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ECONOMIA

Environmental services as an endogenous development strategy: an alternative to deforestation in the state of Acre, Brazil

Ronivaldo Steingraber[1*], Ana Paula Kanoppa[2] and Janaína Fidelis Caetano[2]

*[1]Departamento de Economia e Relações Internacionais, Universidade Federal de Santa Catarina, Rua Engenheiro Agronômico Andrei Cristian Ferreira, s/n., 88040-900, Florianópolis, Santa Catarina, Brazil. [2]Programa de Pós-Graduação em Desenvolvimento Regional, Universidade Federal do Acre, Rio Branco, Acre, Brazil. *Author for correspondence. E-mail: ronivaldo.steingraber@gmail.com*

ABSTRACT. This paper studies the economic actors in the Amazonian deforestation in the State of Acre, Brazil. After a discussion on deforestation causes and its impacts, we propose a development strategy built on forest conservation, as the conservation of the Amazon biome. We conclude that environmental services can be an income-generating alternative for local populations, thereby contributing to the economic development of the State, in accordance with the principles of social equity and environmental protection, especially in new economic sectors, which are related to increased deforestation rate, however, the opportunity costs of these services are higher than those of cattle ranching. To get at this conclusion, it was estimated a linear model by Ordinary Least Squares (OLS) with the annual deforestation rate of the State of Acre between 2000 and 2011 as a dependent variable according to participation of primary sectors; the estimated results indicate the cattle ranching, among others economic activities, as the main cause of deforestation.

Keywords: Amazon Forest; environmental services; economic sectors.

Serviços ambientais como estratégia de desenvolvimento endógeno: uma alternativa para o desmatamento no estado do Acre, Brasil

RESUMO. Este artigo estuda os atores econômicos no desmatamento Amazônico no estado do Acre, Brasil. Depois da discussão sobre as causas do desmatamento e seus impactos, propõem-se uma estratégia de desenvolvimento baseada na conservação florestal, como a manutenção do Bioma Amazônico. Conclui-se que os serviços ambientais podem ser uma alternativa de geração de renda para a população local, contribuindo para o desenvolvimento econômico do estado, de acordo com os princípios de equidade social e proteção ambiental, especialmente nos novos setores econômicos, os quais estão relacionados com o aumento da taxa de desmatamento, entretanto, os custos de oportunidade destes serviços são mais altos do que os da pecuária. Para chegar a esta conclusão, foi estimado um modelo linear por Mínimos Quadrados Ordinários (MQO) com a taxa annual de desmatamento do estado do Acre entre 2000 e 2011 como variável dependente, como função da participação dos setores primários, os resultados estimados mostram que a pecuária, entre outras atividades econômicas, é a principal causadora do desmatamento.

Palavras-chave: Floresta Amazônica; serviços ambientais; setores econômicos.

Introduction

The Amazon region is one of the largest ecosystems in the world and plays a key role in initiatives to prevent climate change. Forests can provide many other benefits that are important to the well-being of human beings. It is a known fact that forests offer multiple environmental services, including the supply of raw materials, food, fuel and shelter; also, microorganisms and vegetation cover interact in the ecosystem to purify air and water, regulate climate and help in the recycling of nutrients and waste. Without forests, hence, in the absence of these goods and other ecosystem services, life as we know would not be possible.

However, about 13 million hectares of forest per year are converted into other land uses and, as a result, end up contributing one-fifth of global carbon dioxide emissions, making land-cover change the second largest contributor to global warming (Parker, Mitchell, Trivedi, & Mardas, 2009).

The causes of deforestation are numerous. Generally, the literature indicates the agriculture expansion as the main factor (Barbier & Burgess, 2011). This implies economic factors among the leading causes of deforestation; Hargrave and Kis-Katos (2013) found a relationship between Amazonian deforestation and the wood prices and agriculture products.

Structural changes are reported in Angelsen and Kaimowitz (1999) with positive impact over deforestation rate. These structural changes are road construction, poverty, shortage of off-farm employment, besides economic factors, as wages, wood and agricultural imput prices, household income levels, technical changes, and economic growth are related with the increased deforestation rate. The government has responsibility over the Brazilian Amazon deforestation, introducing tax incentives, programming the rules of land allocation, and the agriculture credit system (Binswanger, 1991).

