

Pre-Columbian Anthropogenic Changes in Landscapes of the Brazilian Atlantic Forest¹

Cambios antropogénicos en los paisajes del bosque atlántico brasileño en el periodo pre-colombino

Mudanças antropogênicas nas paisagens do bosque atlântico brasileiro no período pré-colombino

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Spatial analysis of pre-Columbian impacts on the vegetation of the American continent is an important tool to understand the history of landscapes and to propose conservation strategies for current times. This text examines the spatial dimension of anthropic changes occurring in the Northeastern Brazilian Atlantic Forest during pre-Columbian times. It is based on cartographic plotting and projections of information contained in chroniclers' accounts and archaeological findings concerning subsistence patterns, demography and changes produced in natural settings by several indigenous populations. Findings indicate that the scale of changes in the natural landscape before the presence of Europeans may have reached 80 percent of the area of the Northeastern Atlantic Forest. Local floral formations suffered different degrees of impacts, with stronger pressures having been exerted on the phytophysiognomies of pioneer formations and dense humid forests.

Key words: Historical Cartography; Native American Culture; Brazilian Atlantic Forest; Environmental Disturbance; Brazilian Northeast Region; Landscapes.

El análisis del impacto en la vegetación del continente americano en el periodo pre-colombino es una herramienta importante para entender la historia de los paisajes y proponer estrategias de conservación en tiempos actuales. Este texto examina la dimensión espacial de los cambios antropogénicos ocurridos en los bosques atlánticos del noreste de Brasil en el periodo pre-colombino. Se basa en levantamientos cartográficos y proyecciones de información contenida en registros de cronistas y hallazgos arqueológicos relacionados con patrones de subsistencia, demografía y cambios producidos en los ambientes naturales por distintas poblaciones indígenas. La información obtenida indica que la escala de cambios en el paisaje natural anterior a la presencia de europeos puede que haya alcanzado el 80% del área de los bosques atlánticos del noreste. Las formaciones de flora local sufrieron distintos niveles de impactos, con mayores presiones ejercidas sobre fitofisonomías de formaciones pioneras y bosques húmedos densos.

Palabras clave: Cartografía Histórica; Cultura Indígena; Bosque Atlántico Brasileño; Disturbio Ambiental; Noreste Brasileño; Paisajes.

A análise do impacto na vegetação do continente americano no período pré-colombino é uma ferramenta importante para entender a história das paisagens e propõe estratégias de conservação em tempos atuais. Este texto examina a dimensão espacial das mudanças antropogênicas ocorridas nos bosques atlânticos do nordeste do Brasil no período pré-colombino. Baseia-se em levantamentos cartográficos e projeções de informações contidas em registros de cronistas e descobertas arqueológicas relacionadas com padrões de subsistência, demografia e mudanças produzidas nos ambientes naturais por diferentes populações indígenas. A informação obtida indica que a escala de mudanças na paisagem natural anterior à presença de europeus pode que tenha alcançado o 80% da área dos bosques atlânticos do nordeste. As formações de flora local sofreram distintos níveis de impactos, com maiores pressões exercidas sobre fito-fisionomias de formações pioneiras e bosques úmidos densos.

Palavras-chave: **Cartografia Histórica; Cultura Indígena; Bosque Atlântico Brasileiro; Distúrbio Ambiental; Nordeste Brasileiro; Paisagens.**

Introduction

Changes caused by Native American populations in the natural environment have been studied by geographers, archaeologists and historians, in both pre-Columbian and post-Columbian times. Findings have converged on the acknowledgment of the occurrence of distinguished changes in the landscape and in specific components of the biota².

On the other hand, few studies deal upfront with the spatial range of these pre-Columbian changes, particularly at the level of specific indigenous villages or groups; this type of study, when conducted in South America, focused mostly on the Amazon basin. Recent evidence shows that changes in the natural environment in the Amazon basin may have been local and sparse, shaped by a spatial organization pattern that is more complex than previously imagined³. However, there is no record of similar studies being made for the Brazilian Atlantic Forest, specifically about its Northeastern ecoregion. A partial exception would be Warren Dean⁴, who dealt in detail mostly with changes made by indigenous populations in the Southeastern part of the Atlantic Forest, particularly in the current states of Rio de Janeiro, Minas Gerais and São Paulo.

Historical accounts of the Brazilian Atlantic Forest usually start in sixteenth century, supposing that it was an underpopulated formation, free from severe anthropic impacts. Changes in the landscape would have been intensified immediately after European settlers created urban centers and plantations dedicated to the intensive monoculture⁵. Nonetheless, recently discovered evidence shows that the coastal forests found in Brazil by Portuguese, Spanish and French explorers in the early sixteenth century, despite being considered primitive by them, were actually densely populated and had been changed in several ways by pre-Columbian inhabitants⁶.

This article seeks to define the spatial range of pre-Columbian anthropogenic changes in the Northeastern Atlantic Forest landscape and therefore establish a historical benchmark for the study of that area just before the moment that modern plantation agriculture was introduced by European colonizers. This spatial approach to pre-historical anthropogenic change is important for the reconstruction of the landscape and consequently to understand landscape dynamics and the design of current conservation strategies. Spatial analysis requires the use of a variety of sources that take into account the size of indigenous populations, their land use practices, and their social structure and organization. Major sources were a selected group of extensively used sixteenth- and seventeenth-century chronicles and a number of recent archeological studies. Using historical cartography techniques, descriptive historical information were transformed into spatial data and combined with demographic estimates, in order to estimate the nature and range of anthropogenic impacts⁷.

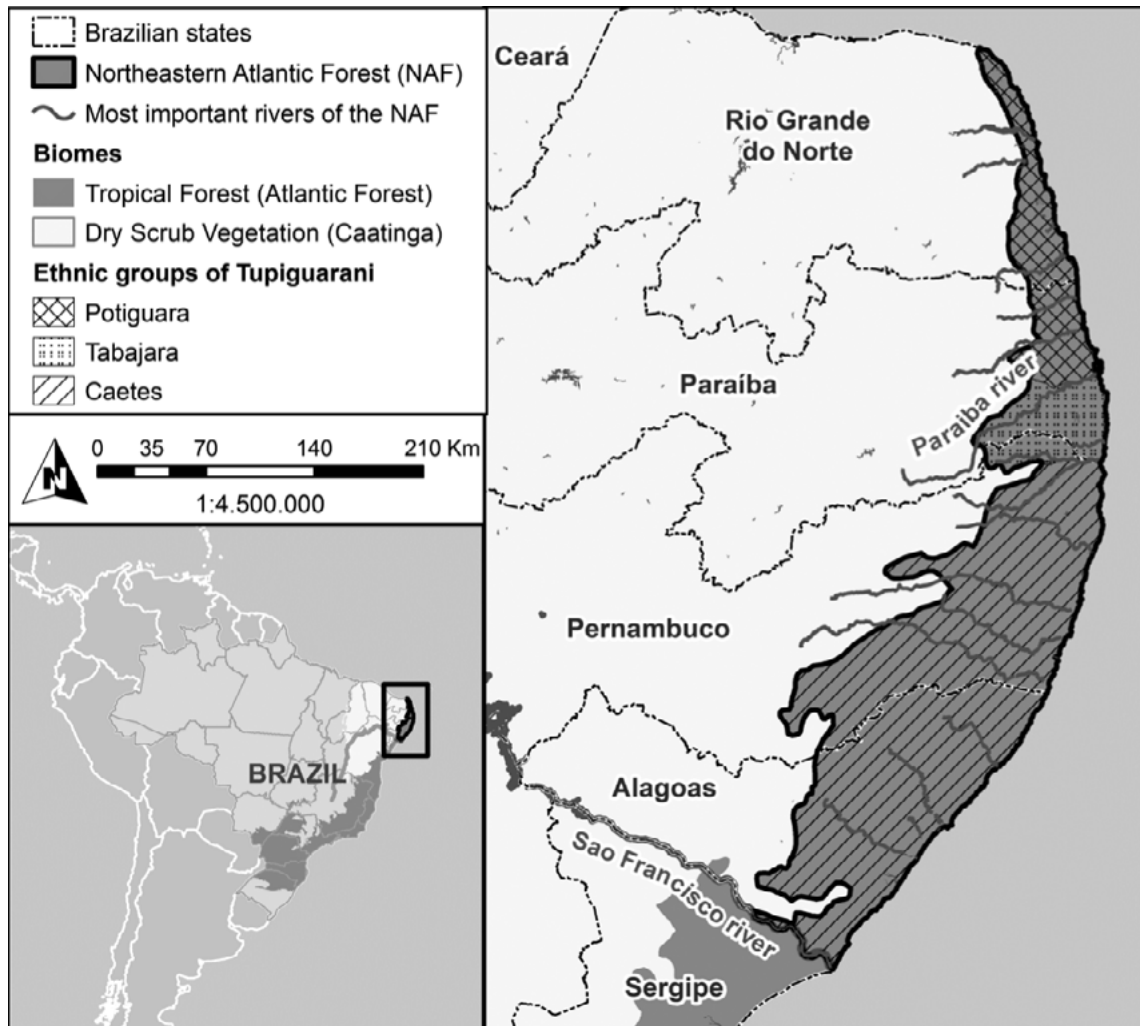
Methods

The Study Area

The study area is a unique section of the Brazilian Atlantic Forest. From North to South, it starts at the northernmost edge of the entire formation, in the state of Rio Grande do Norte, at approximately the latitude 5° South; it ends on the Northern bank of the estuary of the São Francisco River, in the state of Alagoas, at approximately the latitude 10° South. It occupies a long and slender stretch of the Brazil's Northeastern coastline (**Figure 1**), called Northeastern Atlantic Forest (NAF) for the purposes of this text.

