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Challenges for sustainable development in Brazilian Amazonia

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ABSTRACT

Most economic initiatives and infrastructure projects in Brazilian Amazonia have social benefits that are small and ephemeral, while their socio-environmental impacts are severe. More sustainable forms of development are inhibited by barriers such as a decision-making system with heavy influence (including corruption) from actors with interests in non-sustainable activities. These interests have driven a recent surge of legislative threats to environmental licensing. Better alternatives exist for many destructive forms of “development” projects. Examples include transport using rivers (rather than building highways) and electricity generation from Brazil’s vast solar and wind resources (rather than hydroelectric dams). Traditional rural population could receive support from programs that tap the value of the Amazon forest’s environmental services, but institutional mechanisms are in their infancy, among challenges that include differing political interests of countries providing environmental services and those that might pay for them, lack of data, and a “theoretical battlefield” regarding accounting for benefits.

KEYWORDS: Deforestation, Environmental licensing, Environmental services, Global warming, Environmental impact assessment, Amazon

The challenges to sustainable development in Brazilian Amazonia can be divided into two broad categories: counteracting the forces that lead to unsustainable development and offering alternatives to the current economy that is almost entirely based on destruction of natural ecosystems. "Sustainable development" can be interpreted in various ways. At a minimum, in order to be "development" the actions undertaken must lead to an improvement in human wellbeing, presumably of the population at the location in question, and to be "sustainable" these benefits must last indefinitely (or at least for a very long time).

The present paper examines challenges to sustainable development in Brazilian Amazonia, but many of the challenges in this region are similar to those in other parts of the world, including Peru (Doleac, 2015; Erickson-Davis, 2016), Bolivia (Bottazzi and Dao, 2013; Muller et al., 2012a,b; Redo et al., 2011; Tejada et al., 2016), Ecuador (Mosandl et al., 2008;Tapia-Armijos et al., 2015), Indonesia (Busch et al., 2012; Fearnside, 1997a; Purnomo et al., 2017), Malaysia (Bryan et al., 2013; Miettinen et al., 2011) the Democratic Republic of Congo (Ickowitz et al., 2015; Wilkie et al., 2000) and Papua New Guinea (Filer et al., 2009; Shearman et al., 2009).

FORCES IMPEDING SUSTAINABLE DEVELOPMENT

Counteracting unsustainable development, including land-use changes such as deforestation for extensive cattle pasture that can hardly be called "development" (Fearnside, 1997b), must begin with the reforming the decision-making process. Decision making currently leads to government priority on building highways, dams and other large infrastructure projects that destroy ecosystems both directly and by the economic transformations and population migrations they promote. These government decisions do not, in practice, consider alternatives. Examples include the BR-319 (Manaus-Porto Velho) Highway and the many proposed dams in Amazonia (Figure).

[Figure here]

It is relevant to note the revelation by Brazil's Supreme Electoral Court (TSE) in 2013 that the four largest donors to political campaigns in Brazil in the preceding decade were construction firms that build dams and other infrastructure in Amazonia (Gama, 2013). The effect of political campaign contributions, both legal and illegal, became public knowledge in 2015 and 2016 with a series of confessions concerning bribes paid for contracts for building the Belo Monte Dam, both from the companies paying the bribes (*Amazonas em Tempo*, 2015a) and from the politicians on the receiving end (e.g., do Amaral, 2016). The construction firms paid 1% of the contract value as bribes, and these payments were critical to funding the 2010 and 2014 presidential campaigns of the victorious political party, according to the confession (released by federal courts) of the party leader in the Federal Senate (do Amaral, 2016). This provides a rationale for the extraordinary personal involvement of two Brazilian presidents (Luiz Inácio Lula da Silva and Dilma Vana Rousseff) in promoting the dam and pushing for approval of its licensing despite high socio-environmental and financial costs (see: Fearnside, 2017a,b).

The revelations regarding political campaign financing provide an explanation for the mystery of why the Brazilian government would so heavily subsidize a project

with little chance of viability in strictly financial terms, even disregarding its social and environmental impacts. The over US$10 billion cost is 80% financed by Brazil's National Bank of Economic and Social Development (BNDES) at 4% annual interest, while the federal government finances itself by selling bonds at 10% annual interest (e.g., Leitão, 2010). Because of the extended period of the year with low seasonal water flow in the Xingu River, the dam's chance of financial viability is minuscule even assuming no future impacts of climate change (de Sousa Júnior and Reid, 2010; de Sousa Júnior et al., 2006; Fearnside, 2017b,c). Projected decrease in the Xingu River's flow due to precipitation changes predicted to result from global warming (Ângelo and Feitosa, 2015; Sorribas et al., 2016) and altered seasonal distribution of flow due to deforestation (Stickler et al., 2013) make the outlook even more untenable as an investment.

The influence of money on environmentally destructive decisions was dramatically demonstrated by the votes in the National Congress in 2011 and 2012 on reforming (gutting) the country's Forest Code (Law 12.651/2012: Brazil, PR, 2012). The initial vote in the Chamber of Deputies, which has representation proportional to population, was in a ratio of 7:1 against the environment, allowing more deforestation on steep hillsides and in gallery forests along rivers, and forgiving 43 years of violations of the previous Forest Code. Brazil's scientific community had provided ample warning of the environmental consequences of the proposed revision, including a joint report by the Brazilian Society for the Progress of Science (SBPC) and the Brazilian Academy of Sciences (ABC) (da Silva et al., 2011), but this advice was ignored by the National Congress. Brazil's population is 85% urban, and the fraction of the total with a financial stake in being allowed to deforest in these areas is miniscule. Opinion polls at the time showed 85% of Brazil's population opposing any change in the Forest Code (Barrionuevo, 2012). The logical explanation for a 7:1 vote against the interests of the electorate lies in the financial power of agribusiness interests such as soy plantations and cattle ranches. The "ruralist block" that represents large landowners in the National Congress has continued to gain strength; Blairo Maggi, who became Brazil's minister of agriculture on 12 May 2016, is the country's largest soybean producer and was awarded the Greenpeace "golden chainsaw" when he was governor of the state of Mato Grosso (Greenpeace, 2005).

Weakening of environmental licensing in Brazil is a major barrier to counteracting forces for unsustainable development. In 2016 the National Congress produced an explosion of new legislative proposals (and of sudden accelerations of longstanding ones) to weaken or even effectively abolish the licensing system (Fearnside, 2016a). Proposed laws moving forward under "urgent" status (PLS-654/2015 in the Senate and PL-3.729/2004 in the Chamber of Deputies) would allow "strategic" projects (such as dams) to be licensed in a streamlined one-step process (Brazil, Câmara dos Deputados, 2004; Brazil, Senado Federal, 2016a). Approval by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) is demanded within deadlines that make adequate analysis impossible, after which the proposed projects are automatically approved. The proposed law in the Senate is led by Senator Romero Jucá, whose fortune stems from Amazonian gold mining and who has a long record of actions to diminish the rights of Amazonian indigenous peoples (Rocha, 2012). He is currently the leader of the largest political party in the Brazilian Senate. The proposed law in the Chamber of Deputies is led by Deputy Mauro Pereira of the Parliamentary Front for Agriculture and Ranching (FPA, 2016).

