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The History of Fragmentation of the Lowland Atlantic Forest of Pernambuco, Brazil

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ABSTRACT

This short review summarizes and links classical works with recent publications to give an overview about the main processes of fragmentation of the lowland Atlantic Forest of Pernambuco since colonial times and to show how this process continued during the agricultural revolution up to the present. The lowland Atlantic Forest of Pernambuco is an extremely endangered endemism centre and many of its biota are at the rim of extinction. Sugarcane has always been the main economic factor in the forest zone and so up to now sugarcane fields dominate this area. The broad river valleys were the first to be used for sugarcane cultivation. Since the availability of industrially produced fertilizers, the large but nutrient-poor tablelands or *tabuleiros* were used as well. The presently still forested sites are simply not suitable for the cultivation of sugarcane due to their strong inclination or necessary to preserve the water resources. They are protected by law, nevertheless their maintenance is not guaranteed. For the growing demand of biofuels the production of sugarcane turned a focus of international attention.

Keywords: biodiversity conservation, biofuels, landscape
Abbreviations: IBAMA, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis = Brazilian Institute for the Environment and Renewable Natural Resources; **INCRA**, Instituto Nacional de Colonização e Reforma Agrária = National Institute for Colonization and Land Reform

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INTRODUCTION

The Brazilian Atlantic Forest is one of the five most important global hotspots (Myers *et al*. 2000). It contains five areas of endemism. Two of them are located in the very North of the biome: the Brejos de Altitude and the lowland Atlantic Forest north of the Rio São Francisco. The lowland Atlantic Forest, also named Pernambuco endemism area, encompasses the eastern parts of the states Rio Grande do Norte, Paraiba, Pernambuco, and Alagoas (Silva and Casteleti 2003). They are unique for sharing many faunistic and floristic elements with the Amazonian forest from which they are isolated since the Oligocene to Miocene and which differentiates them from the other bio-geographic regions of the Atlantic Forest (Andrade-Lima 1960, 1982; Gottsberger and Silberbauer-Gottsberger 2006a). The total forest cover of the endemism area Pernambuco is only 4.5% of its original extension range (**Fig. 1**) (SECTMA 2002). This article treats only the lowland forests located in the state of Pernambuco, but the described processes took and take place in the neighboring states as well (Andrade 1957, 1959a, 1959b; Freyre 2004; Andrade 2005).

THE EARLY TIME OF COLONIZATION

The indigenous Tupí that lived in the lowland practiced slash-and-burn agriculture and planted yucca, corn, beans, and peanuts besides being hunters and gatherers (Dean 1997; Dantas *et al*. 2006). After Cabral had discovered the route from Europe to Brazil in 1500, Portuguese and French merchants traded with the various Tupí groups. European products were exchanged mainly for Brazil wood (*Caesalpinia echinata*) (Freyre 2004; Andrade 2005).

In 1535, Duarte Coelho arrived in Brazil. He was sent by the Portuguese crown and in charge of the *capitânia* Pernambuco. With him and his followers began the implementation of sugarcane plantations on a large scale, the enslavement of firstly indigenous people and later on Africans, and the fragmentation of the Atlantic Forest of Pernambuco (Andrade 2001; Freyre 2004). However, even he was worried about the way natural resources were wasted (Freyre 2004).

The sugarcane plantations were established along the main rivers, the *rios do açúcar* – the "sugar rivers", where the most fertile soil, the *massap*é was encountered (Freyre 2004; Andrade 2005). Less suitable areas were used for

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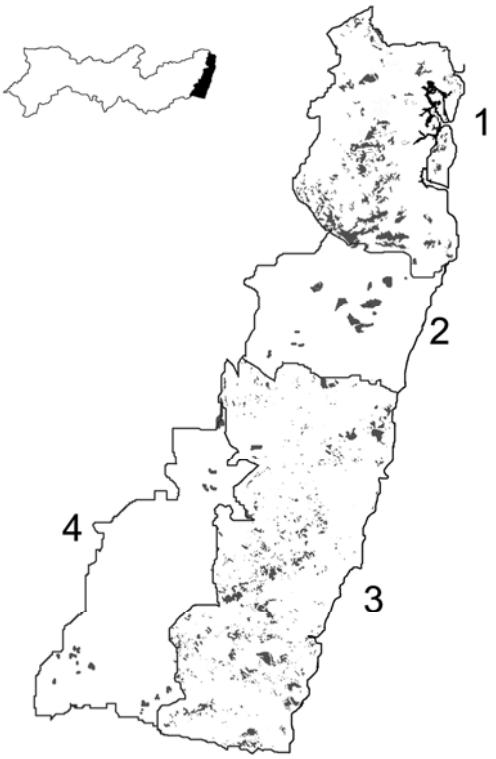

Fig. 1 Forest fragments of the eastern part of the lowland Atlantic Forest in Pernambuco. Upper left the outline of the state of Pernambuco, in black the displayed area, 1 = northern forest zone (CPRH 2001), 2 = municipalities of Olinda, Camaragibe, Recife, São Lourenço da Mata, Moreno, and Jaboatão (SOS Mata Atlântica) 3 = southern forest zone (CPRH 2001), 4 = municipalities of Escada, Ribeirão, Gameleira, and Água Preta (SOS Mata Atlântica).

other crops, necessary for food supply (Freyre 2004; Andrade 2005). The surrounding forests served as source of fuel wood, especially for the sugar mills. The Pernambucan anthropologist, sociologist, and historian Gilberto Freyre (1900-1987) experienced the time when the small sugar mills (*engenhos*) still existed. According to him, even the best woods were burned to ashes that were used as fertilizer, served as firewood or for fence construction (Freyre 2004).

