Forest Economies: A Remedy to Amazonian Deforestation?

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ABSTRACT

Commonly described as the "lungs of the planet," the Amazon rainforest represents over half of the remaining rainforest in the world, constituting an important global carbon sink and one of the most culturally- and biologically-diverse regions of the world. The past half-century has seen a worrisome amount of deforestation in this rainforest, but different regions within the Amazon, however, compare differently in terms of deforestation trajectories. What has been the role of products obtained from managing forests, such as the now globally-consumed açaí palm fruit, in reverting deforestation trends? My hypothesis is that there is a statistically significant negative correlation between such forest products and extent of deforestation. This study examines, within the historical and social context of the Amazon Delta and Estuary, the relationship between açaí agroforestry and deforestation. The focus units are the *municípios* (roughly equivalent to counties) that constitute the Amazon Delta and Estuary, all located in the northern Brazilian states of Amapá and Pará. Statistical data for deforestation obtained from PRODES, a Brazilian governmental project, which monitors deforestation via satellite, is used to ascertain deforestation in the region. This dataset is then correlated with census-based production data for each município for the period from 2002 to 2012. Mapping these variables onto municípios does visually demonstrate a contrast between areas of high deforestation and high açaí production; however, the relationship is not statistically significant.

KEYWORDS: Amazon, deforestation, agroforesty, açai

Just like a mosaic, which can seem a monolithic entity when viewed from afar, but increasingly diverse when examined more closely, so too can large ecosystems house surprising diversity invisible unless studied closely. Surpassed by few in this regard is the Amazon Basin, home to a wide array of not only species, but also landscapes, cultures, and contemporary issues. Well-known and highly-publicized in association with the Amazon is its widespread deforestation: a social, environmental, and developmental concern at local, regional, and global levels. Less well-known is the extent to which deforestation differs across regions within the Amazon. In an area as vast as the Amazon, covering over 6,915,000 square kilometers (*i.e.*, the size of the continental U.S.), deforestation and conservation can and do occur simultaneously.

Deforestation trends actually vary greatly in the region, and their variability increases as the area of analysis becomes smaller (Brondízio & Moran, 2012). However, noticeable regional trends do exist. Most significant is the so-called "Arc of Deforestation" running through the eastern and southern portions of the Amazon Rainforest, where deforestation rates are at some of their highest. This phenomenon is largely due to construction of road networks that have facilitated large scale agriculture, pasture expansion, and migration to new settlements near or within the territory of the forest. Other regions, however, manifest quite different trends, demonstrating, in some cases, the potential for sustainable forest and agroforestry management. One such region is the Amazon Delta and Estuary, which enjoys a strong forest-based economy. This economy is largely based on cultivation of the açaí fruit, but also involves a variety of other forest products.

Due to this divergence from trends elsewhere in the Amazon, this study investigates the relationship between açaí fruit production in agroforestry systems and deforestation in the Amazon Delta and Estuary. Previous research demonstrates an inverse relationship between deforestation and açaí cultivation in parts of the delta-estuary (Brondízio, 2008). This study seeks to examine the presence of such a relationship at a delta-wide level. The data used is obtained from IBGE, the Brazilian Institute of Geography and Statistics, and PRODES, a Brazilian federal project monitoring deforestation via remote sensing (satellite imagery).

This article is organized in the following manner: a background section describing the geographic location of the study is followed by a review of the social and economic context of açaí cultivation. The statement of the hypothesis and an explanation of the methodology appear next, followed by the actual results and their explanation. Finally, a discussion section examines the meaning and implications of the results.

THE AMAZON RAINFOREST

The Amazon is a vast area, with territory distributed across nine countries, and one of the world's most diverse areas, not only biologically but also culturally. The Amazon Basin (*i.e.*, the total area drained by the Amazon River) covers nearly seven million square kilometers and encompasses various types of ecosystems, including savannahs, swamps, and flooded forests. The predominant ecosystem, however, in terms of territory, is rainforest, covering 5.5 million square kilometers within the basin and representing approximately half of the total rainforests remaining on Earth. Due to this fact, its existence is crucial to regulating carbon at a global level and it has historically been called the "Lungs of the Planet" ("Amazon: Lungs of the planet," 2014).

The Amazon Rainforest has been inhabited for millennia, and much evidence indicates, contrary to widespread preconceptions, that there actually existed significant human modification (or management) of the forest environment dating back far before European settlement (Balée, 2013).

