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Tourism as an instrument of forest protection in the Amazon: a multivariate analysis

O turismo como um instrumento de proteção florestal na Amazônia: uma análise multivariada

El turismo como un instrumento de protección forestal en La Amazonía: un análisis multivariante

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Abstract: Purpose of the theme: the growing international demand for primary goods has generated exceptional opportunities for mining and agribusiness in the Amazon. In many cases, this is causing a progressive loss of land cover. Many strategies are proposed to contain regional deforestation, including tourism, which is seen as a more sustainable alternative economic activity for the region. Objective: the purpose of this study was to estimate the relative importance of tourism to the deforestation rates in the Amazon biome in 2015-2016. Methodology and approach: a cross-sectional study was conducted for the 91 geographical micro-regions of the biome, to which multiple linear regression associated to covariance decomposition was applied with Pratt's Measure. Results: the results suggest that deforestation is due to livestock farming, agriculture, logging, rural settlements, protected areas and, among others, tourism. The study identified an inverse correlation between tourism and annual deforestation rates in the biome. Originality: the results of this study allow the proposition of the responsible development of tourism as a strategy for the protection of the forest cover of the Amazon.

Keywords: Regional development. Deforestation. Conservation. Land use.

Resumo: Propósito do tema: A crescente demanda internacional por bens primários tem gerado oportunidades excepcionais para a mineração e para o agronegócio na Amazônia. Isto está promovendo, em muitos casos, a perda progressiva da cobertura do solo. Muitas são as estratégias propostas para a contenção do desmatamento regional, ente elas, o turismo, apontado como uma atividade econômica alternativa e mais sustentável para a

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região. Objetivo: A finalidade deste estudo foi estimar a importância relativa do turismo para o ritmo do desmatamento no bioma Amazônia no período 2015/2016. Metodologia e abordagem: Foram utilizadas séries de corte para as 91 microrregiões geográficas do bioma, nas quais foi aplicada a técnica de regressão linear múltipla associada à decomposição das covariâncias pela Medida de Pratt. Resultados: Os resultados sugerem que o desmatamento é uma função da pecuária bovina, da agricultura, da extração de madeira, dos assentamentos rurais, das áreas protegidas e, entre outros, do turismo. Identificou-se uma correlação inversa entre o turismo e as taxas anuais de desmatamento do bioma. Originalidade: Os resultados deste estudo permitem propor o desenvolvimento responsável do turismo como uma estratégia para a proteção da cobertura florestal da Amazônia.

Palavras-chave: Desenvolvimento regional. Desmatamento. Conservação. Uso do solo.

Resumen: Propósito del tema: La creciente demanda internacional por bienes primarios ha generado oportunidades excepcionales para la mineración y para el agronegocio en la Amazonía. Esto está promoviendo, en muchos casos, la pérdida progresiva de la cobertura del suelo. Muchas son las estrategias propuestas para a contención de la deforestación regional, entre ellas, el turismo, apuntado como una actividad económica alternativa y más sostenible para la región. Objetivo: la finalidad de este estudio fue estimar la importancia relativa del turismo para el ritmo de la deforestación en el bioma Amazónico en el período 2015/2016. Metodología y abordaje: Fueron utilizadas series de corte para las 91 microrregiones geográficas do bioma, en las cuales fueron aplicadas a técnica de regresión linear múltiple asociada a la descomposición de las covarianzas por la Medida de Pratt. Resultados: los resultados sugieren que la deforestación está en función de la pecuaria bovina, de la agricultura, de la extracción de madera, de los asentamientos rurales, de las áreas protegidas y, entre otros, del turismo. Se identificó una correlación inversa entre el turismo y las tazas anuales de la deforestación del bioma. Originalidad: los resultados de este trabajo permiten proponer el desarrollo responsable del turismo como una estrategia para la protección de la cobertura forestal de la Amazonía.

Palabras clave: Desarrollo regional. Deforestación. Conservación. Uso del suelo.

1 INTRODUCTION

The accelerated economic growth since the mid-twentieth century has led to a significant improvement in the quality of life in most countries. As a result, pressures on natural resources reached a never-before-witnessed intensity (Intergovernmental Panel on Climate Change, 2014). Recently, the economic growth of highly populous countries, such as China, India, and Russia (Araújo & Costa, 2010), have greatly increased these demands with worrying trends. In Brazil, which is, historically, a producer of primary goods, the growing demand has generated exceptional opportunities, mainly for the mining-steel industry and agribusiness (Almeida & Marin, 2010). In many cases, however, at the expense of forests, as has occurred in the Amazon.

The Amazon biome is one of the six typologies of nature domains in Brazil, covering an area of 4.2 million km^2, 49.3% of the national territory (Instituto Brasileiro de Geografia e Estatística, 2005). The regional population reached 18.8 million inhabitants in 2010 (IBGE – Censo Demográfico, 2010), 9.6% of the Brazilian population. It is estimated that the region, a set of diverse ecosystems (land areas, rivers, and wetlands), holds about 30% of the remaining tropical forests on the planet (Food and Agriculture Organization of the United Nations, 2016), which contains approximately, 12.5% of all the existing biomass (Baccini, Goetz, Walker, Laporte, Sun, Sulla-Menashe, & Samanta, 2012), and is home to about one-third of all known species (World Wildlife Fund for Nature, 2013).

Deforestation can lead to a restructuring of surface atmospheric dynamics, both in the region itself (Spracklen & Garcia-Carreras, 2015) and as a whole (Medvigy, Walko, & Avissar, 2011). At the regional or local level, deforestation promotes a reduction in rainfall and evapotranspiration, with consequent reduction of soil and surface moisture (Navarrete, Tsai, Mendes, Faust, Hollander, Cassman, & Kuramae, 2015), reduction and contamination of water resources (Lewis, Brando, Phillips, Heijden, & Nepstad, 2011), damaging the health of populations (Hahn, Gangnon, Barcellos, Asner, & Patz, 2014), as well as loss of soil productivity (Lawrence & Vandecar, 2015) and significant damage to biodiversity (Barlow, Lennox, Ferreira, Berenguer, Lees, Mac Nally, & Parry, 2016). Socio-environmental problems such as migration and disorganized urban growth (Caviglia-Harris, Sills, & Mullan, 2013) and social conflicts, often followed by great violence (Solinge, 2010) are also registered. Despite the recognition of its importance, according to the National Institute for Space Research (INPE), up to 2016, 683.0 thousand km^2 of forest cover was lost, 15.2% of its area.

