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Discussion

Environmental impact assessment in Brazilian Amazonia: Challenges and prospects to assess biodiversity

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ABSTRACT

Environmental Impact Assessment (EIA) has the goal of providing decision makers with an indication of the likely environmental consequences of planned actions risking environmental changes and, when necessary, allowing revision of these actions to mitigate adverse impacts. Here we provide an overview of the efficiency of EIA with emphasis on Brazilian Amazonia and discuss the problems and challenges with this type of assessment in highly diverse ecosystems. We concentrate on the methodology and performance of EIAs for three of the most recent and largest infrastructure projects in Amazonia: the Belo Monte hydroelectric dam, the BR-319 Highway, and the Juruti bauxite mine. We conclude that all of these EIAs fall short of properly assessing the expected impact of infrastructure development in situ, and that their results had little or no effect on policy decisions. To improve the reliability and usefulness of EIAs in biologically diverse ecosystems, we suggest three relatively fast and cost-effective complementary approaches for assessing biodiversity: remote sensing, reflectance spectroscopy, and DNA meta-barcoding. We discuss how these emerging cutting-edge techniques can help in identifying environmental threats and the consequences of different activities in Amazonia. The ability to monitor the state of the environment and the likely impacts of human activities on natural resources is fundamental to evidence-based decisions on development choices, to the design of appropriate management strategies, and to mitigate biological and ecological consequences.

1. Background

Environmental Impact Assessment (EIA) can be defined as a technical and legal system for assisting in environmental management and for supporting sustainable development (Jay et al., 2007). The purpose of EIA is the systematic identification and evaluation of potential impacts of proposed projects, plans, programs, or legislative actions, with respect to the physical–chemical, biological, cultural, and socioeconomic environment's components. EIAs also provide mechanisms for amending development proposals when necessary and for mitigating likely adverse impacts (Canter, 1996). EIAs thus supply decision makers with information based on systematic environmental studies as well as inform public opinion (included communicating through public hearings) on the potential environmental impacts of such projects (Jay et al., 2007). Brazilian EIAs are accompanied by the 'RIMA' (meaning "EIA Report" or *Relatório de Impacto Ambiental*, in Portuguese), which is written in a non-technical style addressed to non-specialists.

The purpose of the EIA is to ensure that decision makers account for environmental impacts when deciding whether or not to proceed with any project that may alter the natural environment of a place – such as the construction of a factory, road, or dam. In some cases, the EIA may lead to an outright rejection of a project or proposal, but the primary goal is to mitigate environmental impacts while allowing for economic development. Although EIAs are in a position to identify the main potential environmental impacts, in practice it is not uncommon that their influence on decision-making is limited (Jay et al., 2007).

Many approaches have been proposed for improving EIAs in order to make them more useful, robust, and efficient. Examples include further

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training of practitioners, guidance on best and alternative practices, and regular environmental monitoring (Jay et al., 2007; Toro et al., 2010). Ferraz (2012) introduced 12 guidelines to assess environmental impacts. He suggests the decisions about why, what, when and how to sample should be made on a case-by-case basis' (Ferraz, 2012). Other reviews, evaluations, and discussions have been made of EIAs in Brazilian settings (e.g., Fearnside, 2015a; Fearnside and Graça, 2009; MPE-RO, 2006; Nitta and Naka, 2015), as well as in other countries (e.g., Barker and Wood, 1999; Toro et al., 2010; Wang et al., 2003).

Brazil is the world's 5th largest country both in terms of area and human population size. It is furthermore the country with the largest number of extant species described (UNEP-WCMC, 2016). Brazil's 1989 environmental legislation (see Appendix 1 in the Supplementary online material for a more extensive historical account) requires an EIA for numerous potentially polluting activities, but it is surprisingly vague regarding the demands for licensing each of these activities. For example, the legislation that regulates the biotic environment requires consideration of the "*…biological environment and natural ecosystems - the fauna and flora, highlighting the environmental quality indicator species, scientific and economic value, rare and endangered species and areas of permanent preservation*" (Art. 6º CONAMA resolution 01/86: CONAMA, 1986). However, there are no clear definitions of these species' categorizations. In practice, the biological components of Brazilian EIAs are performed as rapid inventories of specific groups (usually vertebrates, vascular plants and, in some cases, arthropods). Focus is given to rare, endemic, and/or threatened species. These studies are perhaps appropriate in fragmented landscapes and in areas for which extensive biological information is already available, notably in some well-studied fragments of Brazil's Atlantic rainforest near populated areas. In contrast, such cursory approaches are inadequate in megadiverse environments and understudied areas, such as the Amazonian rainforest (Ferraz, 2012; Peres, 2005).

