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LETTER

# Future of oil and gas development in the western Amazon

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## Abstract

The western Amazon is one of the world's last high-biodiversity wilderness areas, characterized by extraordinary species richness and large tracts of roadless humid tropical forest. It is also home to an active hydrocarbon (oil and gas) sector, characterized by operations in extremely remote areas that require new access routes. Here, we present the first integrated analysis of the hydrocarbon sector and its associated road-building in the western Amazon. Specifically, we document the (a) current panorama, including location and development status of all oil and gas discoveries, of the sector, and (b) current and future scenario of access (i.e. access road versus roadless access) to discoveries. We present an updated 2014 western Amazon hydrocarbon map illustrating that oil and gas blocks now cover 733 414 km$^2$, an area much larger than the US state of Texas, and have been expanding since the last assessment in 2008. In terms of access, we documented 11 examples of the access road model and six examples of roadless access across the region. Finally, we documented 35 confirmed and/or suspected untapped hydrocarbon discoveries across the western Amazon. In the Discussion, we argue that if these reserves must be developed, use of the offshore inland model—a method that strategically avoids the construction of access roads—is crucial to minimizing ecological impacts in one of the most globally important conservation regions.

## Introduction

The western Amazon—a vast region encompassing the Amazonian sections of Bolivia, Colombia, Ecuador, Peru, and western Brazil—is one of the world's last high-biodiversity wilderness areas. It is characterized by extraordinary species richness across taxa, and large tracts of roadless and relatively intact humid tropical forest (Bass *et al* 2010). A recent global analysis of biodiversity risks from fossil fuel extraction found that northern South America, i.e. the western Amazon, is under particular threat (Butt *et al* 2013). A second recent global analysis, this one on road building, documented that much of the western Amazon is a 'priority road-free' area (i.e., roadless area with high environmental values, such as biodiversity and wilderness, but only modest agricultural potential) (Laurance *et al* 2014).

In this paper, we combine these two assessments and present the first integrated analysis of the hydrocarbon (oil and gas) sector and its associated road-building in the western Amazon. This integration is paticularly important because such oil and gas roads, particularly in the Amazonian context characterized by hydrocarbon projects in extremely remote locales, have the potential to make 'the first cut' (i.e. the first road (Laurance *et al* 2014)) into otherwise relatively intact wilderness areas.

In 2008, Finer *et al* presented the first general analysis of the hydrocarbon sector across the western Amazon and reported that (a) exploration and development activities had already caused significant environmental and social impacts, and (b) exploration and development concessions cover vast areas of species-rich rainforest, including protected areas and indigenous territories (Finer *et al* 2008). The sector is very dynamic, however, and six years later an updated and enhanced assessment is necessary to keep the literature current with events on the ground. The update is based on detailed data from 2014 and the enhancement consists of two components: (1) location and development status of all known and suspected oil and gas discoveries and (2) mode of access for all developed fields.

We pay particular attention to mode of access because, in general, roads can open a 'Pandora's box' of negative environmental impacts and trigger new deforestation fronts (Laurance *et al* 2014). More specifically, oil access roads, particularly in the Ecuadorian Amazon, are well documented to be a major driver of deforestation and degradation, causing both direct forest loss and indirect impacts associated with subsequent colonization, illegal logging, and over-hunting (Sierra 2000, Greenberg *et al* 2005, Laurance *et al* 2009, Suárez *et al* 2009, 2013, Baynard *et al* 2012, Wasserstrom 2013).

An established alternative to new access road construction is the offshore inland development model. This access mode essentially signifies roadless development (Tollefson 2011). An offshore hydrocarbon operation in a marine environment is characterized by a production platform that is essentially an island in the ocean. All access is by helicopter and/or ship, flowlines are submerged on the sea floor, and there are obviously no access roads. In turn, the offshore inland model imitates this design by treating the forest as an ocean where access roads are not a possibility. Thus, the drilling platform is essentially an island in the forest accessed only by helicopter and/or river transport.