In this context, tourism is seen as an alternative and sustainable economic activity for the Amazon (Oliveira, Silva, Matos, & Hara, 2010; Peralta, 2012; Doan, 2013; Hoefle, 2016). The arguments are diverse. Tourism can act as a monitoring tool for the quality of the environment (Liu, Qu, Huang, Chen, Yue, Zhao, & Liang, 2014). Tourism can help manage protected areas through increased unit revenue, such as entrance fees, or a percentage of related activities (Chen, Nakama, & Zhang, 2017). In addition, it has regional political-economic weight. That is, the more relevant to the regional economy, the smaller the occupations in other areas (Lobo & Moretti, 2009). In terms of politics, the regional importance of tourism tends to be inversely correlated with public support for activities that degrade tourism resources, while its correlation with environmental policies is directly proportional.

Due to these aspects, the present study questions the relationship between tourism and deforestation in the Amazon. What was the contribution of tourism to regional deforestation? Consequently, the objective of this work is to estimate the relative importance of tourism to the rate of deforestation in the Amazon biome in 2015-2016. For this, we conducted ordinary least-squares multiple linear regression (Gujarati, 2006; Pindik & Rubinfeld, 1997) associated with the analysis of Pratt's measure of relative importance (1987). The study was developed in five main phases: 1) literature review on the subject; 2) construction of cross-sectional database by geographic microregions of the Amazon biome; 3) definition of the econometric model for annual deforestation rates due to political-economic forces, including tourism; 4) estimation of the importance of tourism relative to other forces of deforestation; and 5) discussion of model results.

2 TOURISM AND DEFORESTATION

Space is a resource claimed by several economic agents. With population growth, there has been implantation of support infrastructure, horizontal urban growth, constant expansion of agricultural and livestock area, among other factors that occupy part of the space and, frequently, overlap non-anthropized areas or areas that still hold representative and functional vegetation cover. Among these activities, tourism is somewhat responsible. Tourism urbanization through second homes, resorts, or other facilities, generates direct occupation of vast territorial portions, mainly in the case of mass tourism. In addition, the use of construction materials combined with the consumption of food and other goods and services, can indirectly damage ground cover.

When analyzing about 1,500 publications on the relationship between tourism and the environment, Buckley (2011) identified that in most of them tourism was identified as having harmful impacts and that in other cases tourism promoted conservation. There are several studies on the use of tourism for conservation (Nyaupane & Poudel, 2011; Brandão, Barbieri, & Reyes Junior, 2015). Organizations have also suggested developing tourism as a strategy for environmental sustainability (United Nations Environment Programme, 2005; World Wildlife Fund for Nature, 2003; Instituto Chico Mendes de Conservação da Biodiversidade, 2011; World Tourism Organization, 2002, 2013), although its harmful impacts are known, especially those caused by mass tourism at the local level, such as deforestation.

Although specialized literature presents a large collection of studies on the relationship between tourism and the environment, studies aimed at under-standing specific relationships with deforestation itself are rare. In general, the analyses suggest that, on the one hand, tourism has had negative impacts on soil cover in some regions (Araujo, Carvalho, & Silva, 2005; Kuvan, & Akan, 2005; Zhong, Deng, & Xiang, 2008; Almeyda, Broadbent, Wyman, & Durham, 2010; Fox, Witz, Blanc, Soulié, Penalver-Navarro, & Dervieux, 2012); on the other hand, tourism has been considered an important force for the protection and regeneration of forest areas (Gaughan, Binford & Southworth, 2009; Suntikul & Dorji, 2015; Boavida-Portugal, Rocha & Ferreira, 2016; Vijay, Kushwaha, Chaudhury, Naik, Gupta, Kumar, & Wate, 2016). In general, what changes is the local context and the form of tourism practiced.

When investigating the changes in tourism pressure on forests and alpine vegetation for fifty years in the area around Mount Everest, one of the most important mountaineering destinations in the world, Stevens (2003) showed that tourism has improved the living conditions of the local population. However, negative impacts on the forest were identified, such as damage by fire caused directly by visitors or the use of wood to build tourist facilities. According to this author, the continuous use of uncontrolled fire has contributed to the reduction of the average diameter of the trunks in some territorial portions of the forest and loss of vegetation cover in others.

Analyzing the use of forests for developing tourism in the Antalya-Belek region of Turkey, Kuvan (2005) realized that the rapid transition to mass tourism in the region was not accompanied by public policies or projects for protection and sustainability of development, resulting in problems in forest areas. Particularly, forest fragmentation and deforestation in the region have been caused by tourism developments. In coastal areas, the researcher identified that all new facilities were developed over areas that were previously forest areas.

The Changbai Mountain Biosphere Reserve in China receives hundreds of thousands of tourists annually. But despite its great economic and ecological importance, it has suffered with the fragmentation in its buffer zone. When studying the relationship between tourism and deforestation in this region, Zhao, Li, Wang and Xu (2011) concluded that the tourism boom has not helped to reduce pressures on the forest – on the contrary, it has increased the fragmentation around the reserve.

To understand the relationship between tourism and changes in land use in the Li River basin (China) between 1989 and 2010, Mao, Meng and Wang (2014) used a hybrid approach with multi-level modeling and logistic regression to analyze the potential of degradation of the driving forces of these transformations. The results showed that the accelerated development of tourism and urban expansion put the area at great risk of damage or definitive loss of its vegetation cover. Threats also include the construction of highways and scenic viewpoints.

In summary, localized studies that point to tourism as a cause of deforestation have some aspects that should be examined closely. The presence or rise of mass tourism in forest areas generates a great pressure that public policies have difficulty in containing or redirecting. Another important aspect is the punctual nature of impacts. In general, localized direct impacts are observed, mainly in the implementation of support infrastructures and tourist facilities, such as second homes and other lodging establishments. On the other hand, studies find that tourism can prevent deforestation or recover degraded areas (Oosterzee, 2000; Stronza & Pegas, 2008).