The government intervention on the Brazilian Amazon was direct in the decades of sixty to eighty, and with tax incentives from the eighties (Prates, 2008). The structural changes and the government incentives are direct to promote economic growth, and the region occupation. The main beneficiary sector was cattle ranching in recent decades (Margulis, 2003; Diniz, Oliveira Junior, Trompieri Neto, & Diniz, 2009; Rivero, Almeida, Ávila, & Oliveira, 2009).

Social factors are also associated with deforestation of the Brazilian Amazon. Pfaff (1999) focused on population, and suggests two determinants of deforestation, first the population density is not related with the increase in the Brazilian Amazon deforestation, and second, the quadratic distribution of population is positively associated with deforestation growth. It follows that the first migrants had greater impact than later imigrants. As the Brazilian Amazon undergoes a new stage of growth, mainly in the States like Acre, the increase of deforestation rate is combined with the population growth. The population growth hypothesis increasing the deforestation is tested and confirmed in Ehrhardt-Martinez (1998), together with other forces of deforestation, as economic growth rate, level of urbanization, level of sectoral inequality, rate of change in primary product exports, and the rate of change in higher education. Only the last variable is negatively associated with the growth of deforestation.

In part, it is primarily due to the exploitation of timber resources, advances in agriculture and livestock production, and implementation and extension of infrastructure projects, such as the construction of highways, railways, hydroelectric power plants, among others. With these considerations in mind, we set out to discuss the process of forest clearing in the State of Acre, intensified from the 1970s onwards with the development policy for the Amazon region set by the federal government.

The establishment of a military dictatorship in Brazil in 1964 led to the rise of a series of developmental policies that sought to insert the country in the global capitalist system by means of a national modernization project (Scarcello & Bidone, 2007). At that moment, Acre's economy, primarily based on rubber-tapping and nut-gathering, was in crisis, and the State was selected to become a center of extensive cattle ranching in the Amazon region. As stated by Duarte (1987), in view of this situation and in line with the goals of federal government, then-governor Wanderley Dantas (1971-1974) set a policy to boost livestock production in the state. With the use of tax incentives and marketing campaigns, the advantages of investing financial capital in Western Amazon were advertised to entrepreneurs from the south-central region of country.

During the same period, the crisis in the rubber industry reached Acre's rubber plantations. Most *seringalistas* (rubber-plantation owners) had abandoned the land that later came to be occupied by *seringueiros* (rubber tappers). From that moment on, these workers became *posseiros* (squatters) in these areas.

Upon their arrival, large, medium, and small investors from south-central Brazil, attracted by the idea of becoming successful cattle ranchers, bought the rubber plantations that were no longer actively exploited at very low prices. With the acquisition of the land by the '*paulistas*' [1], the *seringueiros* who occupied these areas were expelled, sparking land tenure conflicts between '*fazendeiros*' (cattle ranchers) and '*posseiros*' (Calixto et al., 1985), thereby initiating the suppression of native vegetation for livestock grazing. Therefore, given this historical fact, the process of occupation of the Amazon region in the 1970s has been blamed for much of the deforestation in Acre.

In an attempt to put an end to a situation that continues to this day, Acre's government is currently developing policies aimed at the preservation and conservation of its forests. However, social and economic aspects underlie the issues regarding the development of the region. The aim of this study is to discuss the possible development strategies based on the principles of environmental protection, social equity and economic efficiency, as regards the potentials of the western Amazon region. We followed two studies in this paper. The first is Hargrave and Kis-Katos (2013) and the relationship between the deforestation and the agricultural

[1]Term coined to refer to businessmen from South-Central Brazil coming to the Amazon region.

products growth. The second is Barbier and Burgess (2001) and the Kuznets curve of deforestation. The hypothesis to be tested is the positive impact of economics sectors of the State of Acre, because it presents the primary sector dominating the economy, and there is the possibility of reversal of deforestation rates through environmental services incentive on the primary sectors of the local economy.

This paper is structured as follows: firstly, we examine the processes of deforestation in the State of Acre and their agents, and then we analyze the impacts of this activity and consider possible solutions to reverse the situation. The main ecosystem services offered by the Acre's Amazon region are proposed as alternatives to replace cattle ranching. At last, a panel data model is provided to explain the increase in deforestation in towns in Acre from 2000 to 2011 according to the main economic activities of the State. The estimated results show that the main economic activities, such as cattle ranching and logging, are responsible for the reduction of the forest area in the period under consideration.