In fact, the Western/modern dichotomy of "pristine" environments versus "modified," "touched," or "degraded" ones does not hold much ground here; even areas deep within the forest display signs of significant modification by indigenous populations, who modified and managed the forest to their uses while maintaining forest cover (Heckenberger et al., 2003). The Amazon Rainforest actually did not experience wide-scale deforestation until the 1970's, when colonization programs aggressively started expanding and encouraging the settlement of previously hardly accessible areas (Brondízio & Moran, 2012).

Currently, deforestation (see Figure 1) and conservation in the Amazon result from a complex web of interrelated factors, and there is no one cause or solution. Both large-scale agricultural enterprises and small-scale settlement schemes, influenced by government credit policy, impact the forest, with profitable world markets for beef and soy incentivizing the conversion of forest land to pasture or farmland. Additionally, logging operations, driven by a high domestic and worldwide demand for timber, have resulted in large swaths of both clear-cut and selectively-logged forests, which are subsequently abandoned, often not offering any economic value once the logging operation has moved on. Government policies have themselves greatly aggravated the problem through financing resettlement schemes and a bias toward large scale agriculture and cattle ranching, through building roads facilitating settlement and often environmentally harmful economic development, and through projects such as hydroelectric dams. Finally, while Brazil has one of the most sophisticated satellite monitoring systems (*e.g.*, PRODES), current lax governmental enforcement (due both to lack of political will and to lack of resources to police such a vast territory) is not sufficient to put into effect conservation laws that are in place (Butler, 2015). Although the rate at which it had been occurring has dropped since 2005, net deforestation still is present in the Amazon region and requires much further effort to be adequately addressed.

The focus area of this study is the Amazon Delta and Estuary (see Figure 2), located in the northern Brazilian states of Amapá and Pará. Sitting at the mouth of the world's largest river by discharge, the Amazon River, this area is characterized by an unusual environment containing features of both deltas (*i.e.*, islands formed from sediment) and estuaries (*i.e.*, brackish water resulting from combined seawater and freshwater). As seen in Figures 1 and 2, this region manifests lower deforestation rates than other parts of the Amazon but is vulnerable to demographic, economic, and environmental pressures.

To some extent, the lower deforestation rates in the Amazon Delta and Estuary can be explained by the region's natural characteristics. The soil and climate are not conducive to soy cultivation, and a large part of its central Marajó Island is already grassland and is used, among other things, for cattle herding. Furthermore, although (or because) the area has been inhabited for millennia and, being adjacent to the seashore, was one of the first regions of Amazonia settled by Europeans, it has historically exhibited a high and sustainable degree of human-forest coexistence, with an economy strongly characterized by a combination of forest management and agriculture (Vogt et al., 2015).

Another factor related to lower deforestation rates is the widespread small-scale production of açaí (see Figure 3). Scientifically known as *Euterpe oleracea*, açaí is a palm tree native to northern South America occurring mainly in floodplain areas. Its edible black-brown berry is an important staple food source for rural and urban inhabitants of the region (see Figure 4) and has experienced a great increase in demand in the past three decades, including national and international expansion since the 1990's. Açaí cultivation employs a sizable population and has a marked effect on the society and environment of the region. Its greatest center of production is in the Amazon Delta and Estuary, but production

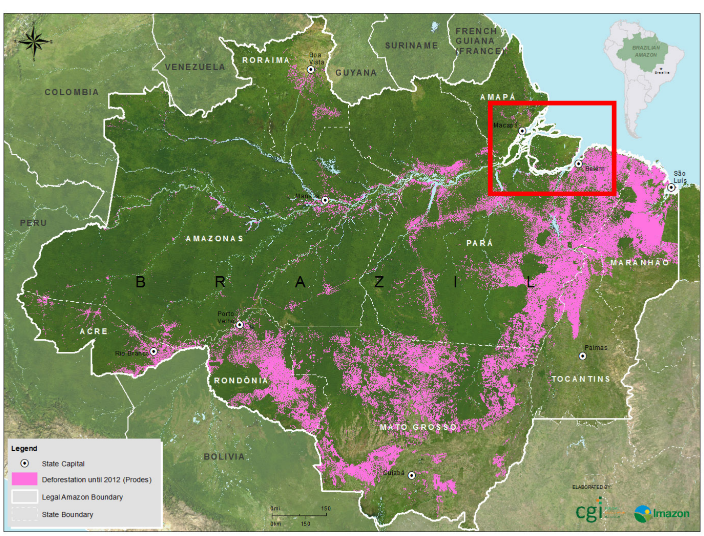

Figure 1. Deforestation in the Brazilian Amazon Rainforest. The pink areas show deforestation up to 2012; the selected area is the Amazon Delta-Estuary ("Deforestation in the Amazon accumulated by the year 2012", IMAZON).