In a study of the driving forces of land use and land cover change in jungle regions of two cities in the south of Mexico, Corona, Galicia, Palacio-Prieto, Bürgi and Hersperger (2016) used satellite imagery and aerial photographs to produce a georeferenced database for the years 1985, 1995, and 2006. A set of statistical techniques was employed to identify the direct and indirect causes of deforestation. The results showed that agricultural activity is the most significant of them, being responsible for approximately 85% of the regional deforestation. However, the authors have identified that the increase in work opportunities linked to the tourism sector has led to a reduction or abandonment of agricultural activities, favoring the regeneration of forests.

In another robust study, Hoang, Vanacker, Van Rompaey, Vu and Nguyen (2014) examined changes in soil cover in the Sa Pa District, China. International tourism began in 1993 with the political opening, deeply changing the daily life of residents.

Using high-resolution satellite images from three different periods and covariance analysis, the authors investigated changes in soil cover between 1993 and 2014. The study showed that between 1993 and 2006 there was an increase in deforestation caused by the advance of the agricultural area. But between 2006 and 2014 the opposite occurred. The results showed that deforestation is much lower in areas that are highly involved with tourism activities. This occurred, according to the authors, because with the diversification of economic activities the rural owners became less dependent on agricultural production. They concluded, therefore, that new production patterns can reduce the pressure on regional forests.

Unforeseen effects can significantly affect the efficiency of public conservation policies. Robalino, Pfaff and Villalobos (2015) found that this has been verified in the creation of protected areas in Costa Rica and the consequent increase in deforestation in the adjacent forest areas. In the surrounding areas (buffer), for up to 10 km this impact has been minimal. However, the research showed that there is great statistical significance between deforestation and the areas near the roads that do not count on tourism and are far from the park entrances. The study concluded that increased transportation costs and the development of tourism in its areas of influence may reduce deforestation rates in Costa Rica.

The results presented in the literature are not conclusive regarding the polarity of the relationship between tourism and deforestation. At the local level, tourism, mainly mass tourism, promotes deforestation of natural areas, but on the other hand, the economic alternative of tourism in relation to other more harmful economic activities has shown significant results, mainly from a macroeconomic perspective.

3 AMAZON: ENVIRONMENT, ECONOMY AND REGIONAL DEFORESTATION

This section presents a review of the main aspects related to the Amazon, its economy (including tourism) and deforestation. Initially, we highlight the main physical and socioeconomic characteristics of the region. Then we review the literature on the causes of deforestation. Finally, we present tourism and its situation in the study area. These aspects are fundamental for the investigation of the problem and for the analysis of the results of this research.

The continental Amazon region extends to nine countries in South America: Brazil, Peru, Bolivia, Colombia, Ecuador, Venezuela, Guyana, Suriname, and French Guiana, associated mainly to the Amazon/Solimões and Tocantins river basins, and part of the Orinoco River. According to political-administrative criteria, the area of the South American Amazon is 6.5 million km^2 (Albagli, 2001). The Amazonian surface is largely covered by dense and open forests, but also shelters a diversity of other ecosystems, such as *igapó* forests, floodplains, seasonal forests, flooded fields, savannas, and *campinaranas* (Brasil, 2009). Forests cover 3.6 million km^2, more than 85% of the area of this biome in Brazil, 69% of the national forest area (Instituto Brasileiro de Geografia e Estatística, 2005). Politically and administratively, the Brazilian Amazon biome spreads across the states of Acre, Amazonas, Rondônia, Roraima, Amapá, Pará, and part of the states of Mato Grosso, Tocantins, and Maranhão.

The economy has always been focused on providing primary products for domestic and international demand, in large part, tied to the major development programs undertaken by the Federal Government since the 1960s. The regional Gross Domestic Product (GDP) reached R$ 420.69 billion in 2014 (IBGE – Contas Nacionais, 2014). A traditional activity since the Europeans arrived in the sixteenth century, agriculture has become, in recent years, the main socioeconomic activity of the Amazon and responsible for much of the transformations occurring in land use and regional vegetation cover. The area harvested in 2016 was 162.3 thousand km^2, an average of 1.8 thousand km^2 per geographic microregion (IBGE – Pesquisa da Produção Agrícola, 2016). Despite the presence of agriculture, the main activity in relation to the area used is undoubtedly beef cattle. Currently, the region has a cattle herd of approximately 78 million head (IBGE – Pesquisa Pecuária Municipal, 2016).

In addition to agriculture, vegetable extractivism is another important economic activity in the area. In 2016, 10.54 million m^3 of timber were produced (IBGE – Produção da Extração Vegetal e da Silvicultura, 2016). Combined with timber production is the production of charcoal, which often adds value to wood, increasing the profits for explorers. Although logging is an important source of income and jobs in the Amazon, its growth worries, as it is assumed that the area of logging can be as extensive as that deforested annually in the Amazon, including in protected areas (Nepstad, Verssimo, Alencar, Nobre, Lima, Lefebvre, & Cochrane, 1999; Uhl & Vieira, 1989), which causes other direct and indirect damages of this activity to the ecosystems. The advance of this agricultural frontier has been mainly restrained by the protected areas that cover much of the region (Gazoni & Mota, 2010a).

Protected areas are territorial spaces under some special protection regime. In the Amazon there are many types of protected areas: Areas of Permanent Preservation, Legal Reserves, Indigenous Lands, *Quilombola* Lands, military areas and, among others, Nature Conservation Units. According to the National Register of Conservation Units of the Ministry of the Environment, until July 2017, the Amazon had 334 Conservation Units, totaling a coverage of 1.166 thousand km^2, 27.89% of its territorial surface. There are 85 integral protection units with 430.2 thousand km^2; 249 units of sustainable use with 736.0 thousand km^2. In addition, Indigenous Lands cover an area of 731.8 thousand km^2, or 14.1% of the regional territory.

