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Quantifying and understanding land cover changes by large and small oil palm expansion regimes in the Peruvian Amazon

Emmalina A. Glinskis[a,*], Víctor H. Gutiérrez-Vélez[b]

[a] Department of Earth and Environmental Sciences, Columbia University, 1200 Amsterdam Ave, New York, NY 10027, USA
[b] Department of Geography and Urban Studies, Temple University, 1115 W. Berks Street, Philadelphia, PA 19122, USA

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ABSTRACT

With rapid increases in global food demand and production, oil palm expansion constitutes a major emerging challenge for forest conservation in Amazonia and other tropical forest regions. This threat is evident in the Peruvian Amazon, where local and national incentives for oil palm cultivation along with growing large-scale investments translate into accelerated oil palm expansion. Environmental sustainability of oil palm cultivation in the Peruvian Amazon is contingent on policy incentives for expansion onto already-cleared lands instead of biodiverse, high carbon primary rainforests. Previous research indicates that while industrial plantations use less land area than local smallholders, companies have a higher tendency to expand into primary rainforests. However, the motivations behind these differing expansion scenarios remain unclear. In this study we combine data from optical and radar satellite sensors with training information, field discussions, and review of public documents to examine the policy incentives and spatial patterns associated with oil palm expansion by smallholders and industries in one of Peru's most rapidly changing Amazonian landscapes: the Ucayali region of the city of Pucallpa. Based on our satellite-based land cover change analysis, we found that between 2010 and 2016, smallholders utilized 21,070 ha more land area for oil palm than industries but industrial expansion occurred predominantly in old growth forests (70%) in contrast to degraded lands for smallholders (56%). Our analysis of national policies related to oil palm expansion reveal policy loopholes associated with Peru's "best land use" classification system that allow for standing forests to undergo large-scale agricultural development with little government oversight. We conclude that both sectors will need careful, real-time monitoring and government engagement to reduce old-growth forest loss and develop successful strategies for mitigating future environmental impacts of oil palm expansion.

1. Introduction

As the pressure of contemporary trends in globalization, climate change, consumption and population rise continues on Earth's limited land resources, efforts to understand and monitor the underlying social, economic, and political incentives and ecological consequences of land cover changes are vital at local to global scales (Lambin and Geist, 2006). Land use decisions such as the allocation of industrial-scale agriculture play a central role in driving cropland expansion patterns, posing a serious challenge for the conservation of critical ecosystems around the world. Current projections estimate a 14% increase in global agricultural land between 2010 and 2030, constituting an increasing pressure on old growth forests and other ecosystems (Schneider et al., 2011).

Palm oil production illustrates how rising widespread global agricultural demands are increasingly impacting tropical forest cover. During the past few decades, oil palm (*Elaeis guineensis*) has become one of the most highly expanding equatorial crops in the world, grown in over 43 countries and utilizing nearly one-tenth of the world's permanent cropland (Koh and Wilcove, 2008). The rapid growth of oil palm plantations can be linked directly to a rising global demand for vegetables oils: in the last fifty years, global demand for the product has grown exponentially and is expected to double by 2030 as population and average incomes increase (Carter et al., 2007). Additionally, oil palm produces the largest oil output for the smallest amount of land—the average oil yield for oil palm is over 4 times the one for any of the other leading oilseeds like soybean, sunflower, and rapeseed (Potts et al., 2014).

Despite oil palm's productivity and land efficiency, oil palm expansion can contribute to large environmental impacts such as deforestation, peat and watershed degradation, biodiversity loss, and forest

* Corresponding author.
E-mail address: alg2218@columbia.edu (E.A. Glinskis).

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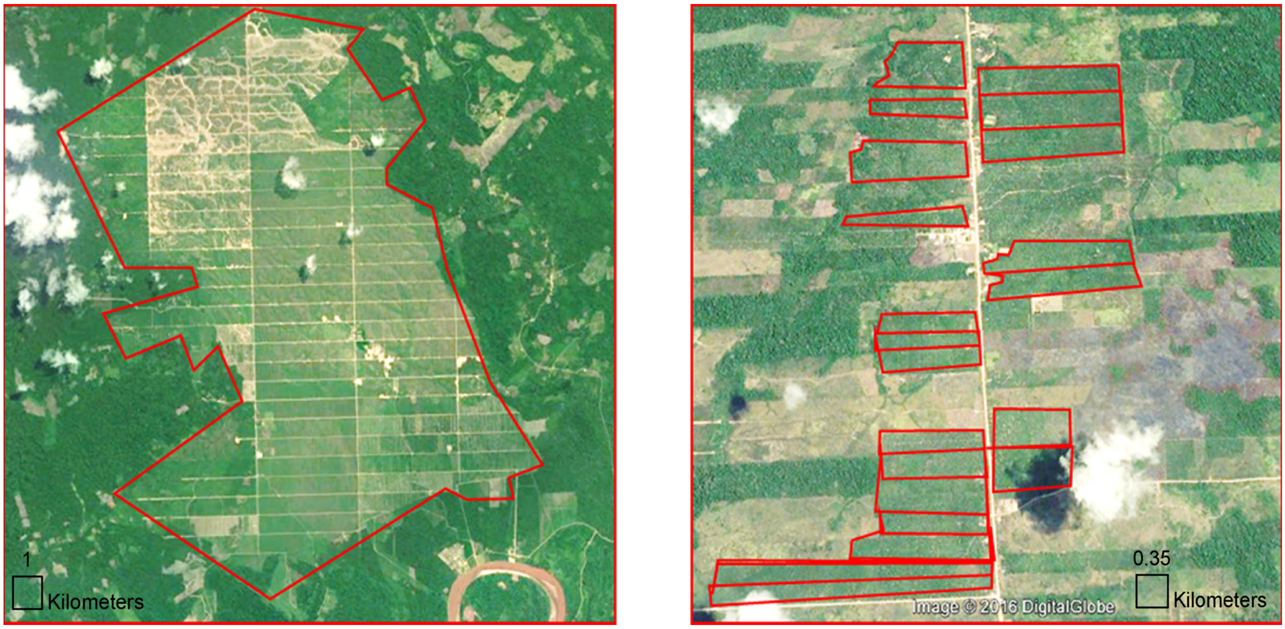