Roadless development is the centerpiece of technical best practice (Finer *et al* 2013). Other components of best practice, such as extended reach drilling and the green pipeline (Finer *et al* 2013), are ultimately primarily strategies to minimize or eliminate new access road construction. Thus, in this study, we consider the western Amazonian hydrocarbon sector in relation to road-building and address two central questions:

(1) What is the current development panorama, including location and status of all oil and gas discoveries?

(2) What is the current and future scenario in terms of access to discoveries (i.e., access roads versus offshore inland model)?

Based on the findings to these questions, we conclude with a discussion of the future of oil and gas development in the western Amazon in relation to the offshore inland model.

## Methods

We obtained status and spatial data for hydrocarbon blocks from the following government sources: Colombia's Agencia Nacional de Hidrocarburos (http://www.anh.gov.co), Ecuador's Ministerio de Recursos Naturales No Renovables (http://www.recursosnaturales.gob.ec/) and Petroecuador (http://www.eppetroecuador.ec/), Peru's Perupetro (http://www.perupetro.com.pe) and Ministerio de Energía y Minas (http://www.minem.gob.pe/), Bolivia's Agencia Nacional de Hidrocarburos (http://www.anh.gob.bo/) and Yacimientos Petrolíferos Fiscales Bolivianos (http://www.ypfb.gob.bo/), and Brazil's Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (http://www.anp.gov.br). We obtained information pertaining to discoveries from the government agencies listed above and news reports.

We classified all known hydrocarbon discoveries across the western Amazon into three categories related to their status and development model: developed with access road (access road), developed with roadless access (roadless access), and not yet developed (untapped) (figure 1). We consider roadless access an operational example of the offshore inland model. Access road and roadless access categories were further broken down by era, older and modern, to account for major shifts in technology and policy. We chose 1990 as the transition from older to modern. Classifications were based on an analysis of satellite imagery, environmental impact studies, and technical reports. We defined roads as routes designed for vehicle traffic—drivable surfaces, permanent waterway crossing structures, and signs of actual vehicle traffic. For the untapped category, we collected information from government and company documents and news reports regarding (a) exploratory wells that yielded positive results for oil and/or gas (confirmed discoveries), and (b) seismic testing campaigns that strongly suggested the presence of hydrocarbon deposit structures (suspected discoveries).

## Results

Figure 1 shows an up to date map of the hydrocarbon sector in the western Amazon. Oil and gas blocks—specific geographic areas designated by national governments for hydrocarbon activities—now cover 733 414 $km^2$, an area substantially larger than the US state of Texas. This is an increase of over 45 000 $km^2$ from 2008 (Finer *et al* 2008).

These blocks come in three categories: extraction (7.1%), exploration (52.1%), and promotion (40.8%). Extraction and exploration blocks, also known as concessions, are those that the respective national government has leased to a state and/or multinational energy company for extraction and exploration-phase activities, respectively. Promotion blocks are those not yet leased by the government to an energy company. Extraction blocks actively producing oil or gas are currently concentrated in southwest Colombia, northern Ecuador, the Urucu area of Brazil, and parts of