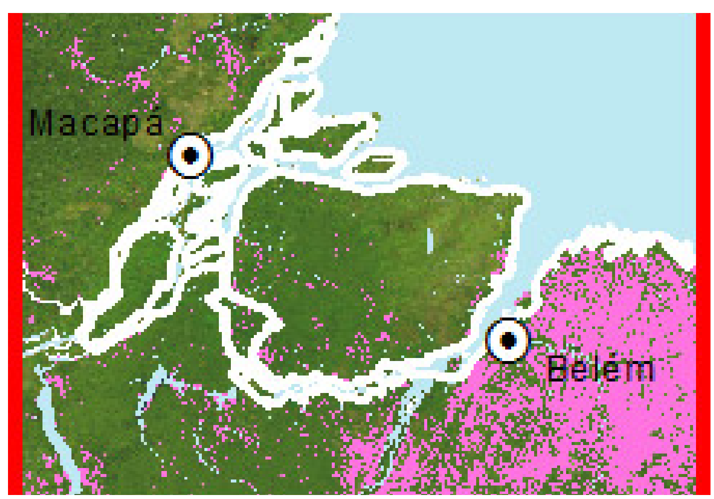

Figure 2. Deforestation in the Amazon Delta-Estuary. This figure shows the much lesser extent of deforestation in the Delta-Estuary ("Deforestation in the Amazon accumulated by the year 2012", IMAZON).

Figure 3. Euterpe oleracea (Photos E. Brondízio, various dates).

does occur in other areas throughout the Amazon, from the state of Maranhão, on the eastern edge of the Amazon, to the far western state of Acre (Instituto Brasileiro de Geografiae Estatística, 2015).

Açaí has been consumed by indigenous populations in the Amazon Delta and Estuary since pre-Columbian times, and even up to today it is strongly associated with caboclos, people of mixed European, indigenous, and African ancestry. Traditionally, as a staple food source, açaí was consumed primarily by rural populations in the region and relatively unknown elsewhere, even within other parts of Amazonia. However, with increasing urbanization starting during the 1970's, this began to change. As rural residents moved to the city, they continued their consumption of açaí obtained from the surrounding areas, introducing the berry to others as well. After the 1980's, açaí consumption was spreading to other urban areas of the Amazon. By the 1990's, açaí was venturing out of the delta-estuary region into other areas of Brazil, including the highly-urbanized and economically affluent south and southeast, and then continued further into international markets. One factor that particularly stimulated the consumption of açaí in Northern markets was its branding as a health food or even a "superfood" (see Figure 4).

Açaí cultivation, particularly in the delta, is characterized by active agroforestry and forest management techniques (Brondízio, 2008). Agroforestry encompasses a broad range of techniques combining forest management with agriculture and/or husbandry, which allows intensification and diversification of production. Specifically in açaí cultivation, where it has been very successful, agroforestry techniques include the selective pruning of branches (preventing açaí clumps from becoming too clustered, which would block sunlight), spacing of trees, and selection and arrangement of tree species in a forest garden. Açaí production does not require many inputs at the time of planting or management but is particularly labor-intensive and even dangerous at harvest, requiring climbing of the palms to cut off the berry and involving the not-uncommon risk of encountering snakes nested within açaí clumps (Brondízio, 2008).

The farmers that engage in açaí cultivation are predominantly small-scale forest farmers living in the delta-estuary region, with families often having lived in the same household and engaged in the same living for generations. Many açaí producers are economically disadvantaged, often living in sharecropping arrangements on land owned by absentee landlords. Though benefiting to some extent from increasing demand for açaí, they still suffer from dependency on middlemen, the high cost of getting açaí to market in urban centers (see Figure 4), and limited opportunities to aggregate value to açaí products locally. Another obstacle facing forest farmers is their societal label as extractivists (Brondízio & Siqueira, 1997). As described earlier, there exist various federally-administered credits and subsidies aiming to promote agricultural expansion and support disadvantaged farmers. However, these programs make a key distinction between intensive and non-intensive/extractive systems, with heavy preference given to intensive ones. Due largely to lack of understanding by outside actors, including government agencies, as well as historical labels, farmers engaging in açaí production are still viewed (and largely stigmatized) as extractivists. The label "extractivist" suggests a passive role for producers obtaining resources from the forest without a significant amount of investment into it (a gross misrepresentation of their actual work), a perception which bars them from access to many types of government credit. In practice, agricultural practices promoting clear-cutting are seen to be intensive and thus enjoy easier access to funding (leading one to question the effectiveness and efficiency of governmental credit programs).