Drivers of deforestation in the state of Acre

Fearnside (2006) argues that the causes behind deforestation in the Amazon vary according to the state and region, and over time, and those large and medium cattle ranchers are blamed for most of the land-use change. Nevertheless, we cannot ignore the role of small land properties that act as important driving forces in the places where they are concentrated. Moreover, Margulis (2000) states that, in addition to agricultural prices, and credit availability, other variables are associated with deforestation, such as road proximity and population growth.

As for Acre, government policies relating to the National Integration Program (*Plano de Integração Nacional da Amazônia*, PIN) favored further occupation of the state in the 1970s (Acre, 2006). The projects linked to the PIN were aimed at taking over the area and solving the problems of the region in order to establish national sovereignty. Among the initiatives that spurred migration to the state, we highlight the Government-Directed Colonization Projects (*Projetos de Colonização Dirigida*, PAD), the construction of highways, and the incentive for land acquisition by domestic or foreign business groups from Southern Brazil (Acre, 2006).

According to Acre (2006), at the core occupation issue was the removal of forest as a guarantee of land ownership. Consequently, these projects accelerated land-use changes in small settlements, mainly due to the introduction of annual crops. With impoverishment of the soil, pastures were established, leading properties to increase in size as a result of land overlap following the acquisition of other settlements. In short, we have that:

> The occupation processes triggered by the projects executed resulted in substantial changes in the vegetation cover and land use, and these changes were almost always followed by deforestation for the implementation of new activities. Rubber plantations were the first to be affected, as many were sold to form large cattle ranches (Acre, 2006, p. 78).

Agriculture and cattle ranching are currently the main economic activities in the State of Acre. According to *Instituto Brasileiro de Geografia e Estatística* (IBGE, 2012), they accounted for 17.7% of the Acre's Gross Domestic Product in 2011 (industry represents 13.4% and services, 68.9%).

However, Margulis (2003) warns that, while cattle ranching is viable from a private perspective, it is neither socially desirable nor environmentally sustainable, firstly because the private benefits of large-scale cattle ranching are distributed in an excluding way, thus increasing social inequalities; secondly, it is due to the fact that its benefits are not worth the environmental burden of deforestation. Therefore, its costs, even taking into account measurement uncertainties, may prove to be substantial when combined with the irreversible losses of genetic and environmental heritage.

About 13 million hectares of forest per year worldwide are converted into other land uses and, consequently, end up being responsible for one-fifth of global carbon dioxide emissions, making land-cover change the second largest contributor to global warming (Parker et al., 2009). Over the past ten years in Brazil, approximately 17 million hectares in the Legal Amazon region[2] were deforested (*Instituto Nacional de Pesquisas Espaciais* [Inpe], 2012). This number includes the 524-thousand-hectare area deforested in the State of Acre during the same period, representing about 3% of its territory.

Impacts of deforestation and possible solutions

Regarding the environmental issues, Fearnside (2005) briefly identifies four major impacts from deforestation in the Amazon, namely:

I. Productivity loss;

II. Changes in the hydrological cycle;

III. Biodiversity loss;

[2]States in the Legal Amazon area: Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima, Tocantins and part of Maranhão.

IV. Greenhouse-gas emissions.

In light of the seriousness of deforestation effects, and the wide range of forces which have historically driven this practice (such as local and regional circumstances), we note that there is no single strategy to curb deforestation. Rather, a set of alternatives must be proposed as short and long-term containment measures.

Fearnside (2005) claims that the issue of deforestation in Brazil should be given priority, either by local authorities and international organizations. According to the author, a monitoring strategy involving effective supervision, and enforcement actions should be adopted to prevent suppression of vegetation; in addition, fines should be collected from those who are not authorized by licensing agencies. That being said, Fearnside (2005) adds that these procedures should be followed by the understanding of social, economic and political aspects, so as to address the problem through changes in the political system itself.

A priori, it is also possible to reduce deforestation by creating protected areas and/or through the sustainable management of forests. Conservation Units (*Unidades de Conservação*, UC) – which is an equivalent term for 'protected areas', according to the International Union for Conservation of Nature (IUCN, 1994) – are places in which restrictive land-use measures are adopted, in order to protect the natural resource or historical feature (Besunsan, 2006, p. 15). However, the benefits obtained through the preservation and conservation of environment also imply costs, which are managed and controlled by government and, therefore, by taxpayers. Thus, in view of Morsello (2006), ensuring part of these benefits to society by designating protected areas places a considerably heavy burden on public sector, which is often the main reason why there is a limited number of them.