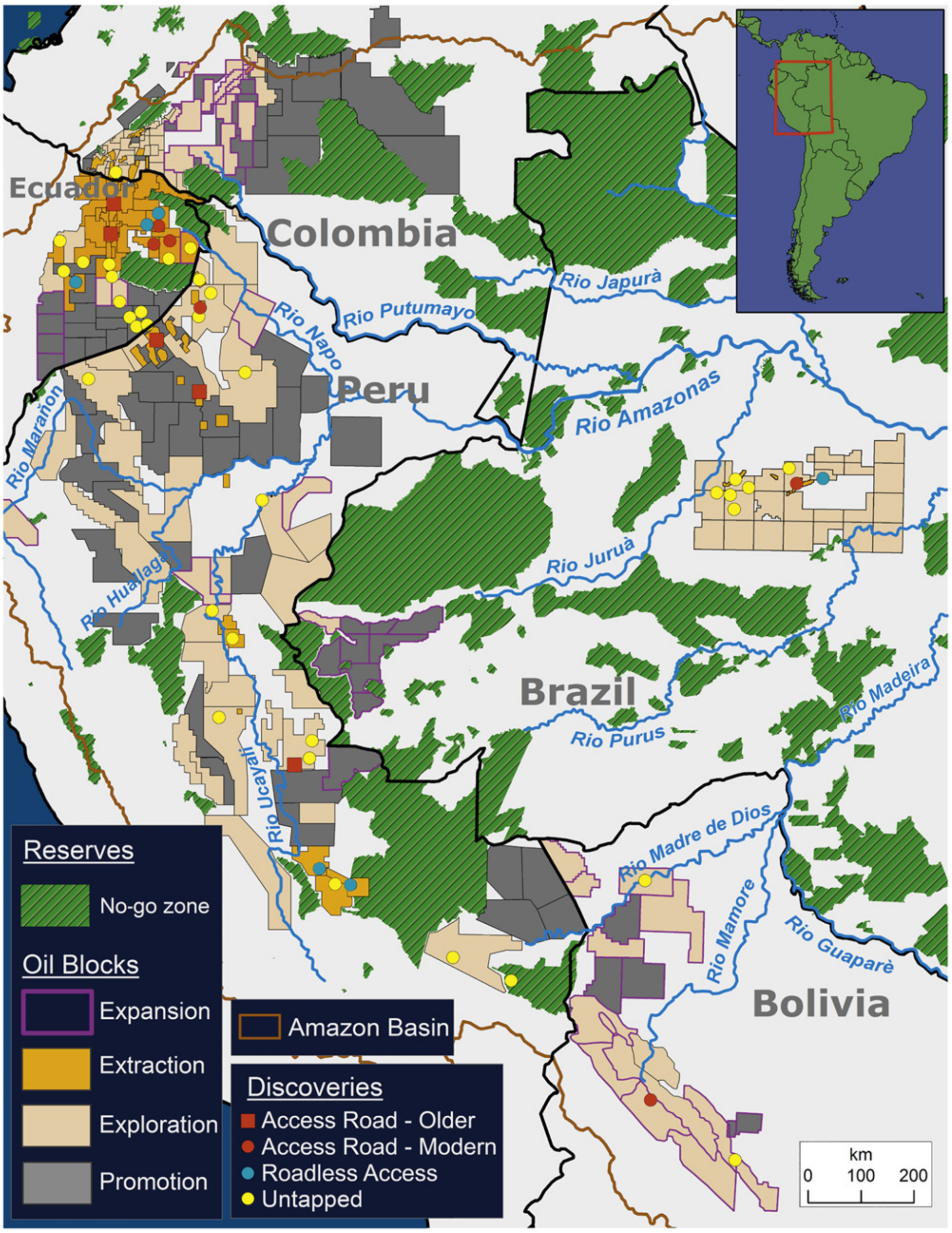


**Figure 1.** *2014 western Amazon hydrocarbon map*. Map features the current state of all hydrocarbon blocks and known discoveries. For discoveries, symbols indicate access type (and era for access roads). Basemap from ESRI ArcGIS™.

northern, central, and southern Peru (figure 1). Exploration and promotion blocks cover vast sections of all five countries.

No-go zones off-limits to hydrocarbon activities cover nearly 1191 000 km$^2$ across Colombia, Ecuador, Peru, and Brazil. These areas include national parks and territories of indigenous peoples in voluntary isolation. Note that in Ecuador and Bolivia national parks are not necessarily off-limits to extractive activities given the overlaps of hydrocarbon blocks with Yasuní and Madidi National Parks, respectively.

Figure 1 also illustrates the recent expansion of the hydrocarbon frontier, over 150 000 km$^2$ since 2008. Our definition of expansion includes not only new exploration or promotion blocks, but also previous promotion blocks that advanced to exploration phase (hence this total is greater than the 45 000 km$^2$ noted above). Nearly half of this expansion occurred in Bolivia.

We documented six examples of roadless access, all modern era. The prime examples are Blocks 57 and 88 in southern Peru (figure 2(a)) and Block 10 in central Ecuador. These projects have complicated social issues with indigenous communities, but in terms of technical best practice, they are exemplary because all access is by air and/or water and the flowline routes are not used as roads.