A proposed constitutional amendment (PEC-65/2012), also progressing under "urgent" status, would make the mere submission of an EIA sufficient to allow major infrastructure projects such as dams and highways to go unstoppably forward to completion (Brazil, Senado Federal, 2016b). This proposal is particularly incongruous given the environmental-licensing failure behind the still ongoing disaster of a mine tailings dam breaking on 5 November 2015, destroying a town near Mariana, Minas Gerais and virtually all aquatic life on one of Brazil's major rivers (Oliveira, 2016). Many senators and federal deputies have given ample indications of their tendency to respond to influences promoting non-sustainable options in debates like this (Fearnside, 2015a). This proposed constitutional amendment was authored by Senator Acir Gurgacz, who, as the founder of a mining company in Rondônia and owner of the largest bus company plying Amazonian highways, is the second wealthiest member of the Senate (*Infomoney*, 2014). Constitutional amendments are very much more common in Brazil than, for example, in the United States. Amendments in Brazil require a 60% majority in two votes in both houses of the National Congress, after which they automatically take effect with no need for presidential sanction. Since coming into force in October 1988, Brazil's current constitution had been amended 90 times by December 2015 (Lima, 2016).

A law passed in September 2016 (Law 13.334/2016, enacting proposal MPV 727) can achieve the same weakening of Brazil's licensing system by another mechanism. This law, which established the Program for Partnerships for Investment (PPI), states (Article 17): "The agencies, entities and government authorities …. on which the viability of a PPI enterprise depends have the duty to act …. so that completion will [occur] on a time-schedule compatible with the national-priority character of the project [of] all processes and administrative acts necessary for [the project's] structuring, release and execution. .... Release means obtaining any …. environmental, indigenous, …. and any other [type of] license necessary for the deployment and operation of the enterprise" (Brazil, PR, 2016). This means that the PPI Executive Board will have power over IBAMA, the National Foundation for the Indian (FUNAI), and all relevant state and municipal agencies, and that the Board is empowered to set deadlines and demand approval of any project regardless of impacts.

There is also a proposed constitutional amendment (PEC-215) that would transfer authority from the executive branch to the legislature for creating indigenous areas and conservation units (Brazil, Câmara dos Deputados, 2014). In practice, this would be the end of creating more of these areas, and this amendment is a top priority of the "ruralist block" (*OEco*, 2015). Indigenous lands would be opened to mining by PEC-210 and PL-1619/1996, which have long been dormant and now have emerged as legislative priorities (Fearnside, 2016a).

Licensing is also weakened by the increasing tendency to override the technical opinions of the licensing staff in IBAMA. Pending approval of the one-step system being considered in the National Congress, licensing is done in three steps: a preliminary license allowing preparations to begin, an installation license allowing the physical structure (such as a dam) to be built, and an operational license, allowing, for example, the reservoir behind a dam to be filled. In the case of the Madeira River dams, a 121-page formal opinion (*parecer*) by the technical staff recommending against approval of the preliminary license (Deberdt et al., 2007) was overruled by changing the

head of the licensing department; the replacement was then promoted to head IBAMA as a whole, in which capacity he overruled a 146-page technical opinion (Brazil, IBAMA, 2008) and approved the installation license (see Fearnside, 2014). In the case of the Belo Monte Dam, two technical opinions totaling 366 pages opposing the preliminary license (Brazil, IBAMA, 2009, 2010) were overruled by changing the head of the licensing department and the head ("president") of IBAMA (Agência Brasil, 2011; Hurwitz, 2011). The installation license was approved overruling a 252-page technical opinion (Brazil, IBAMA, 2011) by changing the head of IBAMA again (Fearnside, 2012a). These precedents demoralize the technical staff and can be expected to increase the tendency to allow politically favored projects to pass without meeting requirements. An additional weakening is the practice of approving licensing steps with a list of "preconditions" (*condicionantes*) that are supposed to be satisfied before the next license in the sequence is granted. Preconditions have only been used since 2003 and are an increasingly common feature of the licensing process, allowing projects to move forward that would previously have been required to meet these demands before receiving the license. An even more drastic precedent has been set by Belo Monte in 2015, when the operating license was granted, overruling a 242-page opinion (Brazil, IBAMA, 2015), even though most of the 40 preconditions established by IBAMA had not been met (Villas-Bôas et al., 2015). This opens the door to any project being completed without satisfying IBAMA licensing demands.

July and August 2017 saw a spectacular series of blows to Brazil's licensing system and other environmental protections in the days (and even hours) leading up to a vote in the Chamber of Deputies on a motion to authorize impeachment proceedings against president Michel Temer on the basis of corruption revelations (see sources referenced in Fearnside, 2017d). Among the setbacks were the president's reneging on a promise to the environment minister regarding the administration's coalition of political parties being obliged to oppose gutting the licensing system under PL-3.729/2004, signing Law 13.465 (formerly MP-759, known as the "land-thieves' law" or "*lei da grilagem*") that includes allowing "legalization" of illegal land claims of up to 2500 ha, effectively pardoning vast sums in fines and debts owed to the government by the agribusiness and ranching sectors, weakening criteria for definition of indigenous lands, support for a controversial highway demanded by ruralists, and measures to reduce Amazonian protected areas. These are in addition to handing out over R$ 4 billion (US$ 1.3 billion) in pork-barrel appropriations known as "*emendas*" to selected federal deputies, with estimates of future "*emendas*" as high as R$ 17 billion (US$ 5.2 billion), in addition to various other expensive concessions. Many of the beneficiaries were among the estimated 231 ruralist representatives in the 454-member Chamber of Deputies. The ruralist block alone is more than sufficient to prevent reaching the two-thirds majority required to begin impeachment proceedings. In the midst of Brazil's economic "crisis," the cost of the pork-barrel "*emendas*" translates into a significant addition to the expenditure cutbacks that are already hampering inspection and enforcement by the Environment Ministry. The impeachment motion was defeated on 2 August 2017, a result for which ruralist votes were critical.

A serious barrier to effective licensing is the existence of "security suspension" laws that allow overruling any judicial decision blocking a development project if halting the project would cause "grave damage" to the public economy. Clearly, any hydroelectric dam or major highway is important for the economy and so can be allowed to go forward using these laws regardless of how many laws, constitutional

protections or international agreements have been violated. Security suspensions were established during Brazil's 1964-1985 military dictatorship (Law 4348 of 26 June 1964: Brazil, PR, 1964), but continue in force today (Laws 8437 of 30 June 1992 and 12,016 of 7 August 2009: Brazil, PR, 1992, 2009). By 2014 these laws had already been used eight times in the case of Belo Monte and 12 times in the case of the Tapajós River dams (Palmquist, 2014). Very few people in Brazil even know of the existence of security suspensions, thereby diminishing any impetus to change these laws (Fearnside, 2015b).

ALTERNATIVES

It is not enough to fight each environmentally and socially disastrous project that is proposed in Amazonia. Proposals of alternatives are needed in some (but not all) cases. There is no need to provide alternatives for entrepreneurs wishing to make profitable investments in destructive activities in Amazonia, such as deforestation for cattle ranching (Fearnside, 1989). These actors can seek out other options on their own, and the penalties and rewards for different choices need to be adjusted to make sustainable options the most attractive.