The sum of the economic, social, physical, and political forces in the Amazonian territory has significantly transformed the region (Becker, 2004). One of the most closely followed results of these transformations is the continuous loss of forest cover through deforestation, usually by shallow cutting (the extreme stage of deforestation, where the observed pattern represents complete removal of the original vegetation) or by slash-and-burn practices and wildfires (Food and Agriculture Organization of the United Nations, 2016).

The annual rates of deforestation in the Amazon has followed a cyclical pattern in the last twenty years, with the highest in (21,393 km^2), 2003 (25,247 km^2) and 2004 (27,772 km^2), and lowest in 2012 (4,571 km^2), 2013 (5,891 km^2) and 2014 (5,012 km^2). According to the National Institute of Space Research (INPE), in 2016 deforestation reached 7,647 km^2. There are many causes for deforestation pointed out in the national and international literature. However, due to several factors, such as the poor quality of data on deforestation, mainly up to the end of the 1990s, most studies carried out so far lack depth. In addition, deforestation does not follow a single pre-established pattern, but multiple processes depending on time and space. Thus, controversy remains regarding some deterministic factors of regional deforestation and the contribution of each factor to forest destruction. Chart 1 lists the factors involved in regional deforestation according to several authors.

The main explanatory aspects of deforestation already identified in the Amazon are: 1) population – demographic density, urban and rural population, urban migration and growth; 2) agriculture and livestock – agricultural production, soybean cultivation, cattle herds and pastures and land ownership; 3) access policies – highway density, implementation and paving of roads, distance from highways; 4) the market – prices of agricultural products, land price and transportation cost; 5) vegetal extractivism – logging, charcoal and non-timber extraction; 6) environmental policies – protected areas and environmental monitoring; 7) the biophysical environment – forest stock, soil fertility, rainfall and the El Niño[3] effect; 8) mining – distance from mineral production centers; 9) rural settlements – number of families settled and lot size; 10) other aspects – rural credit, public development projects and public land grabbing.

A significant reduction in the pace of deforestation of the Amazon is imperative. If, on the one hand, pressures increase over governments from various local, national and international social actors, on the other, there is strong resistance from the groups benefiting from the current situation of continuous destruction. In this context, many proposals and strategies have been used, with a greater or lesser degree of success. Among them: the creation of different types of protected areas, an increase in the intensity and frequency of environmental inspection, the implementation of new legislation and the development of tourism. Although tourism is included in some conservation policies, its potential for having harmful impacts on ecosystems and/or societies, especially at the local level, is undeniable. Therefore, care must be taken in interpreting the results of research and especially in the design of conservation or development policies.

[3] Phenomenon characterized by significant short-duration changes in the distribution of water surface temperature in the South Pacific Ocean, with profound effects on the Brazilian climate.

Chart 1 – Explanatory aspects for deforestation according to different authors

Study area	Period	Explanatory aspects*	Sources
Amazon	Until 1985	Population (+); cultivated area (+); cattle herd (+); timber production (+); highway density (+); distance from the state capital (-).	Reis & Margulis (1991)
Central Amazon	Until 2000	Distance from highways (-), grazing areas (+), cattle herd (+), land ownership (-) and income (-)	Walker, Perz, Caldas & Silva (2002)
Amazon	1970/1996	Livestock (+), agriculture (+), timber (+), mining (+) and land ownership (-)	Andersen, Granger, Reis, Weinhold, & Wunder (2002)
Amazon	1975/1985	Prices of agricultural products (+); price of land (+); rural credit (+); implementation of highways (+); income of rural establishments (-)	Young (1998)
Amazon	1968/1987	Implementation of highways (+); paved highways (+)	Pfaff (1999)
Amazon	1978/1988	Growth in grazing areas (+); growth in agricultural areas (+); timber exploitation (+); mining areas (+); growth of urban areas (+)	Skole, Chomentowski, Salas, & Nobre, (1994)
Amazon	1985/1995	Agricultural production (+). Obs.: Technological innovation in agriculture generates less deforestation	Cattaneo (2005)
Rondônia	1980/2000	Rural settlements (+); size of the lots (+), time of occupation (+), infrastructure (+), forest reserves of common use (-)	Batistella & Moran (2005)
Amazon	1997/2000	Extraction Reserve Areas (-); National Parks area (-); Indigenous Land Area (-)	Nepstad, Schwartzman, Bamberger, Santilli, Ray, Schlesinger & Rolla (2006)
Amazon	2000/2001	Population Density (+); highways (+); severity of drought season (+)	Laurance, Albernaz, Schroth, Fearnside, Bergen, Venticinque & Costa (2002)
Uruará (PA)	Until 2005	Distance from the Trans-Amazonian Highway (-); number of men in rural establishments (+); soil fertility (+); credit (+)	Caldas, Walker, Arima, Perz, Aldrich & Simmons (2007)
Amazon	1996/2006	Distance from highways (-); protected areas (-); El Niño effect (+)	Adeney, Christensen & Pimm (2009)
Oriental Amazon	2007/2008	Farming (+); timber (+); charcoal (+); non-timber vegetation extractivism (-); distance from the closest regional IBAMA office (-); and protected areas (-).	Gazoni & Mota (2010b)
Pará	2006/2010	Rural settlements (+); land ownership uncertainties (+); infrastructure (-); size of the lots (-); timber (+)	Calandino, Wehrmann, & Koblitz (2012)
Amazon	2003/2008	Livestock (+); agriculture (+); timber (+); rural settlements (+); protected areas (-); environmental inspection (-).	Gazoni (2014)
Amazon	1999/2011	Agricultural prices (+); rural credit (+); transportation cost (=); inspection (-)	Ferreira & Coelho (2015)
Amazon (arch)	2008/2012	Livestock (+), permanent farming (+); temporary farming (+); Gross Internal Product (+); population (+); education (-)	Delazeri (2016)
Amazon (UCs)	2015/2016	Forest density (+), Ecological Station (-), Pará (+), controlled public visitation (-)	Gazoni (2018)

* positive correlation (+); negative correlation (-)

Table 1 highlights the tourism facilities and services that were registered at the Ministry of Tourism (MTur) on December 31, 2014 in the nine states that involve the Amazon. The state with the largest offer of accommodation is Mato Grosso, with 21.6 thousand registered beds, or 24.3% of the total. The second largest offer of beds is in the state of Amazonas. There are 20.2 thousand beds, 22.7% of the regional offer. Pará holds another significant portion of the offer, with 15.4 thousand beds (17.3%). In addition to these, Maranhão offers 13.5 thousand beds (15.2%), Acre 6.3 thousand beds (7.1%), Tocantins 5.9 thousand beds (6.6%), Rondônia 4,100 beds (4.6%), Roraima has 1.2 thousand beds (1.3%), and Amapá has 859 beds, only 0.9% of the regional offer registered (Brasil, 2015). The lodging offer is the main indicator of spatial distribution of regional tourist demand. Of course, these numbers are only indicators, since the number of facilities in operation is much larger than the number of companies registered.