We also documented 11 examples of the access road model, six from the modern era. The principal examples are all in Ecuador: Auca Road, Maxus Road —Block 16 (figure 2(b)), and Block 31 (figure 2(c)). Auca is an older (1980s) design and has no access

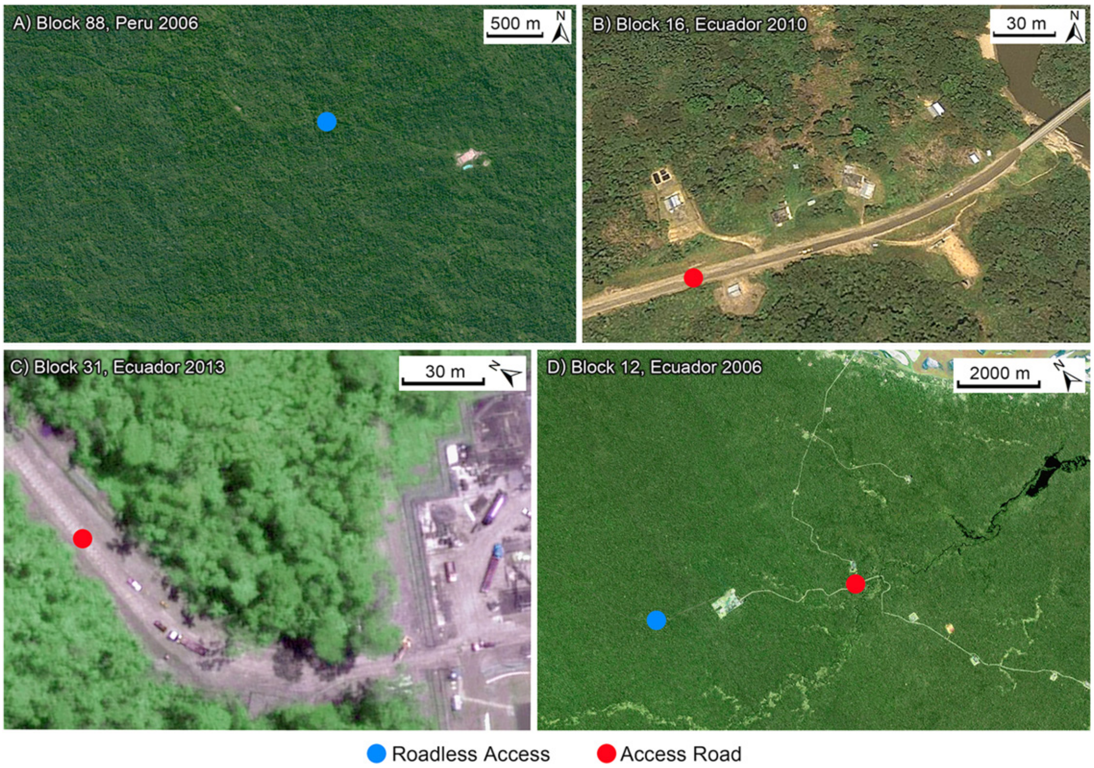


**Figure 2.** *Specific cases of roadless access and access roads.* (a) Block 88 (Camisea), Peru. Imagery from Google Earth, July 2006, shows a roadless flowline extending to the west of a drilling platform; (b) Block 16, Ecuador. Imagery from Google Earth, September 2010, shows an older access road and associated colonization and deforestation; (c) Block 31, Ecuador. Imagery from Worldview 2, September 2013, shows a modern access road; and (d) Block 12, Ecuador. Imagery from Google Earth, September 2006, shows a processing facility in the center, with a roadless pipeline going to the west, and an access road going to the East. Dot colors correspond to figure 1 (i.e., red dot = access road, blue dot = roadless access).

control, while Blocks 16 and 31 are modern era (1990s and 2012, respectively) and have control posts at the entrance. Other modern era access roads in Ecuador (Block 12), Peru (Block 67), Brazil (Urucu) also have access control, although it is unknown if the new road in Bolivia (Lliquimuni) will.

Interestingly, Block 12 in Ecuador (figure 2(d)) and Urucu in Brazil display both roadless access and access road designs within the same project. In Block 12, the pipeline route to the west of the processing facility is roadless, but to the East of the facility is a traditional access road. In Urucu, general access to the area from the rest of the country is only by air or water, but within the project perimeter there are access roads.