Energy alternatives abound in Brazil, making the government's plans for many more dams in Amazonia unnecessary (e.g., Fearnside, 2016b). The plans themselves are based on flawed projections, as costs and construction times of dams are systematically underestimated (e.g., Ansar et al., 2014) and Brazil's assumed future energy demands are based on wildly unrealistic projections of economic growth (Prado et al., 2016). One obvious step is for Brazil to stop exporting electricity in the form of electro-intensive commodities like aluminum, which generate very little employment in Brazil while wreaking great damage through the dams built to supply these industries (Fearnside, 2016c). Brazil has many options for energy conservation, such as eliminating the electric showerheads that consume 5% of the country's electricity (Brazil, CIMC, 2008, p. 58) for a service that can be performed by solar water heaters without using electricity at all (Costa, 2007). Brazil's inefficient electrical transmission system, which wastes 20% of the power transmitted, could be greatly improved without the impact of building more dams (Rey, 2012). Brazil also has enormous undeveloped wind and solar resources, which clearly receive much lower priority than hydropower (Baitelo, 2012; Baitelo et al., 2013). In January 2016 Brazil's president vetoed the inclusion of any funding for "non-hydraulic renewable energy" in the next five-year development plan (PPA) (ISA, 2016).

Some proposed highway projects, such as reconstruction of the BR-163 (Santarém-Cuiabá) Highway, have substantial economic benefits, albeit with serious environmental and social problems (Fearnside, 2007). In other cases, proposed roads are unviable and the best alternative is to simply not build them (Fleck, 2009). Economic viability is determined, in practice, solely from the financial costs and returns of the project, without considering the human and environmental impacts. Since these are high-impact projects, their unviability would very often be clear were these impacts given proper weight.

The transport case with the greatest potential consequences is the proposed reopening of the abandoned BR-319 Highway (Manaus-Porto Velho). This would open approximately half of what remains of Brazil's Amazon forest to entry of deforesters

from the notorious "arc of deforestation" – the strip of land along the southern and eastern edges of the forest where deforestation activity has been concentrated to date. The state of Rondônia, long a deforestation hotspot, would be connected to Manaus in central Amazonia, from which a road network already exists with connections to Roraima and other locations (e.g., Barni et al., 2015). New roads are proposed branching off the BR-319, including one that would cross the Purus River at Tapuã and open the vast block of still-intact forest in the western half of the state of Amazonas. The environmental impact study (EIA) is limited to considering impacts adjacent to the highway route, not the impact of migration along existing roads or of building planned side roads (UFAM, 2009). The EIA endorses the road as "environmentally and socially desirable" based on the unlikely scenario of "strong environmental governance," the example being tourism in Yellowstone National Park in the USA (see Fearnside, 2015c). In a 177-page formal opinion (*parecer*), IBAMA's technical staff concluded that "… the EIA lacks the minimal conditions and information that would permit evaluation of the environmental viability of the undertaking" (Arbocz et al., 2009, p. 175) and that "… even leaving aside the technical quality of the EIA, the preliminary license cannot be emitted" (Arbocz et al., 2009, p. 176). Nevertheless, in April 2015 IBAMA approved what was euphemistically termed "maintenance" of the highway (*Amazonas em Tempo*, 2015b) allowing all but laying down the final pavement. Organized landless farmers have already begun to invade the central section of the highway area even before the "maintenance" is completed (Assayag, 2016).

BR-319 is unnecessary for its supposed purpose of transporting the products of factories in Manaus to markets in São Paulo. Transport of containers to São Paulo is 19% cheaper by the current system of barges between Manaus and Belém and truck transport from Belém to São Paulo, and would be 37% cheaper than this current system if adequate port facilities were installed (for example in Itacoatiara) to carry the freight by ship to Santos, from which it would be distributed using the existing transport system in the state of São Paulo (Teixeira, 2007). These represent much better alternatives not only in terms of cost but also in terms of environmental impact; nevertheless, alternative routes to São Paulo were not considered in the EIA for the BR-319 (Fearnside and Graça, 2009). Promotion of the highway by politicians in Manaus has been an effective means of attracting votes, and this is the most likely explanation for the priority given to the project. The highway, most of the expense for which would be borne by taxpayers in other parts of Brazil, is promoted as allowing Manaus residents to travel freely to population centers in the southeastern part of the country for vacation travel. However, because Manaus is privileged to be a free-trade zone where factories assemble products from imported components, the practical effect of the road would instead be population migration to Manaus from parts of the country with higher unemployment, with negative consequences for urban residents in Manaus (Fearnside, 2010).

Unlike all other major construction projects in Brazil, the reconstruction of Highway BR-319 has no economic viability study. These massive documents assess the financial costs and benefits of proposed public works; in the case of a highway, for example, such a study would estimate the quantity and value of freight to be transported and would compare the costs with other alternatives. The justification for not requiring a viability study was that the highway was a matter of "national security." However, this role is improbable given that the road is far from any international borders. In 2012 General Eduardo Villas Bôas, then head of the Amazonia Command and now head of Brazil's army as a whole, spoke at the National Institute for Research in Amazonia

(INPA) for almost two hours on "national security in Amazonia." The speech was recorded and published (Villas Bôas, 2012). When questioned as to why nothing had been said about reopening Highway BR-319 as one of the priorities, he confirmed that the highway is not a priority for national security (see Fearnside, 2012b). Indeed, the highway does not appear in Brazil's 2008 "Strategy for National Defense" (Brazil, PR, 2008). One might ask, then, why BR-319 is a priority under Brazil's Program for the Acceleration of Growth, given that the project has neither a military nor an economic rationale. The most evident explanation is that supporting it attracts votes in Manaus – provided that the cost is paid by taxpayers throughout Brazil. Politicians in Manaus are invariably in favor of the road and compete with each other to take credit for its construction (e.g., Farias, 2015).

The value of environmental services represents the best alternative for supporting the traditional population in the Amazonian interior (Fearnside, 1997c, 2008a). The roles of Amazon forest in avoiding global warming (e.g., Fearnside, 2000a), in maintaining the hydrological cycle (including supply of water vapor to other parts of Brazil, such as São Paulo; e.g., Arraut et al., 2012), and maintaining biodiversity both for utilitarian and existential reasons (e.g., Fearnside, 1999), represent values that far exceed the monetary returns from most deforestation in Amazonia, for example selling the timber followed by clearing for extensive cattle pasture. Yet the institutional mechanisms for tapping environmental services are only beginning to be developed. A variety of challenges face Reducing Emissions from Deforestation and Degradation (REDD) as an option, but action on this front is essential. Challenges include the differing political interests of countries with forests providing services, such as Brazil, and the countries such as those in Europe that might pay for the services (Fearnside, 2012c, 2013). Another is the need for improved data quantifying the environmental services (Fearnside, 2008b). Finally, there is the "theoretical battlefield," which involves questions on how carbon and other benefits are accounted (Fearnside, 2012d). Issues such as adjustments for uncertainty (Fearnside, 2000b) and the value attributed to time (Fearnside, 2002) can have much greater impact on the value attributed to avoiding Amazonian deforestation than do outstanding uncertainties about forest biomass and carbon stocks (e.g., Fearnside, 1995, 2009; Fearnside et al., 2000). A related question is the relative priority that should be given to creating protected areas near the arc of deforestation, where costs are high and the areas that can be protected are therefore small but where "additionality" is great due to immediate threat, versus creating larger reserves far from the current deforestation frontier.

The many challenges touched upon in the foregoing review suggest the need for a variety of actions if sustainable development is to be achieved in Brazilian Amazonia. More research is not enough in most cases. More fundamental are changes in decision making, elimination of corruption and other features of the business and political systems that lead to destructive outcomes, and legislative measures to eliminate legal loopholes (such as "security suspensions") and creation of the institutional mechanisms for an Amazonian economy centered on environmental services rather than destruction of the forest.