The Atlantic Forest biome in Brazilian territory stretches much farther to the South, all the way to approximately the latitude 30° South. The NAF is therefore the Northern portion of a much more extensive tropical forest formation. It occurs continuously on the humid coastal sections of four current Brazilian states – Alagoas, Pernambuco, Paraíba and Rio Grande do Norte. This ecoregion covers a little over 40,000 square kilometers, a mere 3.6 percent of the Atlantic Forest biome (which measured originally 1,110,182 square kilometers). Its vegetation displays several physiognomies - dense tropical forests, open tropical forests, seasonal semi-deciduous forests, pioneer formations (mangroves, coastal scrub formations, marshes, and beach dunes) and estuarine and transitional formations. The interior areas of each state contrast sharply with their coastlines, as they are covered by the vegetation of the *Caatinga* biome - dry scrub forests dominating the semi-arid sections of the same four states - and transitional vegetation.

FIGURE 1: BRAZIL'S NORTHEASTERN ATLANTIC FOREST (NAF), AGAINST CURRENT BRAZILIAN STATES, DRY SCRUB VEGETATION (CAATINGA BIOME) AND THE SOUTHERN LIMIT OF THE TROPICAL HUMID FOREST (ATLANTIC FOREST)



Source: adapted from IBGE (2010).

The NAF ranks highest among all Brazilian ecosystems threatened by deforestation. Most remaining forest fragments are going through regeneration and it is conceivable that at some time in the recent past the forest reached the point of being completely erased⁸. These fragments amount to almost 10 percent (about 4,000 square kilometers) of the original area of the NAF. They are scattered among 1,200 fragments. Most fragments are smaller than 0.7 square kilometers. Only five of them are larger than 100 square kilometers⁹.

Note on Sources and Documentation

In order to determine the spatial distribution of human-induced changes in the NAF's natural environment in pre-Columbian times, information was taken mostly from historical documents -contemporary chronicles written by Europeans- which describe the demography and the subsistence strategies of local indigenous groups. Areas covered by their agricultural plots or affected by hunting, the sizes of villages, and the distances between villages are recorded in those chronicles. Information contained in these sources was checked against modern maps and confronted with modern anthropological and archeological analyses. Used in this manner, observations made by those classic texts written by well-known chroniclers continue to contribute to the production of colonial history accounts.

The eight chroniclers whose texts were used herein are Pero Vaz de Caminha, Hans Staden, Pero de Magalhães Gandavo, Jean de Léry, Fernão Cardim, Gabriel Soares Sousa, Claude d'Abbeville and Frei Vicente de Salvador. Their texts were written and published in the sixteenth century or in the early seventeenth century. They were selected on the basis of two criteria: (i) they describe the region under study and/or (ii) they contain detailed and coherent descriptions about the social and spatial organization and the everyday life of Tupiguarani¹⁰ indigenes. It should be emphasized that we did not make lengthy quotations of these chroniclers, although this is the most common way of using such sources. We took the relevant data from their texts and used them to evaluate the types and dimensions of the changes caused by native peoples on the landscape, without cluttering the text with extensive citations.

Pero Vaz de Caminha (1450-1500) was a Portuguese writer, member of the Portuguese fleet that officially discovered Brazil in 1500. He was the first to report in writing aspects of the new lands. This report was a letter to King Manuel of Portugal. It was first published in 1817, in Rio de Janeiro, after being lost for nearly 300 years¹¹.

Hans Staden (1525-1579), a native of Homberg, in the Landgraviate of Hesse, currently part of Germany, was an artillery operator who travelled on Portuguese vessels and participated in two expeditions to Brazil, in 1548 and 1555. In 1554 he was captured by natives and held prisoner for nine months in the vicinity of São Vicente, on the coast of the current state of São Paulo. The vivid narrative, published shortly after his return to Europe, described his captivity and many indigenous practices and habits and became a classic of early European accounts of colonial lands and ventures¹².

The Portuguese chronicler Pero de Magalhães Gandavo (1540-1580) lived in Brazil between 1558 and 1572. His account was originally published in Portugal, in 1576¹³. He describes episodes of Brazil's discovery by the Portuguese, local flora and fauna, the colony's political organization, focusing also on several indigenous populations. Gandavo traveled through stretches of the forested coasts of the current states of Pernambuco and Alagoas, examined in this article.

Jean de Léry (1534-circa 1613) was a French Calvinist who lived in Brazil for ten months, approximately in 1557. In 1578 he published his *Histoire d'un voyage en fait la terre du Brésil*, in which he reports his experience of living for two months among natives, near the current site of the city of Rio de Janeiro¹⁴. His narrative also became one of the most popular and influential early accounts of the habits and mores of Tupi peoples.

Fernão Cardim (1540-1625) was a Portuguese Jesuit who moved to Brazil in 1583. He lived in the current states of Bahia, Pernambuco, Rio de Janeiro and São Paulo. His narration is highly relevant to the study of Brazil's early geographic and human aspects¹⁵.

Gabriel Soares de Sousa (1540-1591) was a Portuguese farmer and writer who moved to Brazil around 1560. His text, published in 1587, is the most complete surviving description of Brazil's coastal areas and of early Portuguese settlements. It contains a wealth of precise information about many reference points and distances between them¹⁶.

Claude d'Abbeville (?-1632) was a French Franciscan monk, missionary and naturalist who spent four months in Brazil in 1612, in the current state of Maranhão. In 1614 he published *Historie de la mission des pères capucins en l'isle de Maragnan et terres circonvoisines*, in which he described his stay in Brazil, Brazilian landscapes and the villages and habits of local indigenes¹⁷.

Finally, Vicente de Salvador (1564-1636) was a Franciscan friar, born in Brazil, whose account, originally published in 1627, contains rich details about how people lived in the Portuguese colony, including the indigenes¹⁸.

Demographic data taken from these accounts helped estimate the spatial organization of native peoples. These data were checked against and complemented by studies made by Hemming, Fernandes, Funari & Noelli, Steward and Faron, Abreu, and Barbosa, among other authors who also used these sources. Information concerning "indigenous territories" taken from these documents turned out to be fairly precise, or at least more precise than demographic information. Archaeological findings helped confirm the spatial information contained in these sources, particularly the distribution of indigenous groups, as reported by the chroniclers¹⁹. Several anthropological and historical productions also yielded useful data²⁰.

These were the bases for our estimates of the distribution and range of indigenous settlements, reworked into a cartographic model presented in the following section.

Demographic and Spatial Analysis

We adopted a spatial scale approach²¹ to achieve our goals in this article because it is ideal for historical geographers and environmental historians who need to describe, locate and measure the cumulative impacts of human activities on a studied landscape, during extended time periods. In our case, this approach allowed us to make reasonable estimates of the degree to which

a forested formation was altered by human actions, alterations not as meticulously documented as “modern” activities such as farming, ranching, city building, infrastructure construction etc.

Based on the chroniclers’ reports, we combined and analyzed all the descriptions that provide clues to social and spatial organization of indigenous peoples. Demographic information was combined with spatial data, allowing a better understanding of population density and land uses. Finally, the data on distances between villages were used to plot on maps the indigenous distribution in the landscape.

Results

The First Human Settlements in the Northeastern Atlantic Forest

The earliest human occupation and related changes in the NAF involved indigenous populations from the Archaic period (11,000 to 6,000 ybp)²². Before the presence of these groups, landscape dynamics resulted basically from local biogeographical events and edaphoclimatic changes. In the Holocene (11,500 ybp to the present), rising ocean levels stabilized at current levels and related climate conditions allowed the establishment of a long strip of tropical humid forests along the current Brazilian coastline. Since then, climate conditions have also been relatively stable²³. It was also during the Holocene that humans occupied the area of the NAF for the first time²⁴. There is no evidence of the presence of indigenes in this area during the Pleistocene (up to 11,500 ybp), although it was recorded in other parts of South America²⁵.

Archaeological findings indicate the presence of humans in the vicinities of the NAF in the Archaic period. These records suggest migrations starting from the Andes, crossing the Amazon river basin, and then arriving at open interior areas of the *Cerrado* (savannas), the equally open *Caatinga* (dry scrub forests) and finally transitional vegetation, in the general direction of the Atlantic coast and, consequently, of the Atlantic Forest²⁶. Since the Holocene, when the coastal humid forest consolidated itself in the study area, it was probably occupied by human groups from 8,000 to 6,000 ybp, as indicated by the most ancient shell mound sites found there²⁷.

Although archaic indigenes remained as “hunter-gatherers”, like paleoindigenes, some of them made the first local experiments with plant cultivation. The Archaic phase evolved into the late pre-historic or Formative phase, the origin of which goes back to 2,500 ybp, stretching to the present. This phase is marked by the adoption of agriculture, the use of pottery, population growth and a trend towards sedentary life.²⁸ The dispersal of indigenes from the Formative phase would have culminated, in the eleventh century A.D., with the installation of Tupiguarani peoples in large sections of the current Brazilian Atlantic coast and consequently in the Atlantic Forest biome. Some authors have pointed to a millennial pursuit of a “land without evil” as the driver of this intense Tupiguarani territorial expansion²⁹. This mythical belief contributed to a semi-nomadic

behavior that led the Tupiguaranis to migrate along the Brazilian coast, from the South to the North, until they reached the area of the NAF, where their settlements are clearly younger than those located more to the South. For approximately five centuries the Tupiguaranis dominated most of the coastal area covered by the Atlantic Forest, a situation found and recorded by Europeans in the early 1500s. Considering that it was mostly during this late Formative phase that the forested landscape began to be significantly changed by humans, our analysis will focus on the Tupiguarani tradition, a representative ceramic-making people³⁰.