Another limitation of conservation units created in Brazil, on the basis of the American naturalistic conception[3], is that these are not compatible with the Brazilian reality, because they are home for traditional and indigenous populations dependent on forest resources for their survival. In the State of Acre, other inhabitants of native forest areas (besides the indigenous peoples) are the *seringueiros*, who have carried out traditional latex extraction activities since the twentieth century.

Furthermore, another possibility for curbing deforestation is the implementation of sustainable forest management, which is defined as the management and use of forest lands in a way, and at a rate, that maintain their biodiversity, productivity, restoration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that do not cause damage to other ecosystems (Food and Agriculture Organization of the United Nations [FAO], 2008). In this sense, by encouraging the sustainable management, it is possible to strike a balance between environmental conservation and the society's demand for forest resources and benefits. This is due to the fact that, according to Sachs (1993), rather than seek modernization at all costs, societies should mobilize themselves in the pursuit of lifestyles that do not put much pressure on the inventory of scarce natural resources, so as to provide everyone with decent living conditions, and maintain the planet habitable. In this context, the notion of eco-development proves to be extremely important. As claimed by Romeiro (1991) in light of Stockholm Conference of 1972, economic growth should combine the following aspects:

I. Economic efficiency, which involves the development of productive systems where the costs of production, as measured by productivity, are consistent with the minimally-acceptable levels of social welfare;

II. Social equity, which proposes the synchronic solidarity between social classes and that technology standards enable a more egalitarian distribution of income;

III. Environmental protection, which regards the diachronic solidarity between generations as a requirement, thereby pointing to the need for economical use of renewable resources, and production systems in which the great laws of nature are respected, so as not to turn renewable resources into nonrenewable ones.

Within this scope, Margulis (2003) argues that environmental costs, measured at local, national and global levels, are so high as to render unreasonable any activities leading to deforestation. Thus, it is necessary to offer sustainable alternatives to replace cattle ranching in order to generate larger social, economic and environmental benefits.

Environmental services in the state of Acre, Amazon region

The State of Acre, as the data of Seplan (2011) in Table 1, located in the Brazilian Amazon region, has a land area of 164,221.36 km^2 (16,422,136 ha) and maintains more than 80% of its original forest cover.

[3]The American naturalistic conception is based on creating wilderness 'islands of preservation' protected from men's predatory presence. The Yellowstone National Park is a prime example of this notion.

About 45% of its territory is included in protected areas, where 21.58% is for sustainable use[4].

Table 1. Protected natural areas in the State of Acre.

Category	Area (ha)	State percentage (%)
1. Protected Natural Areas	7,497,948	45.66
a) Conservation Units	5,107,836	31.1
Full Protection Conservation Units	1,563,769	9.52
Sustainable Use Conservation Units	3,544,067	21.58
b) Indigenous Land	2,390,112	14.55
State's Total Land Area	16,422,136	100

Source: *Secretaria de Estado de Planejamento* (Seplan, 2011).

It is a known fact that Acre has great potential in terms of natural resources, but these are combined with a high poverty rate. It has 733,559 inhabitants (IBGE, 2013), among which 72.61% live in urban areas, and, at the same time, it is considered one of the poorest states in Brazil, with approximately 60,000 families (nearly half of the state's population) benefiting from the aid provided by the '*Bolsa Família*' program (*Conselho Indigenista Missionário* [Cimi], 2012).

It has a Human Development Index (Pnud, 2013) of 0.697 (LHDI), which is lower than the national average, ranking 21st among federal units, ahead of only the states of Bahia, Sergipe, Paraíba, Piauí, Maranhão and Alagoas. In this regard, it is important to emphasize that, in Sen[5] (2010)'s view, a low level of income may be a fundamental cause of illiteracy and poor health, as well as of hunger and malnutrition.

Amartya Sen (2010) states that poverty is a deprivation of freedom, especially of basic capabilities, rather than merely the lowness of income; this is reflected in infant mortality, malnutrition, morbidity, illiteracy and other deficiencies. One of the main causes of such poverty is unemployment, which ends up being a source of wide-ranging debilitating effects on people's freedom, initiative and capabilities.