CONCLUSIONS

Sustainable development is impeded by forces that favor land uses and infrastructure projects that are neither sustainable nor development: they are ephemeral

and often worsen rather than improve the wellbeing of the Amazon region's inhabitants. The current decision-making and licensing processes are influenced to favor projects with high environmental and social impacts and few benefits to local populations. Decision-making and licensing procedures must be changed to favor other alternatives, of which Brazil has many. Rather than building more roads, much of the cargo in Amazonia can be transported by water. Rather than building more dams, Brazil's electricity can be obtained by eliminating inefficiency, waste and exports of electro-intensive commodities and by investment in the country's vast wind and solar resources. Traditional rural populations in the Amazonian interior can be supported by tapping the value of the forest's environmental services, a goal that will require progress not only in environmental and social research but also in developing appropriate institutional mechanisms.

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LITERATURE CITED

Agência Brasil. 2011. Ibama concede licença ambiental para Hidrelétrica de Belo Monte. *Gazeta do Povo*, 1 February 2010. http://www.gazetadopovo.com.br/economia/ibama-concede-licenca-ambiental-para-hidreletrica-de-belo-monte-dhifis54m89b4jf13oy3l2dse [1 March 2016]

Amazonas em Tempo. 2015a Delator deverá revelar propina em Belo Monte. *Amazonas em Tempo*, 7 March 2015, p. B-3.

Amazonas em Tempo. 2015b. BR-319: Ibama autoriza o licenciamento. *Amazonas em Tempo*, 5 April 2015, p. C-2.

Ângelo C, Feitosa C. 2015. País poderá viver drama climático em 2040, indicam estudos da Presidência, *Observatório do Clima*, 30 October 2015, http://www.observatoriodoclima.eco.br/pais-podera-viver-drama-climatico-em-2040/

Ansar A, Flyvbjerg B, Budzier A, Lunn D. 2014. Should we build more large dams? The actual costs of hydropower megaproject development. *Energy Policy*, 69, pp 43–56. doi: 10.1016/j.enpol.2013.10.069

Arbocz GF, Magalhães L, Pereira MG, Naliato VJ, Reinecke. W. 2009. Parecer No. 078/2009 - COTRA/CGTMO/DILIC/IBAMA. Assunto: Analise da viabilidade ambiental das obras de pavimentação/reconstrução da rodovia BR-319, no trecho entre os Km's 250 a 655,7, com 405,7 km de extensão no Estado do

Amazonas. Processo n° 02001.006860/2005-95. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA): Brasília, DF, Brazil: 177 pp.

Arraut JM, Nobre CA, Barbosa HM, Obregon G, Marengo JA. 2012. Aerial rivers and lakes: Looking at large-scale moisture transport and its relation to Amazonia and to subtropical rainfall in South America. *Journal of Climate*, 25(2), pp 543-556. doi: 10.1175/2011JCLI418

Assayag Y. 2016. MPF/AM cobra de órgãos ambientais e da polícia providências sobre denúncia de invasão na BR-319. *Amazonas em Tempo*, 28 October 2016. http://www.emtempo.com.br/mpfam-cobra-de-orgaos-ambientais-e-da-policia-providencias-sobre-denuncia-de-invasao-na-br-319/ [10 December 2016].

Baitelo R. 2012. Energias renováveis: Eólica e solar. In: Moreira PF. (ed.) *Setor Elétrico Brasileiro e a Sustentabilidade no Século 21: Oportunidades e Desafios. 2ª ed*. Brasília, DF, Brazil: Rios Internacionais; pp 71-79. http://www.internationalrivers.org/node/7525

Baitelo R, Yamaoka M, Nitta R, Batista R. 2013. *[R]evolução energética: A caminho do desenvolvimento*. Greenpeace Brasil: São Paulo, SP, Brazil; 79 pp. http://www.greenpeace.org/brasil/Global/brasil/image/2013/Agosto/Revolucao_Energetica.pdf [8 March 2016].

Barni PE, Fearnside PM, Graça PMLA. 2015. Simulating deforestation and carbon loss in Amazonia: impacts in Brazil's Roraima state from reconstructing Highway BR-319 (Manaus-Porto Velho). *Environmental Management*, 55(2), pp 259-278. doi: 10.1007/s00267-014-0408-6

Barrionuevo A. 2012. In Brazil, fears of a slide back for Amazon protection. *The New York Times*, 24 January 2012. http://www.nytimes.com/2012/01/25/world/americas/in-brazil-protection-of-amazon-rainforest-takes-a-step-back.html?_r=0

Bottazzi P, Dao H. 2013. On the road through the Bolivian Amazon: A multi-level land governance analysis of deforestation. *Land Use Policy*, 30(1), pp 137–146. doi: 10.1016/j.landusepol.2012.03.010

Brazil, Câmara dos Deputados. 2004. PL-3.729/2004, Projeto de Lei Nº , de 2004. Dispõe sobre o licenciamento ambiental, regulamenta o inciso IV do § 1º do art. 225 da Constituição Federal, e dá outras providências. Câmara dos Deputados: Brasília, DF, Brazil. http://www.camara.gov.br/proposicoesWeb/prop_mostrarintegra;jsessionid=E0835B55D081DCED29036318FAA6A7F1.proposicoesWebExterno2?codteor=225810&filename=PL+3729/2004 [10 December 2016].

Brazil, Câmara dos Deputados. 2014. PEC 215/2000 Proposta de Emenda à Constituição. Câmara dos Deputados: Brasília, DF, Brazil. http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=14562 [10 December 2016].

Brazil, CIMC (Comitê Interministerial sobre Mudança do Clima). 2008. *Plano Nacional sobre Mudança do Clima – PNMC -- Brasil*. Ministério do Meio Ambiente: Brasília, DF, Brazil; 129 pp. http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_01122008060233.pdf [10 December 2016].

Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). 2008. Parecer Técnico No. 45/2008-COHID/CGENE/DILIC/IBAMA de 08 de maio de 2008. Assunto: Análise da solicitação da emissão da Licença de Instalação do Aproveitamento Hidrelétrico de Santo Antônio. IBAMA: Brasília, DF, Brazil; 146 pp. http://licenciamento.ibama.gov.br/Hidreletricas/Santo%20Antonio%20(Rio%20Madeira)/Resposta%20ao%20MP%20-%20F.%20Parlamentar%20Cumprimento%20Cond.%20UHEs%20Rio%20Madeira/Pareceres%20LI%20e%20LO/LOPT_78_2011_Avalia%C3%A7%C3%A3o%20Final%20-%20SAE.pdf [10 December 2016].

Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). 2009. Parecer Técnico No. 114/2009 – COHID/CGENE/DILIC/IBAMA, de 23/11/2009, Assunto: AHE Belo Monte. Ref: Análise técnica do Estudo de Impacto Ambiental do Aproveitamento Hidrelétrico Belo Monte, processo n° 02001.001848/2006-75. IBAMA: Brasília, DF, Brazil; 345 pp. http://www.ibama.gov.br/licenciamento/index.php [3 March 2016].

Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. 2010. Parecer Técnico No. 06/2010-COHID/CGENE/DILIC/IBAMA de 26 de janeiro de 2010. Assunto: Análise técnica das complementações solicitadas no Parecer nº 114/2009, referente ao Aproveitamento Hidrelétrico Belo Monte, processo n° 02001.001848/2006-75. IBAMA: Brasília, DF, Brazil; 21 pp. http://www.ibama.gov.br/licenciamento/index.php [10 December 2016].

Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) 2011. Parecer No 52/2011AHE Belo Monte-COHID/CGENE/DILIC/IBAMA. Ref: Análise da solicitação de Licença de Instalação da Usina Hidrelétrica Belo Monte, processo No 02001.001848/2006-75. IBAMA: Brasília, DF, Brazil; 252 pp. http://www.ibama.gov.br/licenciamento/index.php [3 March 2016].

Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) 2015. Parecer No. 02001.003622/2015-08. UHE Belo Monte - COHID/IBAMA. Ref.: Análise da solicitação de Licença de Operação da Usina Hidrelétrica Belo Monte, processo n° 02001.001848/2006-75. IBAMA: Brasília, DF, Brazil; 242 pp. http://www.ibama.gov.br/licenciamento/index.php [3 March 2016].

Brazil, PR (Presidência da República).1964. Lei nº4.348, de 26 de junho de 1964. Estabelece normas processuais relativas a mandado de segurança. PR: Brasília,

DF, Brazil. https://arisp.files.wordpress.com/2008/12/boletim-ago-fev-1964-65_lei-n-4-348.pdf [10 December 2016].

Brazil, PR (Presidência da República). 1992. Lei nº8.437, de 30 de junho de 1992. Dispõe sobre a concessão de medidas cautelares contra atos do poder público e dá outras providências. PR: Brasília, DF, Brazil. http://legislacao.planalto.gov.br/legisla/legislacao.nsf/Viw_Identificacao/lei%208.437-1992?OpenDocument [10 December 2016].

Brazil, PR (Presidência da República). 2009. Lei nº12.016, de 07 de agosto de 2009. Disciplina o mandado de segurança individual e coletivo e dá outras providências. PR: Brasília, DF, Brazil. http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12016.htm [10 December 2016].

Brazil, PR (Presidência da República). 2012. Lei Nº 12.651/2012, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa; altera as Leis nºs 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nºs 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória nº 2.166-67, de 24 de agosto de 2001; e dá outras providências. PR: Brasília, DF, Brazil. http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm [10 December 2016].

Brazil, PR (Presidência da República). 2016. Lei Nº 13.334, de 13 de Setembro de 2016. Cria o Programa de Parcerias de Investimentos - PPI; altera a Lei nº 10.683, de 28 de maio de 2003, e dá outras providências. Câmara dos Deputados: Brasília, DF, Brazil. http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2016/lei/L13334.htm [10 December 2016].

Brazil, Senado Federal. 2016a. Projeto de Lei do Senado nº 654, de 2015. Senado Federal: Brasília, DF, Brazil. http://www25.senado.leg.br/web/atividade/materias/-/materia/123372 [14 June 2016].

Brazil, Senado Federal. 2016b. Proposta de Emenda à Constituição nº 65, de 2012 - Agenda Brasil 2015. Senado Federal: Brasília, DF, Brazil. http://www25.senado.leg.br/web/atividade/materias/-/materia/109736 [10 December 2016].

Bryan JE, Shearman PL, Asner GP, Knapp DE, Aoro G, Lokes B. 2013. Extreme differences in forest degradation in Borneo: Comparing practices in Sarawak, Sabah, and Brunei. *PLoS ONE*, 8(7), art. e69679. doi: 10.1371/journal.pone.0069679

Busch J, Lubowski RN, Godoy F, Steininger M, Yusuf AA, Austin K, Hewson J, Juhn D, Farid M, Boltz F. 2012. Structuring economic incentives to reduce emissions from deforestation within Indonesia. *Proceedings of the National Academy of Science of the USA*, 109(4), pp 1062-1067.doi: 10.1073/pnas.1109034109

Costa RNA. 2007. *Viabilidades Térmica, Económica e de Materiais de um Sistema Solar de Aquecimento de Água a Baixo Custo para Fins Residenciais*. Masters dissertation in mechanical engineering. Universidade Federal de Rio Grande do Norte: Natal, RN, Brazil; 77 pp. http://bdtd.bczm.ufrn.br/tedesimplificado//tde_arquivos/10/TDE-2008-02-21T011110Z-1119/Publico/RaimundoNAC.pdf

da Silva JAA, Nobre AD, Manzatto CV, Joly CA, Rodrigues RR, Skorupa LA, Nobre CA, Ahrens S, May PH, Sá TD, Cunha MC, Rech Filho EL. 2011. *O Código Florestal e a Ciência: Contribuições para o Diálogo*. Sociedade Brasileira para o Progresso da Ciência (SBPC): São Paulo, SP, Brazil and Academia Brasileira de Ciências (ABC): Rio de Janeiro, RJ, Brazil; 124 pp. http://www.abc.org.br/IMG/pdf/doc-547.pdf

Deberdt G, Teixeira I, Lima LMM, Campos MB, Choueri RB, Koblitz R, Franco SR, Abreu VLS. 2007. Parecer Técnico No. 014/2007 – FCOHID/CGENE/DILIC/IBAMA. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA): Brasília, DF, Brazil; 121 pp. http://philip.inpa.gov.br/publ_livres/Dossie/Mad/Documentos%20Oficiais/Madeiraparecer.pdf [10 December 2016].

de Sousa Júnior WC, Reid J. 2010. Uncertainties in Amazon hydropower development: Risk scenarios and environmental issues around the Belo Monte dam. *Water Alternatives* 3(2): 249-268. http://www.water-alternatives.org/index.php/volume3/v3issue2/92-a3-2-15/file

de Sousa Júnior, W.C., Reid, J. & Leitão, N.C.S. 2006. *Custos e benefícios do Complexo Hidrelétrico Belo Monte: Uma abordagem econômico-ambiental*. Conservation Strategy Fund (CSF), Lagoa Santa, MG. 90 pp. http://conservation-strategy.org/sites/default/files/field-file/4_Belo_Monte_Dam_Report_mar2006.pdf

do Amaral D. 2016. Anexo 07 Belo Monte. In: Termo de acordo de colaboração premiada. Petição 5952 - 22/02/2016. Supremo Tribunal Federal: Brasília, DF, Brazil; pp 69-70. https://drive.google.com/file/d/0BzuqMfbpwX4wYVJlak1qdmIyWUE/view [10 December 2016].

Doleac C. 2015. Deforestation in Peru: Building a dramatic future in the Amazon and the Andean Region. Council on Hemispheric Affairs (COHA). http://www.coha.org/deforestation-in-peru-building-a-dramatic-future-in-the-amazon-and-the-andean-region/ [13 May 2017].

Erickson-Davis M. 2016. Deforestation jumps into Peru reserve, 1,600 hectares of rainforest lost. *Mongabay*, 28 September 2016. https://news.mongabay.com/2016/09/deforestation-jumps-into-peru-reserve-1600-hectares-of-rainforest-lost/ [13 May 2017].

Farias G. 2015. Parlamentares dizem que não há impacto na BR-319. *Diário do Amazonas*, 29 October 2015: p. 4.

Fearnside PM. 1989. Deforestation in the Amazon. *Environment: Science and Policy for Sustainable Development*, 31(7), pp 4-5. doi: 10.1080/00139157.1989.9928956

Fearnside PM. 1995. Global warming response options in Brazil's forest sector: Comparison of project-level costs and benefits. *Biomass and Bioenergy*, 8(5), pp 309-322. doi: 10.1016/0961-9534(95)00024-0

Fearnside PM. 1997a. Transmigration in Indonesia: Lessons from its environmental and social impacts. *Environmental Management*, 21(4), pp 553-570. doi: 10.1007/s002679900049

Fearnside PM. 1997b. Limiting factors for development of agriculture and ranching in Brazilian Amazonia. *Revista Brasileira de Biologia*, 57(4), pp 531-549.