Table 1 – Tourist facilities and services in the Amazon, certified with MTur

Offer		State								
		AC	AP	AM	PA	RO	RR	TO	MA	MT
Hotels and similar	N	86	13	224	161	48	16	122	144	295
	UH's (thousand)	2.3	0.5	9.8	7.3	1.8	0.5	2.7	6.4	10.4
	beds (thousand)	6.3	0.9	20.2	15.4	4.1	1.2	5.9	13.5	21.6
Agencies		71	70	235	254	133	40	57	203	285
Restaurants, bars and similar		111	2	25	83	13	23	42	13	197
Tourist transportation		8	2	55	53	19	4	28	45	206
Car rentals		10	4	5	6	3	2	1	7	33
Event organizers		10	14	40	51	5	20	10	35	34

Source: Brasil (2015)

A region of continental dimensions, the Amazon presents a set of natural and cultural resources with great potential for tourist use. However, some of these resources are being threatened due to the expansion of other economic activities such as agriculture and timber extraction without adequate management, which has caused loss of land cover, among other negative impacts such as pollution of the water bodies and air. Thus, although the process of developing tourism in the Amazon is in its early stages, its capacity as an economic alternative for the region requires an investigation of its relations with the phenomenon of deforestation in the Amazon.

4 METHODOLOGY

Methodologically, ordinary least squares multiple regression (OLS) combined with covariance decomposition using Pratt's Measure (1987) was used to estimate the relative importance of tourism for regional deforestation. The database was constructed with information obtained from official Brazilian government agencies.

Information on deforestation in the Amazon was obtained by the Amazon Forest Deforestation Calculation Program (PRODES) of the National Institute of Space Research (INPE). Since 2003, NISR has adopted the process of computer-assisted interpretation called PRODES Digital Program to distinguish it from the previous process, with evident improvements in data quality since then. In addition to deforestation by geographic microregion from 2003 to 2016, accumulated deforestation and forest area were accessed through the INPE database in 2016. The Brazilian Institute of Geography and Statistics (IBGE) database provides a large part of the variables used in this research. The Municipal Livestock Survey (PPM) provided data about cattle herds. Data about the area harvested for permanent and temporary crops from the Agricultural Production Survey (PPA) was used. The amount of timber produced was obtained from the Survey of Plant Extractivism and Forestry. The digital meshes of the Conservation Units of integral protection and sustainable use (federal and state), the Indigenous Lands, and the road network were obtained from the database of the Ministry of the Environment (MMA). The number of families living in settlements per city was obtained from the Ministry of Agrarian Development (MDA). The Institute of Applied Economic Research (IPEA) database provided information on the distance from the state capital and the cost of transport to the city of São Paulo, fundamental aspects for understanding the spatial distribution of regional deforestation rates. Finally, the Ministry of Tourism (MTur) provided data on the number of beds in lodging facilities, a variable that was used as an indicator of tourist demand in this research.

Multiple regression is a technique of multivariate data analysis that allows the description, through a mathematical model, of relations between two or more explanatory variables and a specific phenomenon (Woodridge, 2010). The term regression was introduced in the specific literature by Francis Galton (1886). Its main objective is to find relationships to estimate the values of the dependent variable according to the behavior of two or more explanatory variables. Its generic model for p explanatory variables is represented in equation (1).

$$y_i = b_0 + \sum_{j=1}^{p} b_j x_{ji} + \mu_i \qquad j = 1, \dots, p. \qquad (1)$$

In it, y is the dependent variable; x_j are the explanatory or independent variables; b are the regression parameters, where b_0 is the linear coefficient and b_j is the angular coefficients; and μ_i is the regression residue, that is, the difference between the actual observations and the values estimated by the model for each observation of the sample. For this, several techniques are used, such as the ordinary least squares method. The OLS imposes that, given n observations of y and x_j, the estimates of the parameters $\hat{b}_0$ and $\hat{b}_j$ are chosen in a way that the sum of the squares of the residuals, $SQR = \sum_{i=1}^{n} [y_i - \hat{y}_i]^2$, get the smallest possible value.

Different from simple regression, in regressions with multiple explanatory variables it is often not possible to immediately measure the individual effect of each of these variables on the behavior of the explained variable, but only to approach their joint effect. This problem is commonly related to the presence of multicollinearity (Gujarati, 2006). Therefore, several techniques have been used to measure the weight of each variable; however, most are defective (Green, Carroll & Desarbo, 1978). A widely accepted measure of relative importance is the one proposed by Pratt (1987). Pratt's measure ($\hat{\delta}$) is highlighted by the equation $\hat{\delta}_{x_j,x_k} = \hat{\beta}_j^{*}\rho_j / \hat{\beta}_k^{*}\rho_k\,,\ j\ e\ k = 1,\dots,p$. In it, $\hat{\delta}_{x_j,x_k}$ is the importance of x_j in relation to x_k; ρ_j and ρ_k are the respective correlations of x_j and x_k with the explanatory variable. Recently, Thomas, Zhu and Decady (2007) have stated that Pratt's formula is the only one that satisfies the natural demand for the measure, including its invariance to linear transformations. The variance of the relative importance estimators $\hat{V}(\hat{\delta}_j)$ can be calculated with the equation (2).