The development of the sugarcane agriculture in Pernambuco was quicker than in the neighboring states of Bahia, Paraíba, and Espírito Santo and continued even in years of crisis (Galvão and Gonçalvez 1986). The number of sugar mills was five in 1550 and increased up to 66 in 1584, 144 at the time of the Dutch conquest (1630-1637) and about 3,500 in the second half of the nineteenth century (Andrade 2001).

The rivers also played a major role in the colonization of the forest zone of Pernambuco because they were the best mean of transport (Andrade 2001). There were little ports at the river estuaries from where the sugar was sent by boat to the capital Recife (Andrade 2001). The development of the western part of the forest zone was much slower (Andrade 2001). The means of transport were oxwagon and donkeys. Only in the nineteenth century, the government constructed roads to support the sugar mills in these areas connecting them with Recife; in the second half of the same century railroads were established (Andrade 2001).

The first lost forest habitats were consequently the broad river valleys. The rivers cross the forest zone from West to East, and the plantations along them fragmented the beforehand continuous forest.

THE NINETEENTH CENTURY

There is evidence that in the nineteenth century large wooded areas still existed in the West of the forest zone. The map "Florestas da Capitânia de Pernambuco" from 1799 shows a strip of cultivated land along the coastline but only forests in the West (Webb 1979). They provided refuge to two rebellious movements: in the north the *quilombolas* inhabiting the forests of Catucá. *Quilombolas* were mainly Africans and Afro-Brazilians that escaped slavery and lived in communities (*quilombos*) (Carvalhos 1996) and in the South the *Cabanos*, called after their housings, mere straw huts (in Portuguese *cabana*) (Andrade 2004).

The forests of Catucá were located at the western frontier of the sugarcane fields, between Apipucos (Recife) in the South, and Goiana in the North, close to the border of Paraíba (Carvalhos 1996). They were not one continuous forest but were intersected by sugar mills and trails along which cattle and cotton were transported from the hinterland to Recife (Carvalhos 1996). Military repression of the *quilombolas* was not always successful but expensive (Carvalhos 1996). It was thus decided to destroy the forests, so that the rebels loose their shelter (Carvalhos 1996). One major step into this direction was the donation of forested lands to German settlers; thus the colony Amélia was founded in 1829 (Carvalhos 1996). These settlers made their living in producing charcoal (Carvalhos 1996). A large part of the forest disappeared this way and the *quilombo* became effectively fought, yet the settlers encountered such difficulties that they finally left the state, whereas the *quilombo* returned strongly attacking even main sugarcane mills (Carvalhos 1996).

The center of combat in the war against the *cabanos* was the dense forests around Água Preta, close to Alagoas (Andrade 2004). The main part of the movement surrendered in 1835 (Andrade 2004). The last *cabano* leader was imprisoned as late as 1849 (Andrade 2004). After fighting the *cabanos*, the governmental forces moved northwards to put an end to the *quilombo* Catucá in 1837 (Carvalhos 1996; Andrade 2004).

THE EMERGENCE OF THE *USINAS* AND THE INDUSTRIALIZATION OF SUGARCANE CULTIVATION

At the end of the nineteenth century emerged the first *usinas*, factories that quickly outran the smaller sugarcane mills and took over their land (Andrade 2001; Freyre 2004). The direct effect of this development was that the forests encountered between the smaller estates and fields were often cleared (Andrade 2001; Freyre 2004). Since the *usinas* are permanently trying to expand their productive land, they forced rural workers and their families to abandon their homes and the sites they used for subsistence agriculture (Andrade 2001; CONDEPE 2001). The resulting rural exodus continues up to the present (CONDEPE 2001). Most people are driven to small towns or cities (Montes and Cosulich 1998; Andrade 2001; CONDEPE 2001). In the first half of the twentieth century, the yields of sugar per hectare in Pernambuco were very low in comparison to other centers of this agriculture (Andrade 2001). Since the thirties new sugarcane varieties were introduced, and irrigation, herbicides, insecticides, and fertilizers were implemented to increase productivity (Andrade 2001). These measures led to a stronger isolation of the forest fragments, firstly, because poisoned fields cleared of any unwanted herbs represent a strong barrier for animal migration and, secondly, the abandonment of a matrix of subsistence farming that meant a much higher connectivity between the forest fragments due to a larger variety of cultivated plants, including many fructiferous trees that offered various resources as nectar, pollen, fruits, and shelter, resulted in a monoculture of a grass (sugarcane) that does not produce any mutual resources (Westerkamp and Gottsberger 2000). The process of intensification of agriculture continues up to the present (Montes and Cosulich 1998; Andrade 2001; CPRH 2001).