Figure 4. Açaí at the market, as a staple (Photos E. Brondízio, various dates), and as a "health food" ("Landing Page").

HYPOTHESIS

In an investigation on land-use change between the 1960's and the present, researchers affiliated with the CASEL center at Indiana University study two municípios in the Amazon Delta and Estuary, Mazagão and Ponta de Pedras, and demonstrate increased forest recovery in correlation with the boom in açaí, confirmed by satellite, archival, and ethnographic data (Vogt et al., 2015). Açaí production is increasing throughout the delta and estuary, but, up to now, there has been little study of this relation at the overall delta-wide level. As there are many other variables that affect deforestation and açaí production, the hypothesis of this investigation is that there is a weak, but statistically significant, negative correlation between deforestation and açaí production in the Amazon Delta and Estuary.

METHODS

This study maps açaí production trends and deforestation for the past decade (2002-2012) throughout the Amazon Delta and Estuary. Census data for volume of açaí produced is obtained from the Brazilian Institute of Geography and Statistics (IBGE), and data for yearly and cumulative deforested area is obtained from the PRODES project. Using ArcMap (GIS) software, volume of açaí and deforested territory are joined to shapefiles for municípios (administrative units roughly equivalent to counties) (N = 44), also obtained from IBGE. As seen in Figures 5 and 6, resulting images show net deforestation and average yearly açaí production for each município between 2002-2012 as a percentage of the regional total (as percentages are easier to understand than absolute numerical values but show the same relative relationships between different municípios). Differing amounts of deforestation or production volume are shown by different shades, allowing for a visual comparison of maps. The base maps were generated by Scott Hetrick (Center for the Analysis of Social-Ecological Landscapes – CASEL, at Indiana University), using maps from the University of Maryland Global Forest Change project (Hansen et al., 2014). Finally, SAS software was used to calculate the regression.

The map designating the increase in deforested area between 2002 and 2012 thus represents the total area forested before 2002 that was deforested by 2012. The map representing açaí production, on the other hand, represents for each município the average volume of açaí production over 12 years (using even years between 2002 and 2012). The reason for this difference is that volume produced can change yearly independently from previous years, while deforestation can be easily measured cumulatively.

METHODOLOGICAL LIMITATIONS

A macro-level study has several limitations. First, the use of municípios as the observation units prevents much more detailed study of local trends as there may be large variation within municípios themselves (especially for some larger municípios). However, there is no açaí data for the census-sector level (which would be ideal). Furthermore, whereas deforestation data is quite accurate (with 20 by 30 meter resolution) and updated yearly using satellite imagery, census data can be notoriously incomplete and/or inaccurate. Açaí production data are estimates at best, but this is the only data available for any quantitative study. There is no data for the different types of açaí cultivation methods (agroforestry versus plantation farming), but this difference does have environmental implications. Due to data and time restraints, this study does not take into account confounding variables such as urbanization, population, and production of other commodities such as wood and beef, which do have environmental implications, nor can it state the direction of the relationship. Finally, a total of four municípios within the delta and estuary were excluded from this study due to inconsistencies within census data.

RESULTS

This map shown in Figure 5 displays the percentage that each município listed contributes to the total production of açaí in the region, averaged over ten years. Production is on average highest on the island of Marajó (toward the center of the delta-estuary) and nearer the urban areas of Belém and Macapá.

