimum salary ($2,400/yr) as compensation for this forest stewardship role, the 940 indigenous families would cost **$2,300,000 per year =>$0.06 per ton** of carbon emission reductions

Half Century of Carbon Payments

Given an historical baseline of deforestation of 1950 km2 per year, it would take nearly **50 years** to completely clear forests outside protected areas in the Xingu. Hence, payments for reduced emissions would have to continue for at least this long, providing a long-term stream of revenue for region which could be tied to ongoing success in maintaining forest carbon stocks

Conclusions

A REDD carbon market mechanism could reduce deforestation in the Xingu headwaters to nearly zero for less than $20 per ton of carbon in a flow of payments to private landholders and indigenous groups that would continue for approximately 50 years with substantial benefits for biodiversity conservation and water quality.

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Financial Support provided by:

EPA STAR Graduate Fellowship
NASA ESS Graduate Fellowship
NSF IGERT Graduate Fellowship
NASA LBA-ECO