Indigenous presence in the NAF has been fairly well studied by archaeologists and anthropologists. They have located and studied systematically areas used by the indigenes -shell mounds, villages, agricultural plots, migrations routes, and related cultural artifacts. The findings of these studies indicate that our study area was occupied by what one author considered a "markedly homogeneous [population] in linguistic and cultural terms", a reference to Tupiguarani peoples³¹. They lived near or used systematically the Atlantic coast, with a special preference for estuaries. However, their villages were located in a manner to use also forested areas distant from the coast, for hunting, gathering and agriculture³².

Tupiguarani peoples were divided into many different ethnic groups³³. These groups formed tribes that lived in distinct villages, spread over most of the Brazilian Atlantic coast and in many parts of Brazil's interior. Groups and villages were geographically dispersed and changed locations at a fairly rapid rate³⁴. In the early sixteenth century, the Potiguaras, Tabajaras and Caetés were the three most carefully documented and studied ethnic Tupiguarani groups (in terms of habits and distribution) present in our study area.

The Potiguaras lived on the coast, to the North of the Paraíba River, with villages spread all the way to the coast of the current state of Maranhão (which lies outside of our study area). Currently, 13,500 remnant Potiguaras live in three small reservations or homelands (with a total area of 27,000 hectares) located on the coast of the state of Paraíba. The Portuguese considered them dangerous: "These heathen are quite belligerent, aggressive and treacherous; they are also friendly with the French, with whom they have good relations; the French use them as enemies of the Portuguese"³⁵.

The Tabajaras were the friendliest towards the Portuguese. They lived in the current state of Paraíba. The Tabajaras no longer exist, as they became extinct or assimilated into the general population. They were enemies of the Potiguaras and unfriendly towards the Caetés.

The Caetés dwelled along the coast, from the Cape of Santo Agostinho to the mouth of the São Francisco River, in lands belonging today to the states of Pernambuco and Alagoas. A fairly numerous group of Caetés migrated North in the sixteenth and seventeenth centuries, to the current state of Pará³⁶. Currently, there are no reservations for the Caetés, although 138 individuals declare themselves as belonging to the Caeté group, as recorded by the Brazilian Census. Like the Potiguaras, the Portuguese considered the Caetés dangerous and treacherous³⁷.

Hostilities and wars among the different Tupiguarani ethnic groups and even among villages of the same group were not rare; actually, they seem to have been a routine feature of Tupiguarani culture. This of course affected their use of resources, as wars destroyed villages and agricultural plots and led to migrations and displacements³⁸.

Before and after European arrival, indigenes from another linguistic group -known by the generic name of Tapuias³⁹- lived and migrated between the contrasting landscapes of the dry scrub *Caatinga* biome and the NAF. The Tapuia linguistic group is now called Gê. They were nomadic hunter-gatherers, who did not practice agriculture and did not build permanent dwellings and villages. Tupiguarani groups made a continuous effort to keep Tapuias away from the coast, leading to frequent warfare between indigenes from the coast and those from the interior. Tapuia thrusts in the direction of the coast seem to have been motivated by episodes of severe draughts, common in the semi-arid interior⁴⁰. The relevance of mentioning Tapuias is to show that there were sizable numbers of indigenes who did not exploit directly or constantly NAF resources, because they lived and/or forayed far away from it, either by choice or by intimidation.

Social Aspects and Distribution of Tupiguarani Groups in the NAF

The Tupiguaranis seem to have had fairly homogenous patterns of resource use, social organization, living standards and productive activities, independently of the precise locations of their villages and of local resource configurations. They were mostly sedentary; their dynamic and remarkable territorial expansion from deep in the Brazilian interior to most of the Atlantic coast would thus have been moved by demographic growth and by the resulting need to split villages⁴¹. This expansive behavior implied the need to acquire knowledge about new areas to be occupied, because available resources would determine the livelihood of migrating groups. This would induce them to migrate preferably at short distances, to areas that previously held their more distant agricultural plots. In their new locations, they would immediately open forested areas to build villages and prepare new plots for slash and burn agriculture⁴².

The Tupiguarani mode of production therefore demanded a fairly large territory, for agriculture hunting and gathering. Supposing that their displacement and migratory trends were not overly strong, and taking into account archaeological evidence, it is believed that Tupiguarani groups held on to their territories for about four years. They would expand to neighboring lands, but they would not necessarily abandon previously used lands⁴³.

It is probable that the limits of continuous occupation of any given location were not determined by soil exhaustion, but by the competition for nutrients and shading caused by pioneering plants and/or by invasions of shrubs, lianas and herbs, which grow rapidly and may hinder the growth of crops. Abandoned cultivated areas could be used for collection and hunting (they attracted some components of the fauna)⁴⁴ -“abandonment” can thus be considered also

a phase of reduced use. The Tupiguaranis preferred to locate their agricultural plots in clearings made in newly deforested areas, with the help of fire. If such forests were in shortage in the immediate vicinity of villages, moving to a new location was an option to be pondered. Sometimes the decision to move to a new location was influenced also by the need to obtain new building materials for the reform or reconstruction of houses and shelters (*malocas*). Thatched roofing lasts also four years on the average; after that, materials rot and cause roofing to no longer protect residents from rain⁴⁵.

As indicated above, the three aforementioned indigenous groups dwelled on the coast or close to it and on riverbanks. They had a special preference for the intersections of rivers and sea – estuaries. Forays through valleys and lowland areas took gatherers and hunters to wetlands, riverbanks, beaches, dunes, sandspits and mangroves, in which they would seek fish, mussels, oysters, shrimp, crabs, birds, eggs, turtles, mammals etc. Shell mounds and other archaeological findings in Alagoas and Rio Grande do Norte confirm the importance of these types of food⁴⁶.

Among the uses that affected the native biota, besides agriculture, there was the regular collection of fruits of many palm trees, land mussels and small mammals; their remains show up at some archaeological sites. Palm leaves, as mentioned, were also widely used for several purposes, especially for building houses and temporary shelters (*malocas*). Together with wood, leaves fueled fire used for cooking, protection and lighting. Early sites show signs of the collection of a wide range of floral species - cotton *Gossypium* spp., tobacco *Nicotiana tabacum*, *genipapo* *Genipa americana*, *urucum* *Bixa orellana*, besides peppers, medicinal plants and fruits. The venom from the *Strychnos* genus (strychnine) was collected and used on arrow tips. In some cases, collection evolved into agriculture or, more exactly, into tropical policulture. Manioc *Manihot* spp., corn *Zea mays*, peanuts *Arachis hypogaea*, although native to the American continent, were not native of the NAF, but were cultivated there. The natives also hunted land and aquatic mammals, other small vertebrates and invertebrates, and several species of salt water and fresh water fish. The basic principle of the indigenous economy was to produce or collect what was required for immediate use, without concern about accumulation⁴⁷.

Agricultural plots opened by the Tupiguaranis required the suppression of portions of the native vegetation, using the well-known method of slash and burn⁴⁸. At the end of the dry season, smaller trees and bushes were cut and left to dry for a few weeks. Fires were lit as close as possible to the first rains. Charred trunks and other burnt vegetation were removed. Ashes added to the fertility of the soil. Clearings were then filled with cultivated plants. All this was done without any metallic instruments⁴⁹.

Human influence on the landscape had a gradient, being stronger in settlements and immediate surroundings, lighter in stretches of dense forests, and intermediate in agricultural plots. There were also large densely forested areas, more distant from settlements and major rivers, in which impacts were negligible or invisible, given that they were used only for hunting, fishing and collecting⁵⁰.

According to what Denevan calls the “pristine myth”, many observers and researchers saw pre-Columbian America as having an untouched nature and a small population⁵¹. Denevan’s research showed, however, that the American landscape as a whole was intensively populated and used and that its natural features -including forests- had at least a strong chance of being modified by human interventions. Hemming’s analysis allows the inference that a population of approximately 128,000 indigenes lived in the NAF in the early 1500s⁵². This figure is in line with the one suggested by Pompeu Sobrinho – he estimated that at that time 120,000 indigenes resided between the mouths of the São Francisco and Paraíba rivers⁵³. 120,000 Tupiguarani natives living in the study area (40,000 square kilometers) translate into an average demographic density of three inhab/km². This slight figure is the same found today in countries such as Australia and Canada, or in the North-American state of Montana. However, it hides the effects of the aggregate spatial distribution of the Tupiguaranis.

Demographic and Spatial Analysis

Pre-Columbian indigenous territories in the NAF were covered by a combination of primary forests and secondary vegetation . Primary forests are those deemed to be untouched, free of any human intervention, endowed with their original floristic and landscape attributes. Secondary vegetation includes a mosaic of formations -agricultural plots and gardens, hunting and gathering grounds, recovering forests, trails, a deforested village or settlement with an open “plaza”, in which there are huts, other residential buildings and footpaths. Each set of such territories is called herein a local group. Although all Tupiguaranis had quite similar life styles and social organization, the size of local groups and the range of their territories could vary considerably.

Computing all used areas -agricultural plots, hunting grounds, wood lots, areas for gathering fruit and thatch-, indigenous territories were much larger than the simple sum of their residential areas and active plots. As described by Léry about the Tupis of the coast of Rio de Janeiro: “The lands of these people consist of agricultural plots and excellent tracts in much larger order than what they need to subsist” . Staden noted that the indigenes lived “quite close to the sea; but their territory extends [to the interior] also beyond the mountains, for about sixty miles [...] and along the shore they have an area twenty eight miles long in which they live” . Thus, the areas of indigenous territories were estimated by us mainly on the basis of the distances between the territories of each local group, factoring in all resource uses.