$$\hat{V}(\hat{\delta}_j) = \frac{\hat{\delta}_j^2}{t_j^2} + \frac{\left[\frac{(1-R^2)}{R^2}\right]\left[\frac{\hat{\beta}_j^{*2}}{R^2} + 2\left(\hat{\delta}_j - 2\hat{\delta}_j^2\right)\right]}{(N-p-1)} + \frac{\left(\frac{\hat{\beta}_j^{*2}}{R^2} - \hat{\delta}_j^2\right)}{N} \quad (2)$$

95% confidence intervals were estimated for Pratt's Measure of Relative Influence ($\hat{\delta}_j$) of each explanatory variable x_j, which is given, for the highest and lowest limits, by $\hat{\delta}_j^{v} = \hat{\delta}_j \pm Z_{\frac{\alpha}{2}}\left[\hat{V}(\hat{\delta}_j)\right]^{\frac{1}{2}}$, $j = 1,\dots,p$. where, $Z_{\alpha/2}$ is the value of the highest point with percentage of $\alpha/2$ in the normal distribution. Through simulations ($N \rightarrow \infty$), the authors have shown that the estimates made by these procedures are very accurate for samples greater than 250 units and accurate for samples above 100 units. However, it must be considered that this is a statistical study, its results represent the estimated probabilities and not the reality itself.

5 TOURISM AND FOREST PROTECTION IN THE AMAZON

This section presents and discusses the estimation of the relative importance of the political and economic factors of deforestation in the Amazon biome in 2015-2016. However, other basic aspects of their interrelations with explanatory variables that are not directly causal and were, consequently, excluded from the model, should be observed to contribute to the analysis of the results.

Physical aspects are the basis on which policies and economic activities, and consequently regional deforestation, develop. In addition to the variables that were (2) d in the final model, it is possible to verify other aspects that are spatially correlated to deforestation, but unnecessary to the objectives of this research: the average annual rainfall (-); the area of water bodies (-); the forest area (+). In addition, the location of the markets for the products of the Amazon agroindustry seems to be fundamental, mainly: the distance from municipal seats to respective state capitals (-) and the cost of transportation from the micro-region to the city of São Paulo. Accesses, especially roads, are essential for the use of the land and its coverage in any geographical space. Two aspects were relevant for deforestation: the road network (federal and state) and the distance to the nearest paved highway. Both the implementation and the paving of roads seems to be decisive for an increase in annual deforestation rates. The effects of these variables were extracted from the econometric model.

The final model used spatial rates to reduce multicollinearity between factors. In addition, the variables were scaled from 0 to 1 to eliminate the effects of differences between measurement scales. To assess the goodness-of-fit in the regression model, the measures most commonly used in multiple regression, and used here, were: adjusted R-squared coefficient of correlation, which measures the proportion of the variance of the dependent variable, which is explained by the regression line; standard-error of estimates; and the F-ANOVA test, which tests the joint effect of the independent variables on the dependent variable. In addition, the statistical significance of the variables was measured by their standard errors and their t-tests, which highlight the probability that their coefficients are statistically zero.

For the assumption of absence of perfect collinearity, the tests of Tolerance (TOL≥0.963), Value Inflation Factor (VIF≤1.038) and Condition Index (CI≤3.854) were used. The presence of heteroscedasticity of residuals was rejected through the Breusch-Pagan test (*p*-value=0.254). Finally, normal distribution of residuals cannot be ruled out according to the results of the Kolmogorov-Smirnov Test (Z=0.823; Sig=0.423). For these aspects, the estimators presented here can be considered the best unbiased estimators (BUE).

The results of ordinary least squares multiple regression of the deforestation rates as a function of political and economic aspects for the period 2015-2016 are presented in Table 2. The linear coefficients (b) and their standard errors (ep), the standard coefficient (β*), the Student's t-test, the confidence interval for the linear coefficients, and the collinearity diagnostics, which presents the tolerance value (TOL) and the value inflation factor (VIF). The summation of the model, developed with the help of the Statistical Package for Social Sciences (SPSS) software, showed an adjusted R-squared coefficient of 0.849. That is, the variables inserted in the model can explain 84.9% of the deforestation behavior. For individual cases, the geographic micro-regions, the standard error of this estimate is 0.358. The ANOVA matrix highlighted Fisher's F-test results (66.971) for eight degrees of freedom. The results of the statistical tests indicate the goodness of fit of the model, which was reflected in the narrow confidence intervals.

Table 2 – Results of the regression model OLS*

Model	Non standardized coefficient		Standardized coefficient			Confidence interval of 95% for β		Collinearity diagnostics	
	b	ep	β*	t	Sig.	INF	SUP	TOL	VIF
Constant	-6.860	-	-	-28.447	0.000	-7.340	-6.380	-	-
Livestock**	0.302	0.039	0.318	7.718	0.000	0.224	0.380	0.990	1.010
Agriculture**	0.159	0.026	0.251	6.059	0.000	0.107	0.211	0.976	1.025
Timber **	0.151	0.026	0.237	5.705	0.000	0.098	0.204	0.970	1.031
Settlements **	0.246	0.036	0.283	6.822	0.000	0.174	0.318	0.974	1.027
Protected areas	-0.304	0.041	-0.309	-7.468	0.000	-0.385	-0.223	0.981	1.020
Tourism	**-0.271**	**0.047**	**-0.242**	**-5.830**	**0.000**	**-0.364**	**-0.179**	**0.971**	**1.030**
Maranhão	1.011	0.109	0.387	9.262	0.000	0.794	1.229	0.963	1.038
Pará	0.654	0.098	0.275	6.686	0.000	0.459	0.848	0.992	1.008

* Dependent variable: deforestation**
** Variable transformed by the natural logarithm

For the estimation of the model some spatial rates were transformed with the natural logarithm. This was because these variables presented strong asymmetry to the right. With the procedure, the series acquired normal behavior, considering the multivariate analysis. The results show that deforestation occurred in the period 2015-2016 in the micro-regions of the Amazon biome can be explained, among other possibilities, by eight variables: 1) the number of heads of cattle; 2) the area harvested in temporary and permanent crops; 3) the quantity of timber produced; 4) the number of families living in rural settlements; 5) the extension of protected areas; 6) the number of beds in lodging; 7) the location in the state of Pará and the state of Maranhão. The pace of deforestation increases as cattle, agriculture, logging, and rural settlements increase. On the other hand, the results suggest that the rate of deforestation decreases as the territorial extension of protected areas (Conservation Units and Indigenous Lands) increases and when tourism increases, there is no distinction as to the form of tourism practiced. Of course, an efficient management of the socio-environmental aspects of tourism, especially at the local level, is important. In addition, the results suggest that if the micro-region is in the states of Pará or Maranhão, the rate of deforestation tends to be much higher.

