



## Trans-boundary infrastructure and land cover change: Highway paving and community-level deforestation in a tri-national frontier in the Amazon

Stephen G. Perz<sup>a,\*</sup>, Youliang Qiu<sup>b</sup>, Yibin Xia<sup>b</sup>, Jane Southworth<sup>b</sup>, Jing Sun<sup>b</sup>, Matthew Marsik<sup>b,c</sup>, Karla Rocha<sup>b,d</sup>, Veronica Passos<sup>d</sup>, Daniel Rojas<sup>e</sup>, Gabriel Alarcón<sup>f</sup>, Grenville Barnes<sup>g</sup>, Christopher Baraloto<sup>h</sup>

<sup>a</sup> Department of Sociology and Criminology & Law, 3219 Turlington Hall, University of Florida, PO Box 117330, Gainesville, FL 32611-7330, USA

<sup>b</sup> Department of Geography and Land Use Change Institute, University of Florida, Gainesville, FL 32611, USA

<sup>c</sup> Natural Capital Project, The Nature Conservancy, Seattle, WA, USA

<sup>d</sup> Universidade Federal do Acre, Rio Branco, Acre, Brazil

<sup>e</sup> Universidad Amazónica de Pando, Cobija, Pando, Bolivia

<sup>f</sup> Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado, Madre de Dios, Peru

<sup>g</sup> School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611, USA

<sup>h</sup> Department of Biology, University of Florida, Gainesville, FL 32611, USA

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### ABSTRACT

Economic globalization manifests in landscapes through regional integration initiatives involving trans-boundary infrastructure. While the relationships of roads, accessibility and land cover are well-understood, they have rarely been considered across borders in national frontier regions. We therefore pursue an analysis of infrastructure connectivity and land cover change in the tri-national frontier of the southwestern Amazon where Bolivia, Brazil and Peru meet, and where the Inter-Oceanic Highway has recently been paved. We integrate satellite, survey, climate and other data for a sample of rural communities that differ in terms of highway paving across the tri-national frontier. We employ a suite of explanatory variables tied to road paving and other factors that vary both across and within the three sides of the frontier in order to model their importance for deforestation. A multivariate analysis of non-forest land cover during 2005–2010 confirms the importance of paving status and travel times, as well as land tenure and other factors. These findings indicate that integration affects land cover, but does not eliminate the effects of other factors that vary across the frontier, which bears implications for the study of globalization, trans-boundary infrastructure, environmental governance and land cover change.

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### Introduction

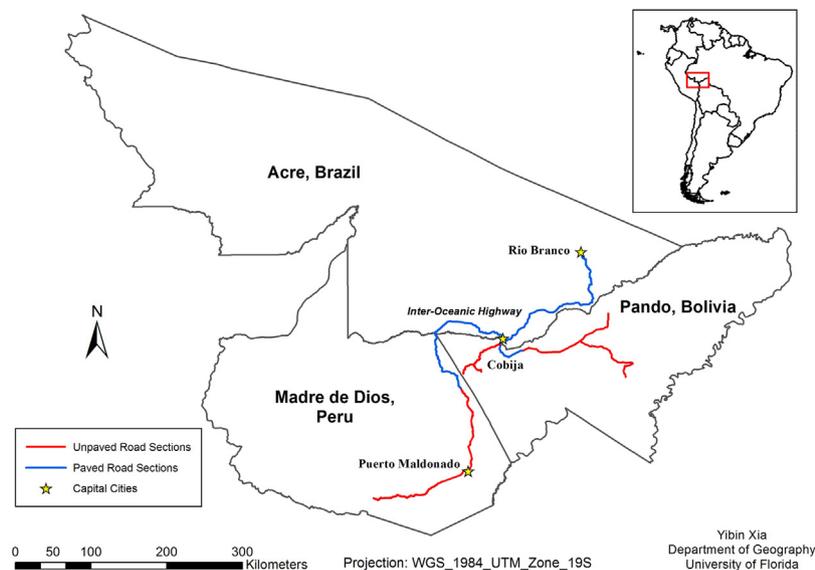
It is well-established that accessibility to land is closely related to land cover change (Chomitz and Gray, 1996; Nelson et al., 2004). In particular, analyses of deforestation in frontier areas such as the Amazon have shown that new roads, and road paving, are associated with deforestation (Anderson et al., 2002; Pfaff et al., 2007). Related work has similarly confirmed that most forest clearing occurs close to road corridors (Laurance et al., 2001; Southworth et al., 2011).

In this paper, we expand on these issues by situating the relationship between accessibility and land cover change in the broader context of regional integration across national boundaries. Initiatives to integrate resource-rich regions into the global economy include trade agreements to facilitate international commerce and new infrastructure to permit the physical transportation of labor, capital and products. Economic research has consistently shown positive effects of infrastructure on economic growth (Calderón and Servén, 2004; Straub, 2008). Infrastructure has therefore become pre-eminent on the development agenda (Bourguignon and Pleskovic, 2008). Trans-boundary infrastructure initiatives have thus taken on considerable significance in the context of globalization.

In Latin America, the debt crisis of the 1980s led to neoliberal policies such as trade liberalization. Notably, this included trade among neighboring countries in the spirit of “open regionalism” as a means of reinvigorating economic growth (Bulmer-Thomas, 2001). But trade agreements, especially the proposed Free Trade Area of the Americas (FTAA), have incurred substantial criticism

\* Corresponding author. Tel.: +1 352 294 7186; fax: +1 352 392 6568.