The first step in plotting indigenous territories on maps was to estimate their sizes, using chroniclers’ descriptions. Relevant information about this concerns the distances between villages, which translated graphically into the sum of the radiuses of adjoining territories. D’Abbeville described the indigenous villages of coastal Maranhão as keeping a distance of six to eight kilometers from each other . Staden estimated that distances fell between nine and twelve kilometers on the coast of São Paulo . Léry and Cardim, describing villages and territories in Rio de Janeiro and Bahia, respectively, identified distances inside the range of 13 to 20 kilometers,

reaching 46 kilometers in a few cases . Discarding the lowest and highest distances, recorded for villages and ethnic groups not belonging to our study area, we established that the most frequent distances recorded by chroniclers fall within the range of eight to 20 kilometers.

The computation of the sizes of the agricultural plots maintained by each local group was based on information about the social organization of indigenous peoples. These sizes varied according to the sizes of the villages and to the number of families and households (malocas). Very useful here are the observations of Salvador, who carefully counted the number of couples residing in each maloca, and of Staden, Gandavo and Caminha, who made the same count and tallied how many malocas existed per local group. Salvador stated that “the dwellings are so long that 70 or 80 couples live in each”. Staden counted four to seven malocas per local group; Gandavo counted seven to eight; and Caminha counted nine to ten. Malocas were large, rectangular, collective huts made of wood and palm leaves; each resident family group (including children) had its own “corner” or “nook”, with several hammocks strung to poles, a fireplace and personal items; footpaths allowed people to move inside the malocas and to reach one of the several doorways. Sometimes there were separate dwellings for teenagers and young, unmarried adults. Using the numbers of dwellings multiplied by numbers of resident families in each dwelling, we estimated that each local group could have up to 1,600 residents, the average being around 1,000 residents.

Archaeological evidence shows that cultivated areas of native tropical forest horticulturalists measured between 0.02 e 0.05 square kilometers per family . Using these data, our computations show that the total area used by each local group could vary from 5.6 to 40 square kilometers per year. These figures result from estimating the yearly area used per family, multiplied by the number of couples living in each maloca and again multiplied by the number of malocas per local group . The range of 5.6 to 40 square kilometers results from considering the minimum and maximum figures recorded by chroniclers, respectively. These values represent about ten percent of the territorial area controlled by each local group, per year, independently of the area size. Thus, over a period of four years, agricultural plots occupied, on the average, 40 percent of those territories. In this manner, almost half of the territory would already have been cultivated at least once and in about ten years the entire territory of any given group would have been cultivated or systematically used for gathering and hunting, affecting also sources of construction materials. The productivity of cultivated areas decreased after four years of continuous planting, on the average. So these areas were abandoned or used only for hunting and gathering. After that, groups moved to another spot and built new villages, located at distances ranging between 1.6 to 6 kilometers from the previous village, close enough so that abandoned plots could be visited regularly for hunting and gathering . Both activities also happened in stretches of primary forests, following trails that had been opened in the group’s territory before the new villages were established.

Therefore, local groups in mutual contact could live at a distance of at least eight kilometers from each other, as attested by printed sources . This distance is related to a linear measurement of non-overlapping areas used by different local groups, or to a delimitation of the areas from which each group should extract the means for its survival, without trespassing

their neighbors' lands. Despite this, as migrations usually covered short distances, we took into account the fact that most probably there were overlaps between previous and current territories of any given indigenous group, meaning that old agricultural plots could still be used before the new ones started to produce.

Allowing used areas to be approximately round, placing their centers to be on the villages, and adopting eight linear kilometers as an average distance between neighboring settlements, we end up with each group inhabiting or using a circular area with a radius of four kilometers. This indicates that each local group used at least 50.3 square kilometers of forested lands during approximately four years. This figure fits well with those mentioned by d'Abbeville in respect to the Tupis of Maranhão. D'Abbeville was commenting on Caetés, the indigenous group resident in the NAF (Pernambuco) which had migrated to Maranhão, a fact that allows us to surmise that the Caetés had the same social organization and resource use patterns when they lived in the NAF .

Table 1 contains the demographic and land use data described above, extracted or estimated from chroniclers' reports.

TABLE 1: DEMOGRAPHIC AND LAND USE DATA ON INDIGENOUS GROUPS RESIDING IN THE NORTHEASTERN ATLANTIC FOREST IN 1500

Item	most conservative data	least conservative data	sources
Average number of dwellings (<i>malocas</i>) per village	4	10	Staden, Gandavo, Caminha
Average population per village *	560	1,600	Salvador
Average distance between villages	8 km	20 km	D'Abbeville, Staden, Léry, Cardim
Average area of territories	50.3 km ²	314.1 km ²	Projected areas considering average distance between neighboring villages
Total area of indigenous use and occupation	21,632.50 km ²	32,661.21 km ²	Calculated by QGis from estimated areas of the villages
Percentage of the area of the NAF used and occupied by indigenous peoples	54%	81,6%	

* Numbers of dwellings multiplied by numbers of resident families in each dwelling. Children and single young adults are not included.

Despite the different sizes of local groups, their territories were invariably located along the coastline, with preference given to riverbanks and estuaries. Thus, the territories used by indigenous peoples (their mosaics of regenerating forests, cultivated areas, and hunting and gathering grounds) were presumed to be swaths of eight and 20 kilometers along rivers. These

swaths were drawn parallel to the banks of rivers belonging to the third, fourth and fifth orders of the local hydrographic system. We selected rivers from the third order and above as references because they were more suitable for fishing and movements and because they had reliable water flows. These are the three highest ranks of the hierarchical classification of drainage networks, indicating the larger and permanent rivers, endowed with more volumes of water. Third-order rivers are formed by the confluence of rivers of the second order or of rivers of second and first orders⁶⁶.

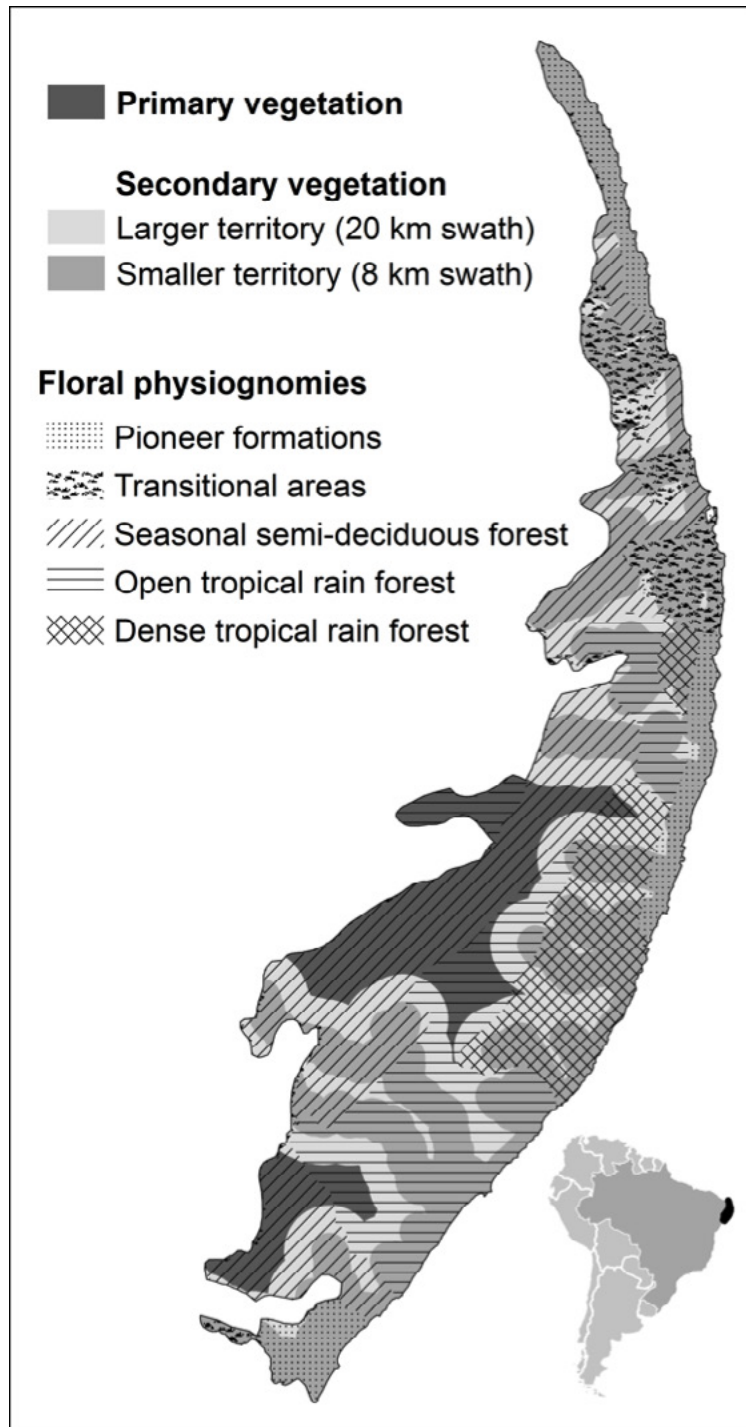
These swaths were covered mostly by secondary vegetation. Their landscapes were filled with clearings that contained forested formations in different stages of natural regeneration; they no longer held large expanses of primitive vegetation. They included interstitial areas that lay between circular areas, which contained forests in regeneration, after short-length migrations typical of the Tupiguaranis. Considering that an area altered for agriculture takes from 20 to 30 years to recover in terms of the amount of biomass and of floral density, any given village could move its cultivated areas between five and seven times during this period⁶⁷. This expanded the mosaic of cultivated and regenerating areas of each local group, to the point that a previously cultivated plot could have its secondary vegetation burnt, prepared and planted again.