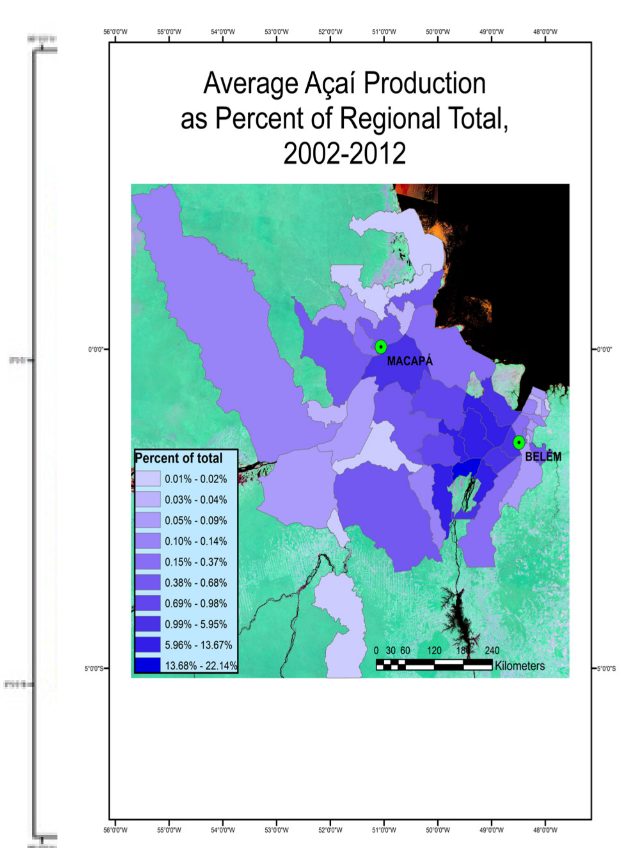

Figure 5. Açaí production per município.

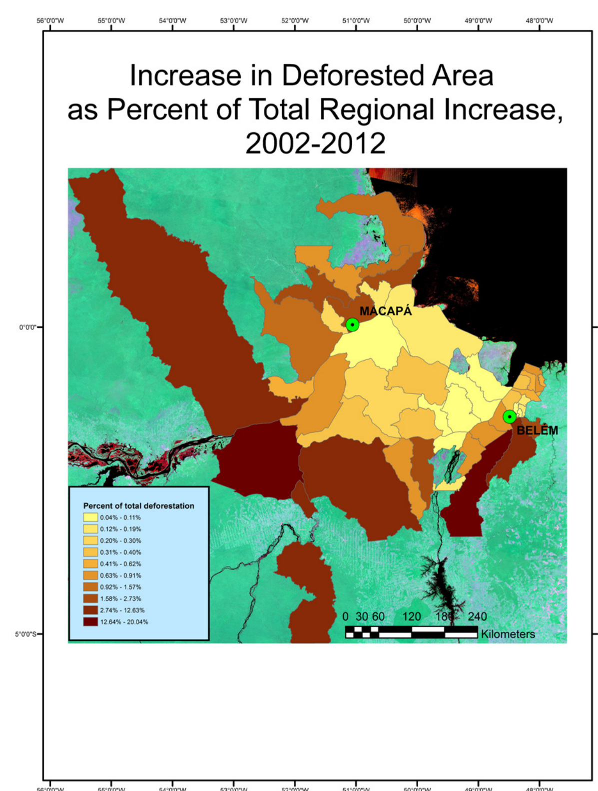

Figure 6. Deforestation per *município*. This map shows the percentage by *município* of the total increase of deforested area between 2002 and 2012 for the entire region. There is much variation across municípios independent of size.

REGRESSION ANALYSIS

The regression analysis shown in Figure 7 plots cumulative deforestation between 2002 and 2012 against average annual açaí produced (entering deforestation is the dependent variable). Each data point represents a município. The correlation, as shown by the trend line, is slightly negative, with a slope of -0.01063. However, analysis does not demonstrate statistical significance: the R^2 value is extremely low (0.0360), and the F ratio is extremely large: 0.2170.

DISCUSSION

A side-by-side comparison of the maps allows an easy visualization of the relationship (see Figure 8). There does appear to be a negative relationship between average açaí produced and increase of deforested area. Areas with lower recorded volumes of açaí produced (shown in lighter shades on the left) tend to have higher increases in deforestation, shown by darker colors on the right. With some exceptions, there is a trend toward increasing açaí production toward the geographical center of the delta-estuary and Marajó Island, with decreasing production (and increasing deforestation) toward the periphery, in areas further from the main market hubs of Belém and Macapá. Additionally, there are higher concentrations of açaí production near urban areas (at least those indicated, Macapá and Belém); while some municípios near urban areas have experienced very high amounts of forest loss, other municípios immediately adjacent to them actually demonstrate some of the lowest rates of forest loss. However, when subjected to a statistically rigorous test, this correlation fails to hold. This result is not surprising, given the complexity of the processes involved. There are many confounding variables and factors affecting deforestation as well as açaí production, including proximity to major urban centers and topography; this complexity increases the larger the area observed becomes.