These results reinforce the conclusions reached by Reis and Margulis (1991) and by Gazoni (2014) about cattle livestock; by Cattaneo (2005) and by Young (1998) about agriculture; by Skole et al. (1994) and by Gazoni and Mota (2010b) about timber extraction; and by Batistella and Moran (2005) and Caldas et al. (2007) about rural settlements. The protected areas corroborate the results of Adeney, Christensen and Pimm (2009) and Nepstad et al. (2006). Besides, the important presence of the dichotomous variables for the states of Maranhão and Pará is not new. There have been many occurrences in recent years related to environmental management in these states (Luíse, 2011; Linhares Jr., 2014). Tourism, however, was not found in any robust study for the Amazon. It is suggested that this variable should be included to help explain regional deforestation in future studies for this purpose.

The linear coefficients (b) can estimate the elasticities between deforestation and the explanatory variables of the model. The elasticity (E) presents the estimate of how much a percentage change in the independent variable represents in terms of percentage variation in the dependent variable. In general, elasticities are low. The elasticity of livestock (0.302) in relation to deforestation suggests that a 10% increase in the cattle herd of the Amazon represents an increase of 3.02% in annual deforestation rates. The elasticity of agriculture (0.159) shows that a 10% increase in the crop area implies a growth of only 1.59% in deforestation rates. Timber (0.151) also presents low elasticity, that is, a 10% increase in timber production represents a 1.51% increase in deforested area. The settlements (0.246) show a slightly higher elasticity. An increase of 10% in the number of family settlements implies a 2.46% increase in deforestation rates. If, on the one hand, these low elasticities allow small fluctuations in productions with low damages, on the other hand, public policies restricting these activities should also have low efficiency.

Livestock farming is a very heterogeneous activity in the Amazon, consisting of cattle breeding, mainly for cutting, but also dairy, and for permanent and temporary crops, both for the international market as well as the national, regional and local market, carried out by family farmers (subsistence or business) or not, in small or large enterprises. One of the major problems related to the activity is its mobility to occupy previously forested areas, especially along the pioneer fronts (Margulis, 2003).

In addition to livestock farming, the exploitation and processing of timber is currently one of the main economic activities of the Amazon. Despite its low elasticity, it is estimated that the area impacted by the logging activity is much larger than the deforested area itself. This is due to two factors: first, because it is more difficult to identify illegal deforestation with sparse interventions; second, because the extraction of the largest species implies a constant need to migrate these activities to increasingly deeper areas of the biome. This causes a reduction in seed spread of large trees, promoting a substantial decrease in forest regeneration.

The highest elasticity is found in relation to protected areas. A 10% increase in Conservation Units and/or Indigenous Lands represents a reduction of 8.48% in annual deforestation rates in the Amazon. That is, an increase of 1.34 thousand km^2 in protected area implies a reduction of 65.1 km^2 per year of deforestation. These results should be interpreted with caution, since these values represent average probabilities. In the case of Conservation Units, for example, there are different degrees of protection depending on the class and the management category. In addition, there is a large difference in the management capacity of these areas (Gazoni & Mota, 2010b). Some of them have several infrastructures such as security cabins, reception, administrative headquarters, fencing, surveillance, signposted trails, visitor centers, among others, as well as equipment such as computers and vehicles (cars and boats). Others only exist effectively on paper, and their protection is guaranteed only by legislation and occasional supervision.

Despite the fact that tourism in the Amazon is still in the early stages of development, its elasticity (-0.271) in relation to deforestation is not insignificant. The results highlight that a 10% increase in regional tourist activity suggests a reduction of 2.71% in the area deforested annually in the region. However, it should be noted that these values represent a regional average. In individual cases, it is necessary to consider the confidence intervals for the linear estimators in the forecast. Although the results of the multivariate model reinforce the hypotheses of this research, the technique is not able to show the importance of each individual factor for deforestation in the period of 2015-2016. This is due to the presence, although reduced, of multicollinearity. Thus, we chose to perform the covariance distribution of the explanatory vectors by applying the measure of relative importance (Pratt, 1987).

Table 3 presents the results of estimates of the importance of each factor for deforestation in the period. The highest relative amounts (δ) are from Maranhão (0.137), livestock (0.106) and protected areas (0.104). On the other hand, the significant but less important aspects in this period are timber (0.063) and tourism (0.039). These results allow estimating the percentage participation of each explanatory variable in the behavior of the explained variable. The results point out that, from August 2015 to July 2016, cattle farming accounted for 19.5% of deforestation in the Amazon biome. This represents the loss of 1,491.2 km^2 of forest area. Agriculture, which expanded strongly in the period, contributed 13.7% to deforestation, or 1,047.6 km^2. Logging was responsible for the suppression of 749.4 km^2 of forest area, 9.8% of the deforestation rate. Rural settlements are another important vector of deforestation in the Amazon. In the analyzed period, they were responsible for 11.2% of all regional deforestation: an additional 856.5 km^2 was lost. In addition to these political-economic aspects, the spatial location in the states of Pará and Maranhão is of great importance for predicting deforestation rates. It is estimated that 18.7% of all regional deforestation is related to some aspect inherent in the state of Maranhão. This means 1,429.9 km^2 deforested in 2015-2016. As in Maranhão, the state of Pará has characteristics that indicate it is responsible for 12.0% of the annual deforestation, that is, 917.6 km^2 destroyed. Other explanatory factors not included in the model represent 15.1% of the regional deforestation, an area of 1,147.1 km^2.