Historical materials yielded information about indigenous modes of production, the size of indigenous territories, and their spatial organization, indicating the scale of their impacts on the landscape. Even if their productive activities did not generate sweeping changes in the landscape, the spatial dimension of their traces is fairly evident. After all, such as many other peoples with similar life styles, their strong dependency on the natural environment led them to engage in efforts to control or manage it. These efforts necessarily imply changing the natural environment so that the provision of resources would become easier and more dependable. This dependency also constrains the choices of the locations to be occupied, because they must make strategic choices, a fact that limits the randomness of the spatial distribution of those groups. Therefore, choice habitable locations would not have been so vast and so numerous, especially if we consider the large number of indigenes, their rivalries, and the existence of territorial boundaries between settlements and groups. These boundaries and the use of their resources were frequently avoided on account of the strong interethnic rivalries, vividly recorded by all chroniclers⁶⁸.

There are different perspectives about anthropic changes of the native landscapes of the American continent.⁶⁹ A strong statement about the indigenous mode of use of the natural resources connected to Brazil's forested coastline was made by Florestan Fernandes, a ranking Brazilian sociologist whose sources were mostly the same chroniclers used herein: "this type of use [...], which does not predict any manner of restitution, is usually defined by the expression destructive occupation"⁷⁰. Therefore, in its nature, native resources use was not different from that of Europeans colonizers or from current uses in modern agricultural frontiers. The distinction is just of scale and technology.

The areas used and occupied by Tupiguarani peoples in the NAF at the close of the fifteenth century are illustrated in **Figure 2** as "secondary vegetation".

FIGURE 2: AREAS USED AND/OR OCCUPIED BY INDIGENOUS POPULATIONS (SECONDARY VEGETATION) PLOTTED AGAINST FLORAL PHYSIOGNOMIES IN THE NORTHEASTERN ATLANTIC FOREST, AT THE END OF THE 15TH CENTURY



Source: adapted from IBGE (2010).

Considering the minimum and maximum width of the proposed swaths, eight and 20 kilometers, the area regularly used by indigenous peoples in the NAF varies from 21,632.50 to 32,661.21 square kilometers (between 54 and 81.6 percent of the NAF's total area). Both figures are far from being insignificant for the assessment of the degree of alterations of the NAF in pre-Columbian times.

As indicated earlier, occupied and used areas were concentrated on the coastline and along rivers, close to their outlets into the ocean or on confluences with other rivers. They included mostly swaths of lowland, dense humid forests, coastal scrub forests and mangroves. Areas that possibly were unoccupied, displaying primitive characteristics, lied mostly in the Western (interior) edge of the NAF, along the interfluves and plateaus of Pernambuco and Alagoas. Besides, there is no evidence or archaeological records of indigenous occupation of the area immediately to the north of the Paraíba River⁷¹. In all of these cases, this potentially primary vegetation corresponded to seasonal semi-deciduous forest formations, most of them located along the inner (Western) edge of the NAF, away from the Atlantic coastline. These data suggest that indigenous occupation and uses affected certain floral physiognomies more intensively than others, as indicated by the data in **Table 2**.

TABLE 2: PERCENTAGES OF DIFFERENT NORTHEASTERN ATLANTIC FOREST FLORAL PHYSIOGNOMIES OCCUPIED BY TUPIGUARANI INDIGENES IN 1500, IN RELATION TO THE TOTAL AREA OF EACH FLORAL PHYSIOGNOMY

Floral physiognomies	Percentage occupied by Tupiguarani indigenes	
	smaller territory (8 km diameter)	larger territory (20 km diameter)
Pioneer formations (mangroves, coastal scrub formations, beaches, dunes)	96%	100%
Transitional areas	78%	96%
Dense tropical rain forest	63%	98%
Open tropical rain forest	50%	82%
Seasonal semi-deciduous forest	36%	66%
TOTAL (over the area of the Northeastern Atlantic Forest)	54%	81%

While seasonal semi-deciduous forest formations were only partially modified, pioneer formations were entirely managed before European arrival. This preference for pioneer formations corroborates the information that Tupiguarani indigenes were highly fond of living along the coast and near estuaries. The spatial occupation map relates also to the availability of potentially useful resources. Pioneer formations, particularly mangroves, hosted a wider variety of these resources. This led to 96 to 100 percent of pioneer formations being modified by pre-historic anthropic changes.

Discussion

Tupiguarani populations residing in the NAF between the eleventh and the sixteenth centuries were semi-nomadic horticulturalists, were fairly numerous, and their living standards required fairly large territories. As seen in the data presented, analytical extrapolations combined with cartographic findings suggest that each village could have between 560 to 1,600 adult indigenes. This means that the indigenous pre-Columbian population in the NAF varied between 166,373 e 240,800. By crossing population data found in sixteenth-century accounts with estimated areas under use and occupation, demographic density estimates vary from 4.15 to 6.02 inhab/km². These densities lie well above the estimates made by Steward & Faron and Hemming of approximately three inhab/km², but are still more conservative than Denevan's estimates of around nine inhab/km² ⁷².

Despite the relatively high population density of pre-Columbian indigenes living in the NAF, several historians and social scientists consider the indigenous mode of life to have been sustainable. They argue that the indigenes did not change the environment significantly. However, our findings show that they did leave the first significant anthropogenic marks on the NAF and this means that they must be taken into account if historical descriptions of the landscape are to be accurate⁷³. These markings embody productive practices and features of indigenous social organization that must be considered so that the modified parts of the landscape can be correctly estimated and spatialized.

A considerable part of the native floral and faunal species, even those quite vulnerable, survived and adapted to the changes caused by native populations in pre-Columbian times. This is not true for the much more extensive and drastic changes introduced by sugarcane, subsistence and cattle farms established there since the early 1530s⁷⁴. Nonetheless, Europeans farmers, colonial officials and missionaries, who were obviously untrained in ecology and probably had never seen even pristine temperate forests, spread the persistent image of the "untouched" tropical forests of the Brazilian coast. Based on the current knowledge about the biota of the Brazilian Atlantic Forest in general (and the NAF in particular), as it existed before contact with Europeans, the chroniclers used herein recorded a relatively primitive scenario, with stretches going through advanced stages of ecological succession, including the presence of flagship species such as jaguar (*Panthera onca*), puma (*Puma concolor*), ocelots (*Leopardus pardalis*), peccary (*Pecari tajacu* and *Tayassu tajacu*), birds of prey (Accipitridae, Falconidae, Strigidae, Tytonidae, among others); they recorded also an abundance of ancient and relict tree species. Although indigenous uses created large expanses of landscapes covered by secondary vegetation, the pattern of change marked by periodically changing mosaics allowed ecological relations, environmental services and natural evolutionary processes to persist, without suffering a "disruption" that affected its resilience⁷⁵.

As stated by Denevan, the forest continued to be a forest, despite becoming secondary. Even though the patterns of abundance and diversity of species may have changed, many faunal and floral species that were characteristic of the primitive ecosystem were preserved in the regional context⁷⁶. It can be said, therefore, that the resilience of the NAF was not destroyed by pre-Columbian human interventions.

Although indigenous uses and occupation of the NAF in pre-Columbian times had different intensities in distinct sections of the landscape, this proves only that indigenous resource use patterns cannot be ignored for the purposes of environmental history investigations, even if these patterns are correctly diagnosed as “light”⁷⁷. Accordingly, the best way to analyze pre-contact landscapes should be based on the understanding of the geographic distribution of native settlements and of their modes of production, more than on the size and dynamics of the native population.

The physiognomy and the structure of some remnant forest in the NAF ecosystem, which many ecologists believe to be primitive, may actually be a by-product of pre-historic changes caused by native peoples, or a human induced artifact. This means, among other things, that the spatial distribution of certain individuals and populations of the flora may not be wholly natural. According to our estimates and computations, in 1500 only 18.4 to 46 percent of the area of the NAF could have been covered by primary vegetation, free from visible human interference. However, these primitive sections would include almost exclusively physiognomies of tropical rain forest and seasonal semi-deciduous forest.

Conclusion

For at least five centuries (eleventh to sixteenth), the indigenous population of the NAF survived at the cost of producing an almost continuous mosaic of natural, modified and recovering landscapes in that tropical rain forest biome. These different patches of landscape were in mutual contact and under constant succession. As a consequence, at the moment of contact between indigenes and Europeans, 54 to 81 percent of the NAF was formed by secondary vegetation. Europeans, with their domesticated plants and animals, carrying Old World transmissible diseases, and deploying their more productive and impactful technologies and tools, introduced their own and much stronger thrust of change in an already anthropogenically changed natural environment. This means that the tropical forest vegetation found by Europeans in the NAF displayed different microclimates, new conditions for recovery, and a faunal and floral structure and composition that were distinct from those of untouched forests. The selective intensity of indigenous management methods remade entire floral physiognomies (such as pioneer formations) in such an extensive manner that they were probably the result of human management, no matter how much colonizers considered them to be expressions of an “untouched” wilderness.

Even if mostly secondary, the NAF and other sections of the all but currently erased Brazilian Atlantic Forest had and in many places still have complex and sometimes poorly known components and important ecological functions, such as the provision of “environmental services” -climate maintenance, watersheds, nutrient recycling, and carbon storage. However, our findings are in line with those of Denevan when he debunks the “pristine myth” of pre-Columbian America and the associated notion that Native Americans did not cause environmental change and damage. Even the most conservative information yielded by early chroniclers allows the inference

that the NAF was thoroughly occupied, used and modified by pre-Columbian indigenes.

Our findings call for a conceptual reevaluation of what we really mean when we distinguish primary vegetation from secondary vegetation, not only in the field of environmental history, but also in the field of contemporary conservation biology. Unless linked to natural causes and disturbances (fires, floods, natural erosion, avalanches, disease outbreaks, volcanic and seismic activity etc.), secondary floral formations are associated with human interventions of the past and the present and thus they can be considered historical or human artifacts, such as they have been studied by many environmental historians⁷⁸.