This boom in açaí contrasts starkly with a similar regional boom in heart-of-palm (also an internationally valued food commodity obtained from *Euterpe oleracea* as well as other palm trees) that occurred around the mid-twentieth century. Heart-of-palm harvesting was accompanied by unsustainable practices, often resulting in depleted forests. The açaí boom, on the other hand, has (at least in the delta-estuary region) been able to draw on traditional agroforestry knowledge, as well as its traditional status as an already-widespread rural staple. This situation poses a challenge to the paradigm of "pristineness" of nature and its desirability. Areas where significant human interaction with the environment has taken place can successfully maintain forest cover; on the other hand, once the "pristine" nature of a location ceases to be a priority and loses to economic concerns, the environment can

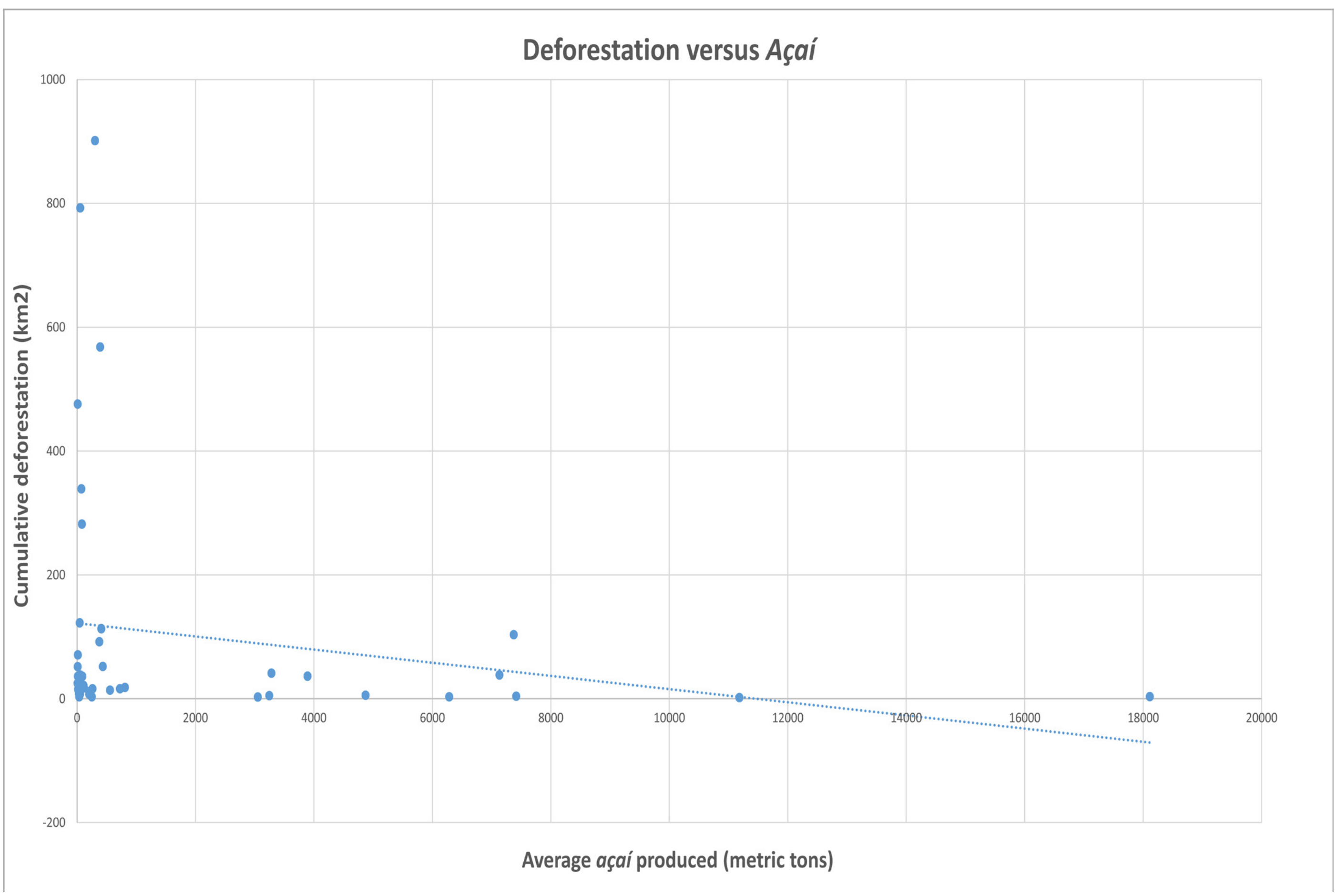

Figure 7. Regression. This scatterplot plots *açaí* produced versus cumulative deforestation for all *municípios* studied.

become quickly degraded.