Table 3 – Importance of tourism for regional forest protection*

						Confidence interval of 95% for δ			
	β*	ρ	E	δ	V(δ)	INF	SUP	D_i	D_i %
Livestock	0.318	0.335	0.302	0.106	0.120	0.061	0.151	1491.2	19.5%
Agriculture	0.251	0.308	0.159	0.077	0.075	0.042	0.113	1047.6	13.7%
Timber	0.237	0.267	0.151	0.063	0.067	0.030	0.097	749.4	9.8%
Settlements	0.283	0.271	0.246	0.077	0.095	0.037	0.117	856.5	11.2%
Protected Areas	-0.309	-0.337	-0.848	0.104	0.113	0.061	0.148	-1361.2	-17.8%
Tourism	**-0.242**	**-0.183**	**-0.271**	**0.039**	**0.070**	**0.010**	**0.056**	**-282.9**	**-3.7%**
Maranhão[1]	0.387	0.355	0.145	0.137	0.177	0.083	0.192	1429.9	18.7%
Pará[1]	0.275	0.262	0.054	0.072	0.090	0.033	0.111	917.6	12.0%
Others[2]	-	-	-	-	-	-	-	1147.1	15.1%

* Standard coefficient (β*); correlation (ρ); elasticity (E); relative importance (δ); variance (V); and deforestation promoted/avoided in the period (Di)

[1] Dichotomous variable.

[2] Estimated by the participation of the constant term (b_0)

Although there are many driving forces behind regional deforestation, other political-economic aspects present themselves as protective forces of land cover, repelling some of the pressures from the explanatory vectors, reducing their impact. This study identified two variables inversely correlated to regional deforestation: protected areas and tourism. The creation of protected areas is, of course, the main strategy of environmental protection in the Amazon. Used with vigor in the arch region of deforestation, it has made the advance of the agricultural frontier to deeper areas of the biome difficult. The main correlations of protected areas are with timber extraction and cattle farming, which suggests a more effective action to protect against the pressure exerted by these important agents of deforestation. No correlation was found between protected areas and agriculture and with rural settlements and agriculture. This was perhaps due to its characteristic heterogeneity in the Amazon.

Tourism, despite having a significant correlation with annual deforestation rates, after extracting other factors correlated to it in space, showed a small, although significant, relative influence on deforestation. The results suggest that if there was no tourism in the Amazon, deforestation rates in the period of 2015-2016 would have been 3.7% higher, that is, tourism was responsible for avoiding the deforestation of 282.9 km^2 of forests only in this period. There are many ways tourism can influence the pace of regional deforestation. Considering their correlations in space, the protection generated by tourism can be more efficient in the face of the pressures caused by livestock and agriculture. Otherwise, its low correlation with timber extraction suggests that, unlike protected areas, tourism has little influence on the pressures of timber harvesting.

The ways in which tourism inversely influences deforestation rates at the regional level should be the subject of further research. However, some hypotheses may be suggested on this aspect. First, at the macroeconomic level, the insertion of tourism into the regional economy reduces dependence on other economic activities, which are often monopolistic in certain subregions of the biome. In addition to reducing pressure on forests by substituting production activities with greater degrading capacities, the growth of tourism in the economy generates greater competition in the allocation of financial resources, whether public or private. All these aspects promote a reduction of the effective impact on forest cover. Second, tourism also promotes greater appreciation of the quality of natural resources. At the same time, environmental problems become increasingly visible and unwanted by visitors, businesses, and residents, demanding more rigorous attention from public authorities, including intensified enforcement. Third, besides increasing its economic importance, tourism can finance the conservation of protected areas, reinforcing its efficiency. Entrance fees and other expenses incurred by visitors in these spaces, combined with receipts for the use of space by private initiatives (hotels, restaurants, etc.) and other fees charged by agencies and operators may be directed to the management of priority conservation areas. Finally, tourism promotes the involvement of the surrounding population with the activity and, consequently, conservation.

However, care must be taken with the impacts of tourism at the local level, which can be serious. It is not always that tourism is an alternative. In many cases there is no conjunction of the factors necessary to generate an effective and relatively stable demand, which makes its development economically unviable. In other cases, areas close to large population concentrations, with easy access and with highly attractive resources may not be an option, especially if there is no confidence in the tourism and environmental management bodies that act at local and regional level, because uncontrolled growth of tourist demand can occur in these spaces.

6 FINAL REMARKS

Tourism in the Amazon is in its early stages of development. However, its development has been pointed out as a strategy for the sustainability of the Amazon, including reducing regional deforestation. In this sense, this work analyzed the relative importance of tourism to reduce the pace of regional deforestation. For this, multiple regression techniques combined with Pratt's Measure were applied. Not surprisingly, multiple regression techniques are well suited to the study of deforestation, which has several explanatory factors. In this study, it was not different, it was only necessary to apply the distribution of covariance by Pratt's measure to obtain an estimator free of multicollinearity influences.

The results suggest that the pace of regional deforestation is due to several explanatory factors: cattle farming (heads); agriculture (area of permanent and temporary crops); extraction of timber (logging); the size of rural settlements (households); the extension of protected areas (Conservation Units and Indigenous Lands); the location in the states of Pará and Maranhão, and the development of tourism (beds). The results also highlighted that if there was no tourism in the Amazon, the increase in deforestation occurred in 2015-2016 would have been higher, suggesting the possibility of using tourism as a regional conservation strategy. It should be noted, however, that this is the first work on a macro-regional level that studies the relationship between tourism and deforestation in the Amazon. Therefore, complementary studies should be carried out to confirm and deepen the understanding of these relationships. As the tourism rate used in this study was a variable at the state level and not micro-regional, it is suggested to search for smaller data (micro-regional) to approximate the estimators. In addition, since a series of cuts was used, several exogenous variables could not be used, such as: the exchange rate, the effect of election years, interest rates, agricultural prices, among others. Therefore, it is suggested to structure a panel data to improve the representativeness of the estimators.

Lastly, it can be suggested that tourism is a good strategy for regional conservation in the long term. However, since the local socio-environmental impacts may be undesirable and often serious, it is imperative that tourism development policies incorporate concerns about these, since in the Amazon, sustainability has become the very purpose of development itself.

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