We documented 35 confirmed and/or suspected untapped hydrocarbon discoveries. They are distributed throughout the entire study area, but especially clustered in eastern Ecuador, northern Peru, and the Urucu area of Brazil (figure 1). Moreover, additional new discoveries are likely in coming years as all five countries aggressively promote increased exploration.

## Discussion

We demonstrate that the western Amazonian hydrocarbon frontier continues to expand, pushing into ever more remote areas. Given (1) the extensive literature on the impacts of roads, (2) the crucial role of roadless development to best practice (Finer *et al* 2013), and (3) our findings regarding the large number of confirmed and/or suspected untapped hydrocarbon discoveries, we argue that universal adoption of the offshore inland development model is one of the most important actions to minimize future ecological impacts from oil and gas development in the Amazon. Consideration of indigenous communities and territories, particularly uncontacted tribes (Finer *et al* 2008, Pappalardo *et al* 2013), is also of utmost importance to minimize social impacts, but beyond the scope of this paper.

Use of the offshore inland development model is now well established in the Camisea-related natural gas projects in the southern Peruvian Amazon. However, the recent Block 31 oil project in Ecuador revealed that roadless access implementation remains controversial. Despite a formal commitment in 2007 to avoid access road construction to the drilling platforms within Yasuní National Park, Ecuador changed course and ultimately allowed this road construction in 2012 (Finer *et al* 2014). This case underscored that one of the most critical components to implementation of the offshore inland development model is ensuring that the flowline or pipeline corridor is not used as an access road (Finer *et al* 2014). In other words, corridors must not be designed for vehicle traffic in any way and possess the following key characteristics: extremely narrow right-of-way (<10 m), no permanent bridge or culvert structures over waterways, and immediate revegetation across the entire corridor after the flowline or pipeline ducts are in the ground.

The primary benefit of the offshore inland development model in relation to more traditional access roads is simply not providing new access to relatively intact tracts of forest. Although advances such as control posts may help reduce impacts of access roads, they are not completely effective. For example, in Ecuador, it has been documented that the Maxus road access restrictions have not effectively controlled over-hunting along the route by indigenous communities (Suárez *et al* 2009, 2013). There are also long-term questions, such as after the responsible operating company leaves the area, what will happen to access control. In other words, access may be controlled for a number of years, but a new road is a long-term commitment that may exceed the lifespan of the hydrocarbon project.

In terms of negative effects of the offshore inland development model, increased helicopter and river transport may bring local impacts, such as noise and pollution. Therefore, it is important that air and river traffic are carefully regulated and monitored (Finer *et al* 2013). In sum, however, we maintain that these impacts are not of the same magnitude as opening up intact areas with new roads. For helicopters, there are also issues associated with not being able to operate during adverse weather events.

One of the main determinates as to why or why not a given company or project has implemented the offshore inland development model may be commitment and technical assistance. For example, in the case of Camisea in southern Peru, technical assistance from the Smithsonian Institution was instrumental in creating the conditions for successful roadless development (Dabbs and Bateson 2002, Dallmeier *et al* 2002). In Block 10 in Ecuador, it was more a case of strong company commitment to not build roads (Williams 1999). Cost may also be a factor, but analysis of a recent oil extraction project in northern Peru revealed that the use of technical best practice does not necessarily bring higher costs, and may actually reduce total expenses (Finer *et al* 2013). The increase in helicopter-related expenses would be offset by eliminating the costly construction and maintenance of roads in a humid tropical forest environment (Finer *et al* 2013).

## Conclusion

Companies exploiting the growing number of untapped reserves, if deemed commercially viable, will have the opportunity to implement either the access road or roadless access development model. The latter is the modern best practice in the form of the offshore inland development model. Although there are operational examples of the offshore inland model, there are still no binding regulations prohibiting new access roads. This critical decision is still largely at the discretion of the operating company and the government agencies that review the environmental impact studies. Given the large amount of hydrocarbon development projects likely to occur in the coming years and decades across some of the most remote and intact corners of the western Amazon, we argue for more consistent use of the offshore inland development model.

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