Fearnside PM. 1997c. Environmental services as a strategy for sustainable development in rural Amazonia. *Ecological Economics*, 20(1), pp 53-70. doi: 10.1016/S0921-8009(96)00066-3

Fearnside PM. 1999. Biodiversity as an environmental service in Brazil's Amazonian forests: Risks, value and conservation. *Environmental Conservation*, 26(4), pp 305-321. doi: 10.1017/S0376892999000429

Fearnside PM. 2000a. Global warming and tropical land-use change: Greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation. *Climatic Change*, 46(1-2), pp 115-158. doi: 10.1023/A:1005569915357

Fearnside PM. 2000b. Uncertainty in land-use change and forestry sector mitigation options for global warming: Plantation silviculture versus avoided deforestation. *Biomass and Bioenergy*, 18(6), pp 457-468. doi: 10.1016/S0961-9534(00)00003-9

Fearnside PM. 2002. Time preference in global warming calculations: A proposal for a unified index. *Ecological Economics*, 41(1), pp 21-31. doi: 10.1016/S0921-8009(02)00004-6

Fearnside PM. 2007. Brazil's Cuiabá-Santarém (BR-163) Highway: The environmental cost of paving a soybean corridor through the Amazon. *Environmental Management*, 39(5), pp 601-614. doi: 10.1007/s00267-006-0149-2

Fearnside PM. 2008a. Amazon forest maintenance as a source of environmental services. *Anais da Academia Brasileira de Ciências*, 80(1), pp 101-114. doi: 10.1590/S0001-37652008000100006

Fearnside PM. 2008b. Quantificação do serviço ambiental do carbono nas florestas amazônicas brasileiras. *Oecologia Brasiliensis*, 12(4), pp 743-756. doi: 10.4257/oeco.2008.1204.12

Fearnside PM. 2009. Carbon benefits from Amazonian forest reserves: Leakage accounting and the value of time. *Mitigation and Adaptation Strategies for Global Change*, 14(6), pp 557-567. doi: 10.1007/s11027-009-9174-9

Fearnside PM. 2010. Impacto do desmatamento Amazônico sobre o ambiente urbano em Manaus. In: Nozawa SR, dos Santos ALW (eds.) *Impactos Urbanos sobre a Biologia do Ambiente Amazônico: Interações entre Moléculas, Organismos e Ambientes*. Editora CRV: Curitiba, PR, Brazil: pp 73-82.

Fearnside PM. 2012a. Belo Monte Dam: A spearhead for Brazil's dam building attack on Amazonia? *GWF Discussion Paper 1210*. Global Water Forum: Canberra, Australia; 6 pp. http://www.globalwaterforum.org/wp-content/uploads/2012/04/Belo-Monte-Dam-A-spearhead-for-Brazils-dam-building-attack-on-Amazonia_-GWF-1210.pdf [10 December 2016].

Fearnside PM. 2012b. Segurança nacional na Amazônia. In: Val AL, dos Santos, GM (eds.) *GEEA: Grupo de Estudos Estratégicos Amazônicos*. Tomo V, Editora do Instituto Nacional de Pesquisas da Amazônia (INPA): Manaus, AM. Brazil: pp 177 & 191.

Fearnside PM. 2012c. Brazil's Amazon forest in mitigating global warming: Unresolved controversies. *Climate Policy*, 12(1), pp 70-81. doi: 10.1080/14693062.2011.581571

Fearnside PM. 2012d. The theoretical battlefield: Accounting for the climate benefits of maintaining Brazil's Amazon forest. *Carbon Management*, 3(2), pp 145-148. doi: 10.4155/CMT.12.9

Fearnside PM. 2013. What is at stake for Brazilian Amazonia in the climate negotiations. *Climatic Change*, 118(3), pp 509-519. doi: 10.1007/s10584-012-0660-9

Fearnside PM. 2014. Brazil's Madeira River dams: A setback for environmental policy in Amazonian development. *Water Alternatives*, 7(1), pp 156-169. http://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/244-a7-1-15/file

Fearnside PM. 2015a. Brazil's São Luiz do Tapajós Dam: The art of cosmetic environmental impact assessments. *Water Alternatives*, 8(3), pp 373-396. http://www.water-alternatives.org/index.php/alldoc/articles/vol8/v8issue3/297-a8-3-5/file [10 December 2016].

Fearnside PM. 2015b. Amazon dams and waterways: Brazil's Tapajós Basin plans. *Ambio*, 44(5), pp 426-439. doi: 10.1007/s13280-015-0642-z

Fearnside PM. 2015c. Highway construction as a force in destruction of the Amazon forest. In: van der Ree R, Smith DJ, Grilo C. (eds.) *Handbook of Road Ecology*. Wiley: Oxford, UK; pp 414-424.

699 Fearnside PM. 2016a. Brazilian politics threaten environmental policies. *Science*, 353,
700 pp 746-748. doi: 10.1126/science.aag0254
701
702 Fearnside PM. 2016b. Tropical dams: To build or not to build? *Science*, 351, pp 456-
703 457. doi: 10.1126/science.351.6272.456-b
704
705 Fearnside PM. 2016c. Environmental and social impacts of hydroelectric dams in
706 Brazilian Amazonia: Implications for the aluminum industry. *World*
707 *Development*, 77, pp 48-65. doi: 10.1016/j.worlddev.2015.08.015
708
709 Fearnside PM. 2017a. Belo Monte: Actors and arguments in the struggle over Brazil's
710 most controversial Amazonian dam. *Die Erde*, 148(1), pp. 14-26. doi:
711 10.12854/erde-148-27
712
713 Fearnside PM. 2017b. Brazil's Belo Monte Dam: Lessons of an Amazonian resource
714 struggle. *Die Erde*, 148(2-3) (in press). doi: 10.12854/erde-148-26
715
716 Fearnside PM. 2017c. Planned disinformation: The example of the Belo Monte Dam as
717 a source of greenhouse gases. In: Issberner L-R, Lena P (eds.) *Brazil in the*
718 *Anthropocene: Conflicts between Predatory Development and Environmental*
719 *Policies*. Routledge, Taylor & Francis Group**:** New York, U.S.A. pp. 125-142.
720
721 Fearnside, P.M. 2017d. Environmental nightmare for the Amazon. *Alert*, 22 August
722 2017. http://alert-conservation.org/issues-research-
723 highlights/2017/8/22/environmental-nightmare-for-the-amazon
724
725 Fearnside PM, Graça PMLA. 2009. BR-319: A rodovia Manaus-Porto Velho e o
726 impacto potencial de conectar o arco de desmatamento à Amazônia central.
727 *Novos Cadernos NAEA*, 12(1), pp 19-50.
728 http://www.periodicos.ufpa.br/index.php/ncn/article/viewFile/241/427 [10
729 December 2016].
730
731 Fearnside PM, Lashof DA, Moura-Costa P. 2000. Accounting for time in mitigating
732 global warming through land-use change and forestry. *Mitigation and*
733 *Adaptation Strategies for Global Change*, 5(3), pp 239-270. doi:
734 10.1023/A:1009625122628
735
736 Filer C, Keenan RJ, Allen BJ, McAlpine JR. 2009. Deforestation and forest degradation
737 in Papua New Guinea. *Annals of Forest Science*, 66(8), art. 813. doi:
738 10.1051/forest/2009067
739
740 Fleck LC. 2009. *Eficiência Econômica, Riscos e Custos Ambientais da Reconstrução da*
741 *Rodovia BR-319*. Conservation Strategy Fund: Rio de Janeiro, RJ, Brazil. Série
742 Técnica Edição 17; 86 pp. http://conservation-
743 strategy.org/sites/default/files/field-file/CSF_Eficiencia_economica_BR319.pdf
744
745 FPA (Frente Parlamentar daAgropecuária). 2016. Licenciamento ambiental. Substitutivo
746 do deputado Pereira dará celeridade e desburocratizará o processo. FPA, 22
747 August 2016. http://www.fpagropecuaria.org.br/noticias/licenciamento-ambiental-

substitutivo-do-deputado-pereira-dara-celeridade-e-desburocratizara-o-processo#.WEwgrYWcF1s [10 December 2016].