Currently, secondary tracts are all that remains of the natural vegetation of the NAF. This may be true also of many other scant remaining formations (less than 10 percent) of the Brazilian Atlantic Forest as a whole. Even if they do not have the characteristics of primitive forests, these secondary formations are the most viable base for the possible long-term recovery of forest cover over large expanses of the Brazilian territory. However, it must be conceded that a pristine scenario cannot exist in the face of the presence of a numerically expressive human population, resident in the NAF for many centuries, endowed with agricultural technology and modes of living that required the management and modification of several components of the native vegetation.

Primary sources

- Abreu, J. C. *Diálogos das Grandezas do Brasil*. Salvador, Ed. Progresso, 1956 (1618).
- Caminha, P. V. de; A. M. Plant, and T. Plant. *The Letter of Pero Vaz de Caminha: To El-rei D. Manuel of Portugal Concerning the Discovery of Brazil*. North Charleston, CreateSpace, 2011 (1500).
- Cardim, F. *Tratados da Terra e Gente do Brasil*. Rio de Janeiro, J. Leite & Cia, 1925 (1583).
- D'Abbeville, C. *Histoire de la Mission des Pères Capucins en L'isle de Marignan et Terres Circonvoisines où est Traicté des Singularitez Admirables & des Moeurs Merveilleuses des Indiens Habitans de ce Pais*. Paris, de l'impr. de F. Huby, 1614.
- Gandavo, P. M. *The Histories of Brazil*. New York, Ed. John B. Stetson, 1922 (1576).
- IBGE-Instituto Brasileiro de Geografia e Estatística. *Sistema IBGE de Recuperação Automática – SIDRA*. <http://www.sidra.ibge.gov.br/bda/pecua/default.asp?z=t&o=24&i=P>. Accessed 31 May 2014.
- IBGE-Instituto Brasileiro de Geografia e Estatística. *Base Cartográfica Integrada do Brasil ao Milionésimo Digital-bCIMd*. Rio de Janeiro, IBGE, 2010.
- IPHAN-Instituto do Patrimônio Histórico e Artístico Nacional. *Cadastro Nacional de Sítios Arqueológicos*. <http://portal.iphan.gov.br/portal/montaPaginaSGPA.do>. Accessed 26 oct. 2011.
- Léry, J. de. *History of a Voyage to the Land of Brazil*. Translated and introduced by Janet Whatley. Berkeley, University of California Press, 1992 (1578).
- Nimuendajú, C. *Mapa Etno-Histórico*. Rio de Janeiro, Fundação Nacional Pró-Memória, 1981 (1944).
- Salvador, V. *História do Brasil. Em que se Trata do Descobrimento do Brasil, Costumes dos Naturais, Aves, Peixes, Animais e do mesmo Brasil*. Rio de Janeiro, Fundação Biblioteca Nacional, 1889 (1627).
- Sousa, G.S. *Tratado Descritivo do Brasil em 1587*. São Paulo, Cia. Editora Nacional, 1971 (1587).
- Staden, H. *Hans Staden: Primeiros Registros Escritos e Ilustrados sobre o Brasil e seus Habitantes*. Rio de Janeiro, Terceiro Nome, 1999 (1555).
- . *Hans Staden's True History: An Account of Cannibal Captivity in Brazil*. Translated and edited by Neil Whitehead and Michael Harbsmeier. Durham, Duke University Press, 2008 (1555).

Bibliography

- Albuquerque, M. and V. Lucena. "Caçadores-coletores no Agreste Pernambucano: ocupação e ambiente holocênico". *CLIO - Série Arqueológica*. Vol. 4, 1991, pp. 73-74.
- Albuquerque, M. "Horticultores pré-históricos do Nordeste". *Arquivos do Museu de História Natural*. Vol. 8/9, 1984, pp. 131-134.
- "O processo interétnico em uma feitoria quinhentista no Brasil". *Revista de Arqueologia*. Vol. 7, 1993, pp. 99-123.
- Barbosa, B.F. *Paranambuco: Herança e Poder Indígena Nordeste Séculos XVI–XVII*. Recife, Editora Universitária da UFPE, 2007.
- Barlow, J., et. al. "How Pristine Are Tropical Forests? An Ecological Perspective on the Pre-Columbian Human Footprint in Amazonia and Implications for Contemporary Conservation". *Biological Conservation*. Nº 151, 2012, pp. 45-49.
- Barreto, C. G. *Devastação e Proteção da Mata Atlântica Nordestina: Formação da Paisagem e Políticas Ambientais*. Ph.D. Dissertation, Universidade de Brasília, 2013.
- Behling Hermann, Negrelle Raquel R. B. "Vegetation and Pollen Rain Relationship from the Tropical Atlantic Rain Forest in Southern Brazil". *Braz. arch. biol. technol.* Vol. 49, Nº 4, July 2006, pp. 631-642.
- Black, B. A.; C. M. Ruffner & M. D. Abrams. "Native American Influences on the Forest Composition of the Allegheny Plateau, Northwest Pennsylvania". *Canadian Journal of Forest Research*. Nº 36, 2006, pp. 1266-1275.
- Cabral, D. C. *Homens e Árvores no Ecúmeno Colonial. Uma História Ambiental da Indústria Madeireira na Bacia do Macacu, Rio de Janeiro, 1763-1825*. M. A. Thesis, Universidade Federal do Rio de Janeiro, 2007.
- *Na Presença da Floresta: Mata Atlântica e História Colonial*. Rio de Janeiro, Garamond/FAPERJ 2014.
- Carvalho, J. L. "Do império marítimo ao proveito da terra, uma cultura territorial em mutação (Capitania da Paraíba, 1574-1654)". *Cadernos PPG-AU/UFBA*. Nº 7, 2008, pp. 13-30.
- Castro, C. F. A. *Gestão Florestal no Brasil Colônia*. Ph. D. Dissertation, Universidade de Brasília, 2001.
- Coimbra-Filho, A. F. e I. G. Câmara. *Os Limites Originários do Bioma Mata Atlântica na Região Nordeste do Brasil*. Rio de Janeiro, Fundação Brasileira para a Conservação da Natureza, 1996.
- Corrêa, D. S. "Historiadores e cronistas e a paisagem da Colônia Brasil". *Revista Brasileira de História*. Nº 26 2006, pp. 63-87.
- Cronon, W. *Changes in the Land*. New York & London, Hill and Wang, 1986.
- Dean, W. *With Broadax and Firebrand: The Destruction of the Brazilian Atlantic Forest*. University of California Press, Oakland, 1997.
- Denevan, W. M. "The 'Pristine Myth' revisited". *The Geographical Review*. Nº 101, 2011, pp. 576-591.
- "The Native Population of Amazonia in 1492 Reconsidered". *Revista de Índias*. Nº 63, 2003, pp. 175-188.
- *The Native Population of the Americas in 1492*. Madison, University of Wisconsin Press, 1992a.
- "The Pristine Myth: The Landscape of the America in 1492". *Annals of the Association of American Geographers*. Nº 82, 1992b, pp. 369-385.
- Diegues, A. C. S. A. *O Mito Moderno da Natureza Intocada*. São Paulo, Hucitec, 2004.
- Drummond, J. A. *Devastação e Preservação Ambiental: os Parques Nacionais do Estado do Rio de Janeiro*. Niterói, Editora da Universidade Federal Fluminense, 1997.
- "Jean de Léry, History of a Voyage to the Land of Brazil". *Luso-Brazilian Review*. Nº 32, 1995, pp. 105-106.
- Fausto, C. *Os Índios antes do Brasil*. Rio de Janeiro, Jorge Zahar Editor, 2000.
- Ferlini, V. L. A. "A depredação da natureza começou no descobrimento". *Revista Pau Brasil*. Nº 8, 1985, pp. 9-13.
- Fernandes, F. *A Função Social da Guerra na Sociedade Tupinambá*. São Paulo, Globo, 2006 (1952).
- *Organização Social dos Tupinambá*. Brasília, Editora Universidade de Brasília, 1988.
- Ferraz, L. P. P. "Resistência indígena em Pernambuco nos séculos XVI e XVII: a visão dos cronistas". *Revista de Humanidades*. Nº 9, 2008, pp. 1-15.
- Funari, P. P. A. & F. S. Noelli. *Pré-História do Brasil*. São Paulo, Editora Contexto, 2009.
- Gadgil, M.; Berkes, F. & Folke, C. "Indigenous Knowledge for Biodiversity Conservation". *Ambio*. Nº 22, 1993, pp. 151-156.
- Gonçalves, R. C. *Guerras e Açúcares: Política e Economia na Capitania da Paraíba. 1585-1630*, EDUSC, São Paulo, 2007.
- Hemming, J. *Red Gold: The Conquest of the Brazilian Indians, 1500-176.*, Cambridge, McGraw-Hill, 1978.
- Horton, R.E. "Erosional Development of Streams and Their Drainage Basins: Hydrophysical Approach to Quantitative Morphology". *Geological Society of America Bulletin*. Nº 56, 1945, pp. 275-370.
- Lombardo, U., et. al. "Human-Environment Interactions in Pre-Columbian Amazonia: The Case of the Llanos de Moxos, Bolivia". *Quaternary International*. Nº 312, 2013, pp. 109-119.
- Mann, C. C. 1491: *The Americas Before Columbus*. London, Granta Books, 2014.
- Martin, G. *Pré-História do Nordeste do Brasil*. Recife, Editora Universitária UFPE, 5ª edição, 2008.
- McKeya, D., et. al., "Pre-Columbian Agricultural Landscapes, Ecosystem Engineers, and Self-Organized Patchiness in Amazonia". *Proceedings of the National Academy of Sciences of the United States of America*. Nº 107, 2010, pp. 7823-7828.