No less important than environmental considerations are economic ones; to what extent is the growth of açaí agroforestry benefiting producers and local economies along with the local environment? For example, there is reason to claim that it has: increased market participation, along with technological improvements has enabled physical mobility, shortening the time it takes to reach urban centers and improving educational and medical prospects for residents of otherwise quite isolated settlements in the delta-estuary, facilitating and encouraging new networks and developing and expanding quite a complex economy (Brondízio, 2008).

However, (at least) two factors limit the benefit accrued to local communities. First, in the açaí commodity chain, the producers themselves are at the very bottom and thus have limited control over the marketing of their product. Second, açaí is still exported from the delta-estuary region either predominantly *in natura*, or depulped and frozen. This condition limits the revenue that can be generated by value-added chains. Processes such as canning of heart of palm do take place, but at a limited scale when compared to the final marketed product in large domestic markets (in other regions of Brazil) or internationally. There are instances of communities successfully engaging in further processing of the product; overall, however, an increase in local manufacturing and processing would do much to capture additional potential value from açaí manufacturing and bring it back to the communities (Brondízio, 2008). The labeling of açaí producers as extractivists in this situation is harmful, reducing the legal and financial incentives to produce açaí (or unnecessarily placing a burden on açaí producers), something which on a legal level ought to be reconsidered for the sake of both conservation and economic equity.

CONCLUSION AND IMPLICATIONS

A spatial representation points to a likely negative correlation between deforestation and açaí, but statistically there is yet no significance to this relationship at the delta-wide level. However, further research and inclusion of additional variables could yield promising results. Potential topics for further investigation include the demographics of açaí producers (to see whether producers have increased in number, or changed in nature), and the extent to which better infrastructure has been a factor in the açaí boom. Additionally, remote sensing data could be used to more quantitatively measure the relationship between density of açaí and deforestation, allowing for a highly detailed analysis, but over a large area. The trajectory of açaí production elsewhere in the Amazon could be compared to that of the Delta and Estuary. Finally,