This preliminary diagnosis raises a fundamental question: what is the optimal development model for states such as Acre, taking into account environmental degradation engendered by deforestation caused by cattle ranching? In this regard, approach of Sachs (2008) to development mechanisms is of great importance. According to the author, such development should be promoted by creating and expanding endogenous strategies according to determinants and subjects to the local area to be developed. In short, it is necessary to aim at a model of growth based on potentials and particularities of each locality.

Perhaps one of the growth possibilities in the State of Acre is exactly the mapping and use of its natural resources, so as to identify the opportunities and restrictions of its biome in order for developing the region according to ecodevelopment principles. In this sense, environmental services have emerged as an endogenous development strategy to serve as an alternative to deforestation in the state. Thus, as stated by Fearnside (2003), rather than destroy forests to produce goods, as is the current practice, it is possible to use forest conservation as a cash-flow generator based on environmental services.

In the ecological aspect of economy, ecosystem functions can be defined as constant interactions between structural elements of an ecosystem, which include energy transfer, nutrient cycling, gas regulation, and climate and water cycle regulation (Daly & Farley, 2004). Ecosystem services are the benefits that people obtain from ecosystems, including the provision of food and water; regulation of floods, diseases, and cultural services (religious or leisure activities); and delivery of supporting services, such as nutrient cycling, which maintain the life conditions on Earth (*Millennium Ecosystem Assessment*, 2005).

Conservation of biodiversity

According to Fearnside (2003), the Brazilian Amazon forest is known for its high species diversity, including many endemic ones, the multiple uses of biodiversity just provide sufficient justification to prevent its loss. The author stresses that, in the case of the Amazon region, there is a large number of people in the world who believe that maintaining biodiversity is important, and value environmental services enough to be willing to pay for them, which translates to a potentially substantial cash flow.

Maintenance of rainfall

Fearnside (2003) argues that the Amazon rainforest plays a key role in water cycle of the region, as half of rainfall originates as water recycled by vegetation. Since evapotranspiration is proportional to leaf area, the amount of water recycled by forest is much greater than the amount recycled by pastures, especially in the dry season when pasture grass is parched, whereas the forest remains green.

According to author, the water that is supplied to the south-central region of the country, comes from Bolivia and the western Brazilian Amazon area (western Rondônia, Acre and western Amazonas) via air currents (low-altitude jet streams). For this reason, the preservation and conservation of these

[4]For details of classification, see Act No. 9985 of 18 July 2000 which established the National System of Conservation Units (SNUC).

[5]1998's Nobel Prize winner for his contributions to welfare economics and social choice theory.

areas lead to a greater provision of water vapor to South-Central Brazil and, if deforestation continues, the main population centers (Rio de Janeiro and São Paulo, for instance) may become subject to energy rationing due to low water levels in reservoirs in other regions than the Amazon. The role of water vapor originated from the Amazon in rainfall distribution over the area should raise awareness about the importance of conserving the Amazon rainforest. In this respect, Fearnside (2003, p. 12) states that:

> Maintaining the water cycle is of strong national interest to Brazil, but, unlike conserving biodiversity and preventing the greenhouse effect, it does not exert a direct impact on European, North-American and Asian countries. Therefore, it does not have the same potential to generate international cash flows. Nevertheless, by the same token, the importance of the water originated from the Amazon to Brazil should at least encourage the government to accept international cash flows to help support the forest alongside the other ecosystem services, especially those related to the greenhouse effect.

In addition, the importance of rainfall is further underscored by its adding substantial economic value to the country, for maintaining adequate and stable rainfall levels is beneficial to the main agricultural areas in the South-Central region.

Maintenance of the aesthetic beauty

In terms of aesthetic value, people appreciate the scenic beauty of landscapes found in the ecosystem. This can be seen in their willingness to spend their free time pursuing a leisure activity in a particular location chosen on the basis of importance of its natural (or cultivated) features (Millennium Ecosystem Assessment, 2005).