- McMichael, C. H., et. al. "Sparse Pre-Columbian Human Habitation in Western Amazonia". *Science*. Nº 336, 2012b, pp. 1429-1431.
- "Spatial and Temporal Scales of Pre-Columbian Disturbance Associated with Western Amazonian Lakes". *The Holocene*. Nº 22, 2012a, pp. 131-141.
- Metraux, A. *A Religião dos Tupinambás e suas Relações com a das demais Tribos Tupi-Guaranis*. São Paulo, Companhia Editora Nacional, 1979.
- Miller, S. W. *An Environmental History of Latin America*. Cambridge, Cambridge University Press, 2007.
- *Fruitless Trees. Portuguese Conservation and Brazil's Colonial Timber*. Stanford, Stanford University Press, 2000.
- Neves, S. M. & Neves, M. M. "Ocupação humana e a probabilidade da presença de sítios arqueológicos do tipo sambaqui no litoral da Paraíba". *Revista de Geografia UFPE*. Nº VIII, 2010, pp. 277-289.
- Noelli, F. S. "The Hypothesis About Origin Center and Expansion of the Tupian". *Revista de Antropologia*. Nº 39, 1996, pp. 7-54.
- Pádua, J. A. *Um Sopro de Destruição. Pensamento Político e Crítica Ambiental no Brasil Escravagista (1786-1888)*. Rio de Janeiro, Jorge Zahar Editora, 2002.
- Pompeu Sobrinho, T. "Povoamento do Nordeste Brasileiro". *Revista do Instituto do Ceará*. Nº 51, 1937, pp. 107-162.
- Prous, A. *Arqueologia Brasileira*. Brasília, Editora da Universidade de Brasília, 1991.
- Ribeiro, G. L. "Ambientalismo e desenvolvimento sustentado: ideologia e utopia no final do século XX". *Ci. Inf.* Nº 21, 1992, pp. 23-31.
- Ribeiro, M. C., et. al. "The Brazilian Atlantic Forest: How Much is Left, and How is the Remaining Forest Distributed? Implications for Conservation". *Biological Conservation*. Nº 142, 2009, pp. 1141-1153.
- Ruffner, C. M., et. al. "Assessing Native American Disturbances in Mixed Oak Forests of the Allegheny Plateau". *Proceedings of the National Silviculture Workshop*. Nº 19-22, 1997, pp. 96-103.
- Samojlik, T.; Rotherham, I. D. & Jedrzejska, B. "Quantifying Historic Human Impacts on Forest Environments: a Case Study in Białowież'a Forest, Poland". *Environmental History*. Nº 18, 2013, pp. 576-602.
- Sampaio, T. *O Tupi na Geographia Nacional*, Rio de Janeiro, Editora Nacional, 1901.
- Schwartz, S. B. *Sugar Plantations in the Formation of Brazilian Society: Bahia, 1550-1835*, Cambridge, Cambridge University Press, 1985.
- Silva, J. C. *Arqueologia no Médio São Francisco. Indígenas, Vaqueiros e Missionários*. Ph. D. diss., Universidade Federal de Pernambuco, 2003.
- Sodré, N. W. "A gênese da economia predatória do Brasil". *Revista Pau Brasil*. Nº 7, 1985, pp. 6-8.
- *Formação Histórica do Brasil*. São Paulo, Editora Brasiliense, 1967.
- Steward, J. H. & Faron, L. C. *Native Peoples of South America*. New York, McGraw-Hill, 1959.
- Tabarelli, M., et. al. "Prospects for Biodiversity Conservation in the Atlantic Forest: Lessons from Aging Human-Modified Landscapes". *Biological Conservation*. Nº 143, 2010, pp. 2328-2340.
- Tabarelli, M.; Silva, J. M. C. & Gascon, C. "Forest Fragmentation, Synergisms and the Impoverishment of Neotropical Forests". *Biodiversity and Conservation*. Nº 13, 2004, pp. 1419-1425.
- Waguespack, N. M. & Kelly, R. L. "An Update on New World Colonization Research: The Paleoamerican Odyssey Conference". *Evolutionary Anthropology: Issues, News, and Reviews*. Nº 23, 2014, pp. 47-48.
- White, R. *Land Use, Environment and Social Change: The Shaping of Island County*. Seattle, University of Washington Press, 1980.
- *The Organic Machine: The Remaking of the Columbia River*. New York, Hill & Wang, 1995.
- Willey, G. R. & Phillips, P. *Method and Theory in American Archaeology*. Tuscaloosa & London, University of Alabama Press, 2001.
- Worster, D. *Dust Bowl: The Southern Plains in the 1930's*. Oxford, Oxford University Press, 1982.

Notes

¹ This article is based on research conducted for the first author's Ph. D. dissertation (Barreto, 2013), which studied the deforestation of the Northeastern section of the Brazilian Atlantic Forest from before European presence until the present. The indigenous groups focused in the first part of this article were present at European arrival, although their land and resource uses started much earlier. The authors acknowledge the support of Brazil's National Research Council - CNPq, for the financial support provided to both authors.

² U. Lombardo, et. al., "Human-Environment Interactions in Pre-Columbian Amazonia: The Case of the Llanos de Moxos, Bolivia", *Quaternary International*, Nº 279, 2012, p. 534; C. H. McMichael, et. al., "Spatial and Temporal Scales of Pre-Columbian Disturbance Associated with Western Amazonian Lakes", *The Holocene*, Nº 22, 2012, pp. 131-141; C. C. Mann, 1491: *The Americas Before Columbus*, London, Granta Books, 2014; S. W. Miller, *Fruitless Trees. Portuguese*

Conservation and Brazil's Colonial Timber, Stanford, Stanford University Press, 2000; W. M. Denevan, *The Native Population of the Americas in 1492*, Madison, University of Wisconsin Press, 1992; J. Hemming, *Red Gold: The Conquest of the Brazilian Indians, 1500-1760*, Cambridge, Harvard University Press, 1978; C. M. Ruffner, et. al., "Assessing Native American Disturbances in Mixed Oak Forests of the Allegheny Plateau", *Proceedings of the National Silviculture Workshop*, Nº 19-22, 1997, pp. 96-103.

³ McMichael, et. al., "Spatial and Temporal Scales...", *op. cit.* McMichael, et. al., "Sparse Pre-Columbian Human Habitation in Western Amazonia", *Science*, Nº 336, 2012, pp. 1429-1431; J. Barlow, et. al., "How Pristine are Tropical Forests? An Ecological Perspective on the Pre-Columbian Human Footprint in Amazonia and Implications for Contemporary Conservation", *Biological Conservation*, Nº 151, 2012, pp. 45-49; D. McKeya, et. al., "Pre-Columbian Agricultural Landscapes, Ecosystem Engineers, and Self-Organized Patchiness in Amazonia", *Proceedings of the National Academy of Sciences of the United States of America*, Nº 107, 2010, pp. 7823-7828.

⁴ W. Dean, *With Broadax and Firebrand: The Destruction of the Brazilian Atlantic Forest*, Oakland, University of California Press, 1997.

⁵ S. B. Schwartz, *Sugar Plantations in the Formation of Brazilian Society: Bahia, 1550-1835*, Cambridge, Cambridge University Press, 1985; N. W. Sodré, *Formação Histórica do Brasil*, São Paulo, Editora Brasiliense, 1967; J. A. Pádua, *Um Sopro de Destruição. Pensamento Político e Crítica Ambiental no Brasil Escravagista (1786-1888)*, Rio de Janeiro, Jorge Zahar Editora, 2002; V. L. A. Ferlini, "A depredação da natureza começou no descobrimento", *Revista Pau Brasil*, Nº 8, 1985, pp. 9-13; N. W. Sodré, "A gênese da economia predatória do Brasil", *Revista Pau Brasil*, Nº 7, 1985, pp. 6-8.

⁶ D. C. Cabral, *Na Presença da Floresta: Mata Atlântica e História Colonial*, Rio de Janeiro, Garamond, 2014; D. C. Cabral, *Homens e Árvores no Ecúmeno Colonial. Uma História Ambiental da Indústria Madeireira na Bacia do Macacu, Rio de Janeiro, 1763-1825*, M. A. thesis, Universidade Federal do Rio de Janeiro, 2007; C. F. A. Castro, *Gestão Florestal no Brasil Colônia*, Ph.D. Dissertation, Universidade de Brasília, 2001.

⁷ B. A. Black, C. M. Ruffner & M. D. Abrams, "Native American Influences on the Forest Composition of the Allegheny Plateau, Northwest Pennsylvania", *Canadian Journal of Forest Research*, Nº 36, 2006, pp. 1266-1275; T. Samojlik, I. D. Rotherham & B. Jedrzejska, "Quantifying Historic Human Impacts on Forest Environments: a Case Study in Białowieża Forest, Poland", *Environmental History*, Nº 18, 2013, pp. 576-602; M. Tabarelli, et. al., "Prospects for Biodiversity Conservation in the Atlantic Forest: Lessons from Aging Human-Modified Landscapes", *Biological Conservation*, Nº 143, 2010, pp. 2328-2340.

⁸ M. C. Ribeiro, et. al., "The Brazilian Atlantic Forest: How Much is Left, and How is the Remaining Forest Distributed? Implications for Conservation", *Biological Conservation*, Nº 142, 2009, pp. 1141-1153; C. G. Barreto, *Devastação e Proteção da Mata Atlântica Nordestina: Formação da Paisagem e Políticas Ambientais*, Ph.D. Dissertation, Universidade de Brasília, 2013; M. Tabarelli, J. M. C. Silva & C. Gascon, "Forest Fragmentation, Synergisms and the Impoverishment of Neotropical Forests", *Biodiversity and Conservation*, Nº 13, 2004, pp. 1419-1425.

⁹ Barreto, *op. cit.*

¹⁰ This term defines a ceramist tradition that archaeologists have correlated with Native Americans who spoke Tupi and Guarani languages. They predominated along most of the current Brazilian Atlantic coastline (including the Northeastern coast) as of European arrival, to the detriment of dozens of other native groups who lived in the interior of the current Brazilian territory.