E-mail addresses: [sperz@ufl.edu](mailto:sperz@ufl.edu) (S.G. Perz), [yqiu@ufl.edu](mailto:yqiu@ufl.edu) (Y. Qiu), [xiayibin@ufl.edu](mailto:xiayibin@ufl.edu) (Y. Xia), [jsouthwo@ufl.edu](mailto:jsouthwo@ufl.edu) (J. Southworth), [jingsun520@ufl.edu](mailto:jingsun520@ufl.edu) (J. Sun), [mmarsik@gmail.com](mailto:mmarsik@gmail.com) (M. Marsik), [rocha@ufl.edu](mailto:rocha@ufl.edu) (K. Rocha), [veronicapassos@uol.com.br](mailto:veronicapassos@uol.com.br) (V. Passos), [darcbp@hotmail.com](mailto:darcbp@hotmail.com) (D. Rojas), [galarcona@hotmail.com](mailto:galarcona@hotmail.com) (G. Alarcón), [gbarnes@ufl.edu](mailto:gbarnes@ufl.edu) (G. Barnes), [Chris.Baraloto@ecofog.gf](mailto:Chris.Baraloto@ecofog.gf) (C. Baraloto).



**Fig. 1.** The inter-oceanic highway and other primary roads in the tri-national MAP frontier of the Southwestern Amazon, Bolivia, Brazil and Peru.

and protest (e.g., Harris, 2003; Kellogg, 2007). By contrast, trans-boundary infrastructure projects are proceeding forward, driven in part by analyses showing infrastructure deficits in Latin American countries when compared to their Asian competitors (Carranza, 2002; Calderón and Servén, 2004; Munakata, 2006).

No endeavor for trans-boundary infrastructure in Latin America is more significant than the Initiative for the Integration of Regional Infrastructure in South America (IIRSA). IIRSA was constituted by a meeting of presidents from 12 South American countries in 2000 (CEPEI, 2002; IIRSA, 2008). Subsequent IIRSA meetings included multilateral development banks and led to agreements to fund 350 projects at a total projected cost of \$38 billion. IIRSA was explicitly conceptualized as a spatial strategy organized around “axes of integration” targeted for infrastructure investments. Such axes constitute strategic growth corridors for commerce among neighboring countries.

Because many IIRSA projects focus on relatively remote and environmentally intact but resource-rich areas, IIRSA has given rise to concerns about environmental impacts. The record of environmental impact assessments in IIRSA projects highlights oversights and limitations (Killeen, 2007; Dourojeanni et al., 2010). There are also doubts that regional integration under IIRSA will generate economic growth (Moreira Mesquita, 2007; Van Dijck and den Haak, 2007). Such observations contribute to debates over the prospective impacts of IIRSA projects.

Debates over the wisdom of infrastructure investments are long-standing, and have generated numerous empirical studies documenting negative ecological effects of road networks. The road ecology literature includes several reviews which take as their point of departure the observation that roads fragment habitats and modify stream networks (Trombulak and Frissell, 2000; Forman et al., 2003; Coffin, 2007). From there, ecologists catalog a host of largely negative consequences including habitat loss, isolation and degradation (e.g., Hawbaker and Radeloff, 2004; Eigenbrod et al., 2008). Parallel to the road ecology literature, the question of roads in the Amazon has resulted in extensive work on deforestation and forest fragmentation (Laurance and Bierregaard, 1997; Laurance et al., 2002).

We focus on the case of the Inter-Oceanic Highway (IOH), one of the first IIRSA projects, which proceeded forward during 2005–2010 (Dourojeanni et al., 2010). The IOH constitutes the “Peru–Brazil” axis of integration under IIRSA (CEPEI, 2002; IIRSA,

2008). As its name suggests, the IOH spans South America, and under IIRSA, the last unpaved segments in the southwestern Amazon were paved to permit trans-boundary commerce between Brazil and Peru along the Bolivian border. This strategic investment is intended to integrate the southwestern Amazon and other portions of the interior of South America into the global economy by providing export outlets via Atlantic ports in southern Brazil as well as Pacific ports in Peru. Fig. 1 shows the IOH where it passes thru the southwestern Amazon.

The exceptionally high biodiversity of the southwestern Amazon (Myers et al., 2000) and the largely intact forest cover there (Southworth et al., 2011) have stimulated considerable concern as to the environmental consequences of the IOH (Killeen, 2007; Dourojeanni et al., 2010). However, there are crucial differences between older infrastructure initiatives in the Amazon and those advancing under IIRSA. Whereas the previous generation of infrastructure projects in the Amazon were driven largely by geopolitical concerns to integrate interior frontiers into national economies (e.g., Goodland and Irwin, 1975; Schmink and Wood, 1992), the current generation has a fundamentally different strategic imperative of integration across borders (CEPEI, 2002; IIRSA, 2008). In other words, highways such as the Transamazon were built to connect regions within countries (Walker et al., 2011); but IIRSA projects such as the IOH seek integration across countries. Correspondingly, previous work on roads and deforestation in the Amazon has generally focused on one country or specific landscapes therein. But given the current context, defined in large measure by IIRSA, there is now a need for multi-national evaluations of trans-boundary infrastructure and its land cover impacts.

Trans-boundary infrastructure presents certain analytical opportunities. On the one hand, study of a national frontier area being integrated permits cross-border comparisons within the same ambit. This facilitates comparisons due to proximity, though one might also expect cross-border differences among countries. On the other hand, regional integration begs questions about localized variation and distance gradients along a highway corridor as well as distance gradients from the highway itself. While the Land Use–Cover Change (LUCC) science plan highlighted regional comparisons (Turner et al., 1995), less attention went to comparisons in the context of trans-boundary integration initiatives. The Global Land Project’s (2005) science plan devotes attention to questions of globalization and local land use as well as comparative case

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