With regard to tourism, information on ecotourism in the Amazon is yet to be systematically collected, as it is still early days for these activities in the region (Margulis, 2003). However, the State of Acre has potential for ecotourism development. Some of the major tourist and recreational attractions provided by the scenic beauty of the biome are:

a) Geoglyphs: Perfectly symmetrical geometric drawings made by an ancient civilization;

b) Ecotourism Practice: A lodge within an active rubber plantation property (*Seringal Cachoeira*)[6] gives its visitors the opportunity to contemplate nature, as it is located in the middle of the Amazon forest. Tourists can either stay in the accommodation provided or opt to just enjoy the recreational activities offered by the lodge, which, for a fee, allows them to go tree climbing and hiking deep in the jungle. Moreover, typical regional dishes are available as gastronomical choices.

Cultural preservation

According to the Millennium Ecosystem Assessment (2005), ecosystem diversity is the only factor influencing cultural diversity. This is because many religions are attached to spiritual and religious values of an ecosystem and its components, which, in turn, have an impact on wisdom system developed by several cultures, and on different social relations established between them. For instance, fishing communities differ from nomadic communities, which are not similar to peasant communities, either. Moreover, cultural heritage provides a common ground between formal and informal education in many societies, other than being a rich source of inspiration especially in the fields of art, folklore, architecture, and more.

In the perspective of the NGOs Forest Trends and The Katoomba Group (Forest Trends and ISA, 2010), rainforests maintain a strong cultural connection with the numerous populations that inhabit it. Over thousands of years, different indigenous ethnic groups and traditional populations have created myths, beliefs, rituals and traditional knowledge related to forests and their natural resources[7]. In this sense, it is worth noting that the wet and dry seasonal changes are responsible for setting the pace for life in forest and mark a number of rituals and festivities in different cultures.

The State of Acre is home to 14 indigenous people[8] (*Fundação Nacional do Índio* [Funai], 2013) that help perpetuate the local cultural heritage and, at the same time, depend on the Amazon biome for their survival. These groups comprise 17,578 people, among which 13,308 live in indigenous territories (TI) and 4,270 in urban areas (IBGE, 2013).

Carbon sequestration and storage

Through photosynthesis, a process in which forests absorb carbon dioxide (CO_2) and release oxygen[9], the capture or sequestration of CO_2 from atmosphere emerges as an important mechanism to prevent global warming, and consequent climate change (Forest Trends and ISA, 2010).

Thus, REDD[10] (avoided deforestation) projects could be a viable alternative in reducing deforestation in states such as Acre, promoting the

[6]Located in the town of Xapurí, 174 km distant from Rio Branco, the state capital.

[7]The use of medicinal plants is one example.

[8]Namely: Mawáka, Arara, Ashaninka, Deni, Jaminawa, Katukina, Kaxinawá, Kulina, Manxinéri, Nawa, Nukuini, Poyanawa, Shanenawa and Yawanáwa.

[9]Where carbon dioxide, water and sunlight turn into glucose, a sugar used as food by plants.

[10]'Reduction Emission from Deforestation and Degradation'.

development of the region and its economy in accordance with the environmental sustainability goals. Add to this the fact that the State has approximately 7.5 million hectares of forest, representing 45% of its territory included in protected area program (Seplan, 2011), which contributes to preservation of forest resources for future generations, and yields functional and aesthetic benefits to all mankind.

The State of Acre experienced economic growth in the last decade on some sectors, besides the purpose of sustainable development in action. We estimate the effects of economic impact on annual tax of deforestation at these sectors, which should be rethinking about the ecodevelopment strategies discussed. The model and data are explained in the next section.

Estimated model

The econometric model uses the deforestation rate per town between 2000 and 2011 in relation to Acre's economic activities. The deforestation rate was provided by the National Institute for Space Research (Inpe), while economic activity variables refer only to primary sector, and was calculated by the Brazilian Institute of Geography and Statistics (IBGE). The estimated model is as follows Equation 1:

$$D_{mt} = \propto_{mt} + \beta \boldsymbol{E}_{mt} + \varepsilon_{mt} \quad (1)$$

where:

D_{mt} represents deforestation in a town m for the time t. The $\boldsymbol{E}_{mt}$ vector is composed of the production of *açaí* berries, Brazil nuts, rubber, livestock, firewood, coal and timber in a town m for the time t. Errors are measured by ε_{mt} and the linear coefficient by $\propto_{mt}$.

The results were estimated with fixed- and random-effects models. The Hausman test did not suggest using a random-effects model, for the calculated values for towns, duration, and towns and duration together when treated as random were 0. For this reason, we present in Table 2 only the fixed-effects model, which produced more significant results.