The industrialization of the sugarcane production had severe effects, especially on forests located on sandy tablelands, the *tabuleiros*, which are typical for the northern part

of the forest zone (Andrade-Lima 1954). The soil of the *tabuleiros* is poor in nutrients and organic matter (Andrade-Lima 1970). Hence, they were not used initially for the cultivation of sugarcane, but their forests were partially cut to extract the wood and afterwards secondary forests established (Andrade-Lima 1970), while other parts were used to raise cattle (Andrade 2005). The conversion into sugarcane fields began only in the fifties, since when the vinasse, a by-product of sugar production, is being used as fertilizer (Andrade 2001). Large parts of the state of Alagoas resembled recently colonized, with sugarcane fields full of burnt tree trunks (Andrade 1959b). Andrade-Lima reported in the seventies that this process was still going on and that conversely sites of strong inclination were taken out of usage and developed into secondary forests (Andrade-Lima 1970). This is partly due to mechanization, which made the plain *tabuleiros* the best suited areas to plant sugarcane (CPRH 2001; Andrade 2005). Only one forest fragment (Mata da Usina São José = Mata de Piedade), north of Recife is reported to be well-preserved (CPRH 2001) and covering parts of a *tabuleiro* (SECTMA 2002). According to Andrade-Lima (1974), the largest forest reserves of all north-eastern Brazil occurred in the south of Pernambuco and the north of Alagoas. They were even recommended for sustainable logging (Andrade-Lima 1974). These large forests do not exist any more (SOS Mata Atlântica 2008). During the Proalcool campaign of the Brazilian government initiated in 1975, that had as its goal an increase in the alcohol production, about 10% of the forests in southern Pernambuco disappeared (Ranta *et al*. 1998); according to aerial photographs taken in 1969 and 1981 the percentage was probably higher in the North.

The National Institute for Colonization and Land Reform (INCRA) distributed more than 30,000 ha among settlers in Pernambuco (CONDEPE 2001). How much of this land was covered by forest is not published, it can only be deduced, as in reports forested land was referred to as "unproductive" (Dean 1997). On the photographs mentioned above can be recognized that, e.g., the settlements Engenho Caiana, Pitanga I and II were completely forested.

CURRENT SITUATION

The economic development and disorganized occupation of land in the last years led to many losses of natural habitats (Ranta *et al*. 1998; CPRH 2001; SECTMA 2002). The largest current threats to the forest remnants are the uncoordinated growth of cities, due to growing population, allotment of farms and rural residences, and the extraction of wood and fuel wood consumed in rural areas or urban centers (CPRH 2001). Of 40 ecological reserves only two are sufficiently protected, the others suffer heavy environmental pressure (SECTMA 2002). The forest of the ecological reserve São Bento in the municipality of Abreu e Lima north of Recife, almost disappeared. During ten years it became to 90% devastated by an invasion of members of the movement of landless people (CPRH 2001). The percentage of forest cover on private properties declined about 35% from 1980 to 1995 (Sampaio and Gamarra-Rojas 2002).

CONCLUSIONS

There were some decisive events that led to a gradual fragmentation of the Pernambucan lowland Atlantic Forest. Many of these took place in recent time and the forest fragments are still endangered by ongoing deforestation. One of the most elaborate and influential works upon this topic is by Ranta and co-workers (1998). Despite its obvious values in analyzing the fragmentation pattern that they encountered, they drew some conclusions that are probably based on insufficient investigations: firstly, they regard the fragments mainly as results of deforestation that took place 300 to 500 years ago and hence assume that extinction processes of vulnerable species must already have taken place. Secondly, they believe the situation was stable. Conversely, a lot of fragmentation occurred in recent time and the precarious situation of the existing forest fragments should not be underestimated. In fact, measures must be taken to preserve the existing remnants from further degradation, ranging from protection against over-exploitation to the implementation of biological corridors between neighboring fragments (Ranta et al. 1998, SECTMA 2002). This is especially important in cases where populations of rare or endemic animals could be joined or where they could re-colonize neighboring forest fragments (Oliveira and Langguth 2006; Farias et al. 2007). The movements of animals are of course also a main vehicle for pollen and seeds, which is essential for ecosystem functioning (Gottsberger and Silberbauer-Gottsberger 2006b). A monitoring of the sugarcane industry by consumers of bio-fuel, as e.g. the European Union, might be an incentive for conservation efforts, but certification schemes are lacking (Friends of the Earth Europe 2008). The growing demand is much more likely to have a devastating effect upon the environment and local people (Friends of the Earth Europe 2008). The juridical framework is theoretically clear: the decree 750/93 does not allow any cutting, exploitation or repression of natural vegetation in the Atlantic Forest domain, if not exceptionally authorized by the Brazilian Institute for the Environment and Natural Resources (IBAMA) (Decreto 750 1993). The legislation further demands that along rivers and on inclined sites natural vegetation should be allowed to grow which, if implemented, would increase connectivity between forest remnants (Código Florestal 2003).

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