Gama P. 2013. Maiores doadores somam gasto de R$1 bi desde 2002. Construtores e bancos são principais financiadores de campanhas eleitorais. *Folha de São Paulo*, 21 January 2013. p. A-6. http://www1.folha.uol.com.br/fsp/poder/89730-maiores-doadoras-somam-gasto-de-r-1-bi-desde-2002.shtml [8 March 2016].

Greenpeace. 2005. Humoristas do Pânico entregam prêmio motosserra para Maggi. Greenpeace: São Paulo, SP, Brazil. 17 June 2005. http://riosvivos.org.br/a/Noticia/Humoristas+do+Panico+entregam+premio+Motosserra+para+Maggi/6985 [10 December 2016].

Hurwitz Z. 2011. IBAMA President resigns over Belo Monte licensing. International Rivers: Berkeley, California, USA, 13 January 2011. https://www.internationalrivers.org/blogs/258/ibama-president-resigns-over-belo-monte-licensing [8 March2016].

Ickowitz A, Slayback D, Asanzi P, Nasi R. 2015. Agriculture and deforestation in the Democratic Republic of the Congo: A synthesis of the current state of knowledge. CIFOR Occasional Paper no. 119. Center for International Forestry Research (CIFOR), Bogor, Indonesia. doi**:** 10.17528/cifor/005458

Infomoney. 2014. Senador eleito mais rico tem quase R$ 400 milhões; veja onde eles investem. *Infomoney*, 9 October 2014. http://www.infomoney.com.br/onde-investir/fundos-de-investimento/noticia/3624539/senador-eleito-mais-rico-tem-quase-400-milhoes-veja-onde [10 December 2016].

ISA (Instituto Socioambiental). 2016. Dilma veta energias renováveis não hidráulicas no Plano Plurianual. *Notícias Socioambientais*, 21 January 2016; updated 27 January 2016. http://www.socioambiental.org/pt-br/noticias-socioambientais/dilma-veta-energias-renovaveis-nao-hidraulicas-no-plano-plurianual [8 March 2016].

Leitão M. 2010. Belo Monte's Avatar. International Rivers: Berkeley, California, U.S.A., 24 June 2010. https://www.internationalrivers.org/resources/belo-monte%E2%80%99s-avatar-2762.

Lima GMR. 2016. *Constitucionalização de Políticas Públicas e Emendamento Constitucional no Brasil*. Ph.D. thesis in public administration and government. Escola de Administração de Empresas de São Paulo: São Paulo, SP, Brazil; 102 pp. http://bibliotecadigital.fgv.br/dspace/bitstream/handle/10438/16375/TeseGiovannaLima.pdf?sequence=1 [10 December 2016].

Miettinen J, Shi C, Liew S. 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology*, 17, pp 2261–2270. doi 10.1111/j.1365-2486.2011.02398.x

Mosandl R, Günter S, Stimm B, Weber M. 2008. Ecuador suffers the highest deforestation rate in South America. In: Beck E, Bendix J, Kottke I, Makeschin F, Mosandl R. (eds.) *Gradients in a Tropical Mountain Ecosystem of Ecuador*. (Ecological Studies Vol. 198), Springer-Verlag, Heidleberg, Germany. pp 37-40. doi: 10.1007/978-3-540-73526-7_4

Muller R, Muller D, Schierhorn F, Gerold G, Pacheco P. 2012a. Proximate causes of deforestation in the Bolivian lowlands: An analysis of spatial dynamics. *Regional Environmental Change*, 11(3), pp 445-459. doi: 10.1007/s10113-011-0259-0

Muller R, Rohde S, Gerold G, Pacheco P. 2012b. Policy options to reduce deforestation based on a systematic analysis of drivers and agents in lowland Bolivia. 2013. *Land Use Policy*, 30(1), pp 895-907. doi: 10.1016/j.landusepol.2012.06.019

OEco. 2015. Ruralistas não desistirão da PEC das terras indígenas. *OEco*, 5 February 2015. http://www.oeco.org.br/salada-verde/28908-ruralistas-nao-desistirao-da-pec-das-terras-indigenas

Oliveira N. 2016. Collapsed dam the largest accident of the kind in 100 years. *Agência Brasil*, 15 January 2016. http://agenciabrasil.ebc.com.br/node/994429 [10 December 2016].

Palmquist H. 2014. Usina Teles Pires: Justiça ordena parar e governo federal libera operação, com base em suspensão de segurança. *Ponte*, 27 November 2014. http://ponte.org/usina-teles-pires-justica-ordena-parar-e-governo-federal-libera-operacao-com-base-em-suspensao-de-seguranca/ [8 March 2016].

Prado AP, Athayde S, Mossa J, Bohlman S, Leite F, Oliver-Smith A. 2016. How much is enough? An integrated examination of energy security, economic growth and climate change related to hydropower expansion in Brazil. *Renewable and Sustainable Energy Reviews*, 53, pp 1132-1136. doi: 10.1016/j.rser.2015.09.050

Redo D, Millington AC, Hindery D. 2011. Deforestation dynamics and policy changes in Bolivia's post-neoliberal era. *Land Use Policy*, 28(1), pp 227–241. doi: 10.1016/j.landusepol.2010.06.004

Rey O. 2012. Um olhar para as grandes perdas de energia nos sistema de transmissão elétrico brasileiro. In: Moreira PF. (ed.) *Setor Elétrico Brasileiro e a Sustentabilidade no Século 21: Oportunidades e Desafios*. 2ª ed. Rios Internacionais: Brasília, DF. Brazil; pp 40-44. http://www.internationalrivers.org/node/7525

Rocha M. 2012. Por que Romero Jucá defende a exploração de ouro em áreas indígenas. *Época*, 31 August 2012. http://revistaepoca.globo.com/Brasil/noticia/2012/08/por-que-romero-juca-defende-exploracao-de-ouro-em-areas-indigenas.html [10 December 2016].