There are few conflicting points between the estimates listed in the Table 2. However, F-test and Chi-square test values for the models vary. For the model where towns were considered fixed, the values are F = 15.286826 and CS = 227.363342; with fixed time, F = 1.189216 3 and CS = 13.732421; and when both towns and time are treated as fixed, we have F = 16.241792 (towns), F = 2.507137 (duration) and F = 11.601532 (towns and time). Chi-square values are as follows: CS = 244.283703 (towns); CS = 30.652782 (time); and CS = 258.016124 (towns and time).

Table 2. Fixed-effects estimates of deforestation in Acre's towns in the period from 2000 to 2011, according to the economic activities.

Variable	Towns	Time	Towns and Time
Constant	586.92*	175.1650*	729.6558*
	(16.11295)	(6.812740)	(11.48366)
Açai	0.24561*	0.988386*	0.066266ns
	(3.152428)	(7.229978)	(0.788435)
Brazil nut	0.028467***	0.0344293****	0.016478ns
	(1.818541)	(1.426051)	(0.844808)
Rubber	-0.413303*	0.609197*	-0.222815****
	(-4.349954)	(2.949657)	(-1.634793)
Ranching	0.002144*	0.005432*	0.001447*
	(11.48428)	(20.29537)	(2.843331)
Firewood	0.001983***	0.000237ns	-0.000839ns
	(1.670267)	(0.716390)	(-0.687568)
Coal	0.019808ns	0.482175*	-0.009426ns
	(0.214137)	(6.164740)	(-0.100158)
Timber	0.000152****	-0.000294ns	0.000592***
	(1.259353)	(-0.426558)	(1.790010)
R^2	0.943240	0.872510	0.949462
F	139.4730	93.15097	107.9058
Akaike	13.08010	13.81355	13.04733
Schwarz	13.47292	14.07091	13.58914
Hannan Quinn	13.23795	13.91697	13.26504
Durbin Watson	2.13033	1.012976	2.154158

t-test in parentheses. *significant at 1%, **significant at 5%, ***significant at 10%, ****significant at 25%, nsnon-significant. Source: Calculated by the author using data from Inpe and IBGE.

Thus, the best estimates were found when using towns as a fixed effect and towns and time as fixed effects. The model in which only duration is treated as fixed is not significant.

One observation that we can draw from the results of the first and third estimates shown in Table 2 is that coal production is not significant in explaining deforestation in Acre. As for rubber production, it is negatively correlated with deforestation, i.e., the increase in rubber production in the State from 2000 to 2011 curbed deforestation; considering that rubber production was reduced during that period, we can conclude that the increase in deforestation is linked to rubber's replacement with other products, such açaí berries, nuts, firewood, timber and ranching.

The estimated data shows that the deforestation rate increases with the expansion of economic activities, as ranching and açaí production, in the cities of the State of Acre along the period.

Conclusion

The major driver of deforestation in Acre is cattle ranching, whose consequences extend to the social and environmental spheres. Still, the production of timber, nuts, açaí berries and firewood are also related to the increased deforestation in the State.

Rubber production was in decline, being replaced by the production of goods that influenced the increase in deforestation between 2000 and 2011.

Regarding the conservation policies previously discussed, it was evidenced that the measures from American Naturalistc are effective from an environmental perspective, but not as regards the aspects related to the economic development of populations.

The environmental services may be a possibility for promoting endogenous development among the inhabitants of states such as Acre, provided that this strategy is effectively expanded. Yet, it should be noted that an economy developed on the basis of environmental services will have an opportunity cost as high as that of cattle ranching, because of the cultural, aesthetic and functional benefits obtained from the living forest.

The negative impact from the expansion of economic activities over the Amazon forest is identified in the literature and along the estimated data. It can be seen the relationship between the deforestation and the agricultural products growth in the State of Acre between 2000 and 2011.

We conclude that there is the possibility of decrease in the deforestation rate in the State of Acre. As the State has large indigenous and preservation areas, the primary economic activities are limited, and there is the possibility of reversal of deforestation rates through environmental services incentive on the primary sectors of the local economy. Other studies can test the hypothesis of Kuznets curve for deforestation in the State of Acre and the Amazon forest. The central idea is the possibility of stagnation or even reduction of cattle ranching in the Amazon area. For this, it is necessary the improvement of public policies with environmental orientation, and the reduction of financing of economic activities with high environmental damage.

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