Fig. 1. Industrial (left) versus smallholder expansion patterns. Note the scale in the left image is bigger than the right. Source: Google Earth, 2016.

fires (Wilcove and Koh, 2010). The draining of peatlands, slash-and-burn forest clearing practices for new plantations, and other methods of agricultural expansion, when quantified, result in net positive global carbon emissions (Carlson et al., 2012). Given unprecedented growth of oil palm production and expansion, efforts to minimize the environmental footprint of agricultural development through targeted financial mechanisms such as the UN initiative for Reducing Carbon Emissions from Deforestation and Forest Degradation (REDD) must meet their goals through close monitoring of expansion practices and carbon changes, especially in the richly biodiverse tropics.

Most of the global area suitable for oil palm cultivations is currently within tropical forests with deep, flat, permeable soils 10 degrees north and south of the equator (Murphy, 2014; FAO, 1983). Oil palm production is recognized as a major driver of deforestation in regions such as Southeast Asia, where more than 80% of the world's palm oil is produced (Abood et al., 2015). With rapid increases in global land use for oil palm production, oil palm plantations have quickly spread to South America's Amazon tropical forest region (Butler and Laurance, 2009). Presently, Amazonian countries comprise 60% of the tropical area suitable for oil palm (Persson and Azar, 2010) and the practice has been actively promoted by local governments in lands associated with primary rainforests (Pacheco, 2012). Among the countries that comprise Amazonia, Peru has the second largest forest area suitable for oil palm plantations (Stickler et al., 2007). Rising global demand, national political support, and economic incentives for oil palm production in South America all constitute increasing threats to forest conservation in areas like Peru, which still retains a high proportion of forest cover relative to developed lands and with low historical deforestation rates (Da Fonseca et al., 2007).

On a national scale, the Peruvian government has publicly promoted the cultivation of oil palm as an economic alternative to illegal drug trafficking after publically declaring oil palm as a cultivation of national interest in 2000. Political incentives for oil palm in Peru include tax exemptions for investments in oil palm production and a mandate to mix 5% biodiesel in diesel oils (USDA GAIN Report, 2012). While the government has put incentives for oil palm production in place, in 2014 the national government also signed a letter of intent for "Zero Net Deforestation" with Germany and Norway, committing to increasing five million hectares of forested titles to indigenous peoples on lands which they hold legal, communal, or customary rights to ensure those tenure rights are respected and forests are protected (Joint Declaration of Intent, 2014).

In order to minimize impacts to forests as industrial plantations enter the Western Hemisphere, the future environmental performance of oil palm in the Peruvian Amazon is contingent on political incentives for expansion onto cleared lands instead of highly biodiverse tropical forests (Gutierrez-Velez and Defries, 2013). Methods to monitor and map real-time oil palm expansion between large and small stakeholders provide vital tools to spatially assess the successes of such political incentives and ecological outcomes. Earlier work has shown that map-based information on both the natural controls and ecosystem threats to carbon density affords targeted interventions to reduce greenhouse gas emissions in developing tropical nations (Asner et al., 2014a). Thus, understanding the area change from land conversions to oil palm by different acting regimes are equally crucial to ultimately promote better forest management policies in the future.

Previous research efforts have focused on monitoring and mapping oil palm expansion in the Peruvian Amazon region in order to help identify carbon and forest loss from the expansion patterns of different regimes of production (Asner et al., 2014b; Gutierrez-Velez et al., 2011). In Peru, two models of oil palm expansion occur. The first, defined as industrial expansion, is normally operated by private companies who have access to enough capital and technology to invest in optimizing higher yields over larger extensions of lands. Smallholder plantations are those operated mostly by local farmers with more restricted access to capital and land, often producing lower yields. (Gutierrez-Velez et al., 2011). Well-defined uniformly sized geometric shapes and road infrastructure are characteristic of industrial regimes, while smallholder plantations are normally clustered along main access roads with variable shapes and sizes typically ranging between 5 to 10 ha, rarely exceeding 20 ha (Bruinsma, 2009, Fig. 1).

Using remote sensing to classify expansion patterns and map the conversion of land covers to oil palm over a period of 10 years (2000–2010), Gutierrez-Velez et al. (2011) found that while industrial plantations use less land area than local smallholders, plantation companies have a higher tendency to expand into primary rainforests. If the effects of expansion are quantified further, this result could mean that in the Peruvian Amazon, industrial oil palm production occurs at a higher expense than smallholder groups for forest conservation. However, recent differences in the landscape impacts between the two