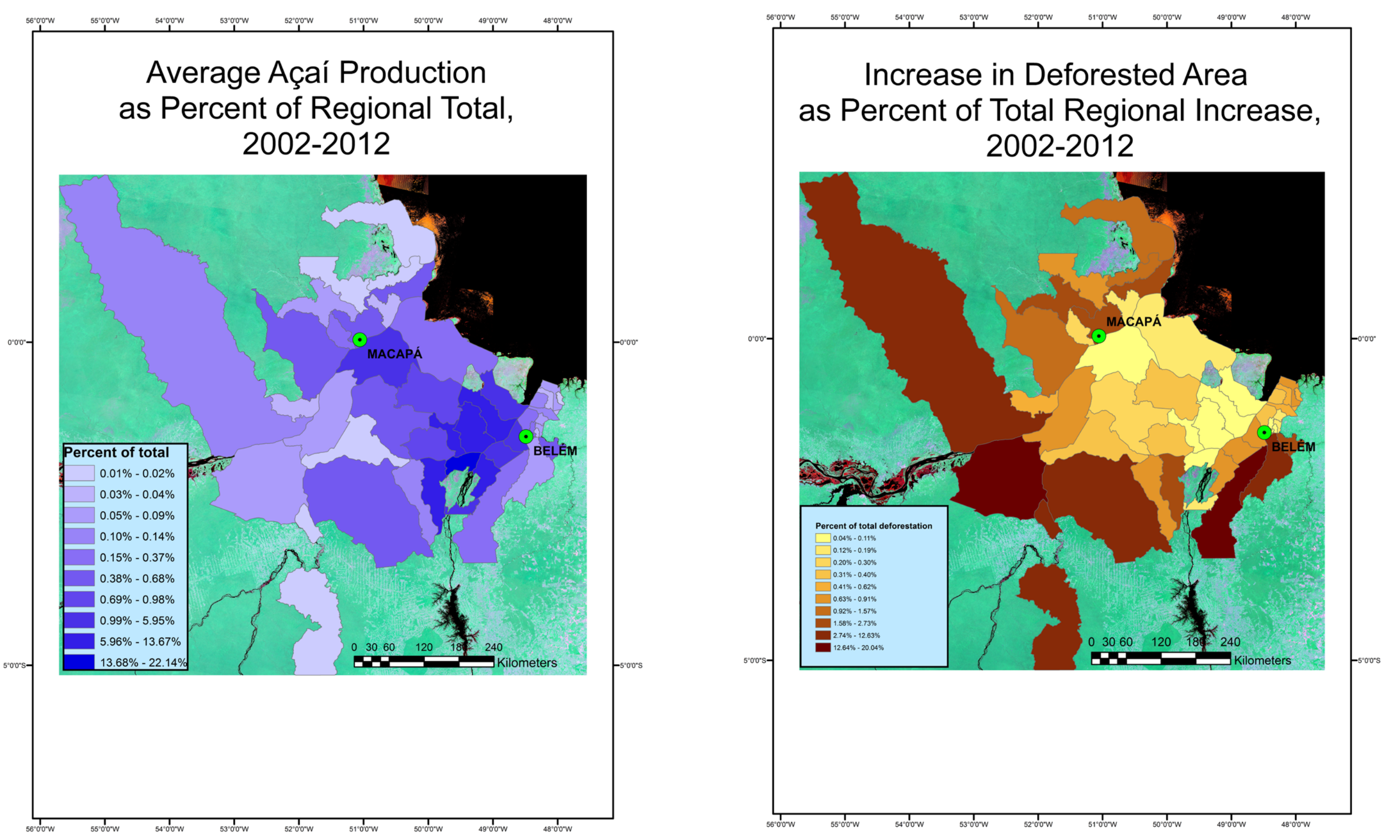

Figure 8. Visual comparison of *açaí* and deforestation.

global market trends should be studied: is this increased demand and international market likely to remain stable, or will there be an ensuing "bust"? If so, what would the ramifications be for producers—and the forest itself?

Extensive research has demonstrated the monetary and non-monetary economic value of tropical rainforests. Extractable products, such as various medicinal plants, have already proven profitable. However, ecosystem services go even further in their economic value. Especially for such a colossal entity as the Amazon Rainforest, the total monetary value of the services obtained from it is immense; just the value for the prevention of erosion has been estimated, for instance, at $238 per hectare (Verweij et al., 2009). Various economic sectors (such as agriculture throughout the region) benefit directly from, or depend on, these natural processes. However, as these prices are not included in the costs of products that detract from these natural processes (such as timber products or soy cultivated in formerly forested territory), these services are not captured in the market, thus resulting in perverse market forces that often incentivize deforestation. As açaí cultivation shows, however, this need not always be the case. In addition to products that can be commodified (such as açaí and medicinal products), there are also intergovernmental programs, such as Reducing Emissions from Deforestation and forest Degradation (REDD), that seek to revert current environmental trends by changing the underlying economic incentives, adding a monetary value to the forest. Further research should investigate other potential forest commodities and better mechanisms to capture the value of non-commodifiable ecosystem services.

Açaí is no panacea. First, as described earlier, the conditions in the Amazon Delta and Estuary, which lead to already lower incentives to deforest as well as a strong forest economy, differ significantly from those in other regions of the Amazon. Second, the advent of international açaí production has had at least one harmful side effect: an increase in açaí plantations, which bring with them many of the same problems other types of land-cover change do. Although there are no reliable statistics as to the share of plantation açaí in the total share of açaí produced, this is a concerning trend that, if left unchecked, can reverse the

Figure 9: Local *açaí* processing (Photo E. Brondízio, 2007).

environmental benefits brought about by açaí production. Finally, it remains to be seen to what extent demand for açaí will continue at its current growth. Nonetheless, the example of açaí demonstrates that integration of local economies with national and global marketplaces is possible in a largely environmentally harmonious manner and shows what factors need to be considered to do so. In turn, this example can be carried over to inform other attempts at reconciling economic growth with environmental concerns. Just as the Amazon is a mosaic, addressing deforestation in the Amazon will require a mosaic of various localized solutions; açaí may very well be one of those tiles.

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