Shearman PL, Ash J, Mackey B, Bryan JE, Lokes B. 2009. Forest conversion and degradation in Papua New Guinea 1972–2002. *Biotropica*, 41(3), pp 379–390. doi: 10.1111/*j*.1744-7429.2009.00495.x

Sorribas MV, Paiva, RCD, Melack JM, Bravo JM, Jones C, Carvalho L, Beighley E, Forsberg B, Costa MH. 2016. Projections of climate change effects on discharge and inundation in the Amazon basin. *Climatic Change*, 136(3-4), pp 555–570. doi 10.1007/s10584-016-1640-2

Stickler CM, Coe MT, Costa MH, Nepstad DC, McGrath DG, Dias LC, Rodrigues HO, Soares-Filho BS. 2013. Dependence of hydropower energy generation on forests in the Amazon Basin at local and regional scales. *Proceedings of the National Academy of Science of the USA*, 110(23), pp 9601–9606. doi: 10.1073/pnas.1215331110

Tapia-Armijos MF, Homeier J, Espinosa CI, Leuschner C, de la Cruz M. 2015. Deforestation and forest fragmentation in south Ecuador since the 1970s – Losing a hotspot of biodiversity. *PLoS ONE,* 10(9), art. e0133701. doi: 10.1371/journal.pone.0133701

Teixeira KM. 2007. *Investigação de Opções de Transporte de Carga Geral em Conteineres nas Conexões com a Região Amazônica*. Doctoral thesis in transport engineering. Universidade de São Paulo, Escola de Engenharia de São Carlos: São Carlos, SP, Brazil; 235 pp. http://www.dominiopublico.gov.br/pesquisa/PesquisaObraForm.do?select_action=&co_autor=33564 [10 December 2016].

Tejada G, Dalla-Nora E, Cordoba D, Lafortezza R, Ovando A, Assis T, Aguiar AP. 2016. Deforestation scenarios for the Bolivian lowlands. *Environmental Research*, 144(Part B), pp 49–63. doi: 10.1016/j.envres.2015.10.010

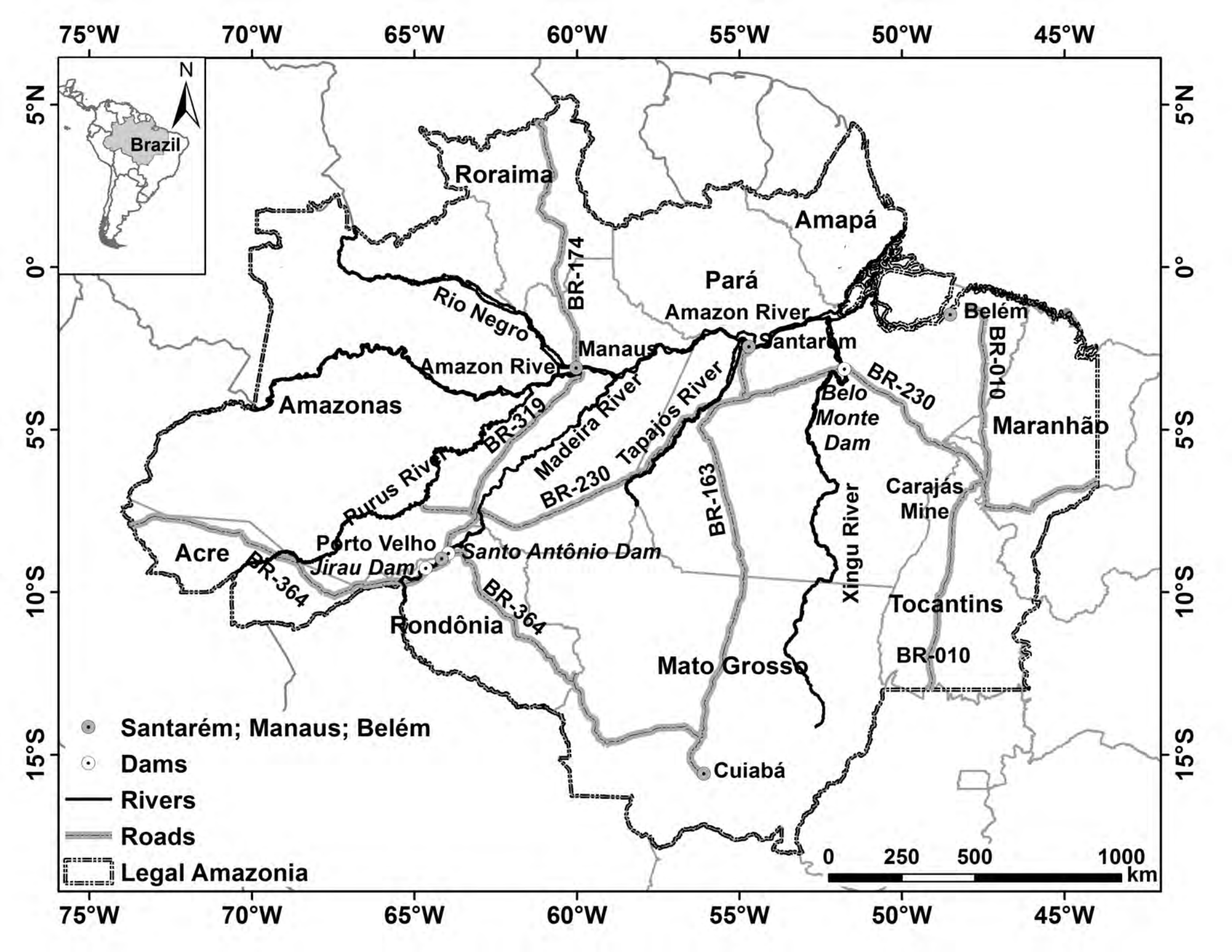
UFAM (Universidade Federal do Amazonas). 2009. *Estudo de Impacto Ambiental – EIA: Obras de reconstrução/pavimentação da rodovia BR-319/AM, no segmento entre os km 250,0 e km 655,7*. UFAM: Manaus, AM, Brazil; 6 Vols. + Annexes. http://philip.inpa.gov.br/publ_livres/Dossie/BR-319/BR-319.htm [10 December 2016].

Villas-Bôas A, Garzón BR, Reis C, Amorim L, Leite L. 2015. Dossiê Belo Monte: Não Há Condições para a Licença de Operação. Instituto Socioambiental (ISA): Brasília, DF, Brazil; 55 pp. http://t.co/zjnVPhPecW [8 March 2016].

Villas Bôas EDC. 2012. Segurança nacional na Amazônia. In: Val AL, dos Santos, GM (eds.) *GEEA: Grupo de Estudos Estratégicos Amazônicos*. Tomo V, Editora do Instituto Nacional de Pesquisas da Amazônia (INPA): Manaus, Amazonas. Brazil.. pp. 151-174.

Wilkie D, Shaw, Rotberg EF, Morelli G; Auzel P. 2000. Roads, development, and conservation in the Congo Basin. *Conservation Biology*, 14(6), 1614–1622. doi: 10.1111/j.1523-1739.2000.99102.x

895 **FIGURE LEGEND**
896
897 Figure. Map of Brazilian Amazonia with locations mentioned in the text.


75°W
70°W
65°W
60°W
55°W
50°W
45°W
5°N
0°
5°S
10°S
15°S
N
Brazil
Roraima
Amapá
Pará
Amazonas
Acre
Rondônia
Mato Grosso
Maranhão
Tocantins
Rio Negro
Amazon River
BR-174
Manaus
Santarém
Belém
BR-010
BR-230
Belo Monte Dam
Tapajós River
Madeira River
BR-319
Purus River
BR-163
Xingu River
Carajás Mine
Porto Velho
Jirau Dam
Santo Antônio Dam
BR-364
Cuiabá
Santarém; Manaus; Belém
Dams
Rivers
Roads
Legal Amazonia
0
250
500
1000
km