The Amazon Basin comprises the largest tropical forest in the world, encompassing 5.5 million km^2 and accounting for approximately 40% of the rainforests and possibly 40% of all extant species on the planet (Hansen et al., 2013). It also holds 15 to 20% of the global freshwater supply (Salati and Vose, 1984). Amazonia provides essential environmental services to the world such as maintenance of biodiversity, water cycling, and carbon stocks (Fearnside, 2008; Ojea et al., 2012). Finally, Amazonia is fragile: relatively small alterations may lead to major impacts (Malhi et al., 2008). Amazonia is therefore a relevant and important area for evaluating the current and potential role of EIAs at the interface between ecosystem management and human development.

2. Environmental impact assessment in Amazonia

Here we assess three of the most recent and largest infrastructure projects in Amazonia, with a particular focus on whether ecosystem threats and potential environmental impacts were properly assessed and in accordance with the EIA principles. We chose these projects because they included activities linked to some of the most significant threats in Amazonia and because these could have synergistic, detrimental effects. We also suggest faster and more cost-effective tools to aid in the identification and quantification of biodiversity in highly diverse ecosystems. For more information about biological sampling and impact assessment see Appendix 2 in the online Supplementary material.

2.1. BR-319 highway (Fig. 1A)

The BR-319 is an 870-km long road connecting the cities of Manaus and Porto Velho. The road was initially built in 1972 and 1973, but cheaper shipping alternatives (such as barges along the rivers) resulted in the road's traffic being insufficient to justify the high maintenance costs. Due to the difficult soil conditions (unstable clay, recurrent landslides), low economic importance, and high rainfall, the road quickly degraded and was abandoned in 1988 (Fearnside and Graça, 2006). Sections of the road at the southern and northern ends of the highway were reconstructed and paved, but work on the central stretch was held up until April 2015 when the euphemistically termed "maintenance" was approved, amounting to the proposed reconstruction in all relevant aspects except the final paving.

In 2008, after the presentation of the first version of the EIA for the central stretch (between kilometers 250 and 656, a total of 406 km) by the National Department of Traffic Infrastructure (DNIT), the EIA was rejected due to non-compliance with the terms of reference established by the Brazilian Institute of Environment and Natural Resources (IBAMA). The Ministry of the Environment then created a working group to develop guidelines and to monitor the environmental licensing of BR-319 (Brazil, MMA, 2008).

2.1.1. Prediction of impacts

Roads constitute one of the main drivers of deforestation in Amazonia (Alves, 2010; Fearnside, 2015b). Studies indicate that 87% of the deforestation in Brazilian Amazonia occurs within 25 km of a highway (Alves, 2001). Soares-Filho et al. (2006) used the SimAmazonia model to estimate deforestation in the Amazon due to construction of the BR-319. Their main conclusion was that reconstructing and paving the highway would lead to deforestation of up to 39 million hectares of forest and CO_2 emissions exceeding 4.8 billion tons by 2050. In a more conservative study, Fearnside et al. (2009) estimated the deforestation caused by the road to be in the order of 5.1 million hectares, and the CO_2 emission to be up to 950 million tons. These studies only considered the area along the highway route – essentially the interfluve between the Madeira and Purus Rivers. However, the highway's potential impact is much greater: a planned road (AM-366) branching off of BR-319 would give access to the large block of intact forest to the west of the Purus River, opening a new frontier to deforestation and biodiversity loss (Graça et al., 2014). Migration from Rondônia would presumably not stop in Manaus at the northern end of BR-319, but would continue along the existing road network in the states of Amazonas and Roraima. A simulation of deforestation in Roraima suggests that the impact there would be substantial (Barni et al., 2015).

According to National Environmental Council (CONAMA) Resolution 1/1986, the EIA must "*define the extent of the geographical area to be directly or indirectly affected by the impacts, called the area of influence of the project, considering, in all cases, the hydrographic basin in which it is located*". The *direct influence area* defined by the EIA (in this case 5 km on each side of the road, a total of 4057 km^2) disregards important factors such as degradation by illegal logging, forest conversion to agriculture, and ranching due to the facilitation of access to areas that had been previously isolated.

The main area affected by BR-319 is the Madeira-Purus interfluve. The area has one of the highest levels of species richness in all of Amazonia (Py-Daniel et al., 2007), outstandingly high levels of endemism (Ribas et al., 2011), and is still little perturbed. Indeed, even in the 21st century, new species in well studied groups such as mammals (Röhe et al., 2009) and birds (Cohn-Haft et al., 2013) have been described from this area. It is reasonable to assume that many more species, biological interactions, and ecological niches await discovery and formal scientific description. In the lower Madeira River region, more than 60% of the area is considered "very important," 39% is considered a "priority for establishing conservation units," and 19% as a "priority for conservation" (Câmara Legislativa, 2016).

The main arguments for the construction of this road are to facilitate production in the Manaus industrial pole, connecting Manaus to the rest of Brazil through a highway system (UFAM, 2009: Vol. 1). Counterarguments include increased deforestation, loss of natural resources and biodiversity, increased carbon emissions, impacts on indigenous populations, swelling human populations through migration, overload of urban services, and the high costs of road maintenance (Fearnside et al., 2009). The EIA does not present economic evidence to justify the