¹¹ P. V. de Caminha, A. M. Plant, & T. Plant, *The Letter of Pero Vaz de Caminha: To El-rei D. Manuel of Portugal Concerning the Discovery of Brazil*, North Charleston, CreateSpace, 2011[1500].

¹² H. Staden, *Hans Staden's True History: An Account of Cannibal Captivity in Brazil*, translated and edited by Neil Whitehead and Michael Harbsmeier, Durham, Duke University Press, 2008 (1555). We also used H. Staden, *Hans Staden: Primeiros Registros Escritos e Ilustrados sobre o Brasil e seus Habitantes*, Rio de Janeiro, Terceiro Nome, 1999 (1555). This edition has the distinction of having been translated directly from the original in the German language into Portuguese, by Angel Bojadsen.

¹³ P. M. Gandavo, *The Histories of Brazil*, edited by John B. Stetson, New York, The Cortes Society, 1922 (1576). We also used the 1858 edition, from the "Collecção de opusculos reimpressos", of the Academia de Ciências de Lisboa, printed by Typographia da Academia Real de Sciencias.

¹⁴ Léry was translated into English: J. de Léry, *History of a Voyage to the Land of Brazil*. Translated and introduced by Janet Whatley, Berkeley, University of California Press, 1992. See also the review of this translation by J. A. Drummond, Jean de Léry, *History of a Voyage to the Land of Brazil, Luso-Brazilian Review*, Nº 32, 1995, pp. 105-106.

¹⁵ F. Cardim, *Tratados da Terra e Gente do Brasil*, Rio de Janeiro, J. Leite & Cia, 1925 (1583).

¹⁶ G. S. Sousa, *Tratado Descritivo do Brasil em 1587*, São Paulo, Cia. Editora Nacional, 1971 (1587).

¹⁷ C. d'Abbeville, *Histoire de la Mission des Pères Capucins en L'isle de Marignan et Terres Circonvoisines où est Traicté des Singularitez Admirables & des Moeurs Merveilleuses des Indiens Habitans de ce Pais*, Paris, de l'impr. de F. Huby, 1614.

¹⁸ Fr. V. Salvador, *História do Brasil. Em que se Trata do Descobrimto do Brasil, Costumes dos Naturais, Aves, Peixes, Animais e do mesmo Brasil*, Rio de Janeiro, Fundação Biblioteca Nacional, 1889 (1627).

¹⁹ M. Albuquerque & V. Lucena, "Caçadores-coletores no Agreste Pernambucano: ocupação e ambiente holocênico", *CLIO - Série Arqueológica*, Nº 4, 1991, pp. 73-74; M. Albuquerque, "Horticultores pré-históricos do Nordeste", *Arquivos*

do Museu de História Natural Nº 8/9, 1984, pp. 131-134; M. Albuquerque, "O processo interétnico em uma feitoria quincentista no Brasil", *Revista de Arqueologia*, Nº 7, 1993, pp. 99-123; G. Martin, *Pré-História do Nordeste do Brasil*, Recife, Editora Universitária UFPE, 5ª edição, 2008; A. Prous, *Arqueologia Brasileira*, Brasília, Editora da Universidade de Brasília, 1991; C. Nimuendajú, *Mapa Etno-Histórico*, Rio de Janeiro, Fundação Pró-Memória, 1981 (1944); J. C. Silva, *Arqueologia no Médio São Francisco. Indígenas, Vaqueiros e Missionários*, Ph.D. dissertation, Universidade Federal de Pernambuco, 2003.

²⁰ F. Fernandes, *Organização Social dos Tupinambá*, Brasília, Editora Universidade de Brasília, 1988; P. P. A. Funari and F. S. Noelli, *Pré-História do Brasil*, São Paulo, Editora Contexto, 2009; Hemming, *op. cit.*; J. H. Steward and L. C. Faron, *Native Peoples of South America*, New York, McGraw-Hill, 1959; J. C. Abreu, *Diálogos das Grandezas do Brasil*, Salvador, Ed. Progresso, 1956 (1618); D. S. Corrêa, "Historiadores e cronistas e a paisagem da Colônia Brasil", *Revista Brasileira de História*, Nº 26, 2006, pp. 63-87; B. F. Barbosa, *Paranambuco: Herança e Poder Indígena Nordeste Séculos XVI - XVII*, Recife, Editora Universitária da UFPE, 2007.

²¹ The spatial scale approach follows McMichael, *op. cit.* Its purpose is to (i) enrich the findings of demographic studies and investigations about the social organization of the indigenes, (ii) help define the range of their settlement patterns, and (iii) identify the extent of their impacts on the landscape. We used cartographic tools to develop this approach.

²² The Archaic Period is an archaeological period of Brazilian pre-history that spans 11,000 to 6,000 ybp. After the extinction of American macrofauna, at the end of the Pleistocene, this "archaic" culture emerged, expressing adaptations to climate changes and new subsistence strategies. See G. R. Willey & P. Phillips, *Method and Theory in American Archaeology*, Tuscaloosa & London, University of Alabama Press, 2001.

²³ Coimbra-Filho, A. F. and I. G. Câmara, *Os Limites Originais do Bioma Mata Atlântica na Região Nordeste do Brasil*, Rio de Janeiro, Fundação Brasileira para a Conservação da Natureza, 1996.

²⁴ Martin, *op. cit.*; A. F. Coimbra-Filho and I. G. Câmara, *Os Limites Originais do Bioma Mata Atlântica na Região Nordeste do Brasil*, Rio de Janeiro, 1996.

²⁵ IPHAN - Instituto do Patrimônio Histórico e Artístico Nacional, *Cadastro Nacional de Sítios Arqueológicos*, <http://portal.iphan.gov.br/portal/montaPaginaSGPA.do>, accessed 26 oct. 2011.

²⁶ Funari and Noelli, *op. cit.*; Fausto, C. *Os Índios antes do Brasil*. Rio de Janeiro, Jorge Zahar Editor, 2000.

²⁷ N. M. Waguespack & R. L. Kelly, "An Update on New World Colonization Research: The Paleoamerican Odyssey Conference", *Evolutionary Anthropology: Issues, News, and Reviews*, Nº 23, 2014, pp. 47-48; *Cadastro Nacional de Sítios Arqueológicos*, Instituto do Patrimônio Histórico e Artístico Nacional, <http://portal.iphan.gov.br/portal/montaPaginaSGPA.do>, accessed 26 oct. 2011; Funari and Noelli, *Pré-História do Brasil*; Fausto, *op. cit.*; Barbosa, *Paranambuco: Herança e Poder Indígena Nordeste Séculos XVI - XVII*; Martin, *op. cit.*

²⁸ Willey & P. Phillips, *op. cit.*

²⁹ Known in Portuguese as "terra sem males". Quoted in A. Metraux, *A Religião dos Tupinambás e suas Relações com a das demais Tribos Tupi-Guaranis*, São Paulo, Editora Nacional, 1979, p. 185.

³⁰ Prous, *op. cit.*; Albuquerque & Lucena, *op. cit.*; Metraux, *A Religião dos Tupinambás e suas Relações com a das demais Tribos Tupi-Guaranis*; Nimuendajú, *op. cit.*

³¹ Fausto, *op. cit.*, p. 68.

³² Barbosa, *Paranambuco: Herança e Poder Indígena Nordeste Séculos XVI - XVII*; Silva, *op. cit.*; Funari and Noelli, *Pré-História do Brasil*; Albuquerque, *op. cit.*, 1984; Albuquerque, *op. cit.*, 1993; Martin, *op. cit.*; Denevan, *The Native Population of the Americas in 1492*.

³³ Nimuendaju, *op. cit.*

³⁴ F. S. Noelli, "The Hypothesis About the Origin Center and Expansion of the Tupian", *Revista de Antropologia*, Nº 39, 1996, pp. 7-54.

³⁵ Sousa, *op. cit.*

³⁶ L. P. P. Ferraz, "Resistência indígena em Pernambuco nos séculos XVI e XVII: a visão dos cronistas", *Revista de Humanidades*, Nº 9, 2008, pp. 1-15.

³⁷ *Sistema IBGE de Recuperação Automática - SIDRA*, Instituto Brasileiro de Geografia e Estatística, <http://www.sidra.ibge.gov.br/bda/pecua/default.asp?z=t&o=24&i=P>, accessed 31 May 2014; Ferraz, *op. cit.*

³⁸ F. Fernandes, *A Função Social da Guerra na Sociedade Tupinambá*, São Paulo, Globo, 2006 (1952).

³⁹ This term is taken from sixteenth-century chronicles and was possibly used by the Tupiguaranis themselves. For the Portuguese, however, the term designated generically all indigenous groups from the vast colony's interior, with habits and languages different from those of the Tupiguaranis.

⁴⁰ Funari & Noelli, *op. cit.*

⁴¹ *Idem*.

⁴² Noelli, *op. cit.*

⁴³ Albuquerque, *op. cit.*; Noelli, *op. cit.*

⁴⁴ Funari & Noelli, *op. cit.*; Staden, *op. cit.*

⁴⁵ Albuquerque, *op. cit.*, 1984; Fernandes, *op. cit.*, 1988.

⁴⁶ IPHAN, *op. cit.*; Barbosa, *op. cit.*; S. M. Neves & M. M. Neves, "Ocupação humana e a probabilidade da presença de sítios arqueológicos do tipo sambaqui no litoral da Paraíba", *Revista de Geografia UFPE*, Vol. VIII, 2010, pp. 277-289; Hemming, *op. cit.*

- ⁴⁷ Albuquerque & Lucena, *op. cit.*; Fernandes, *op. cit.*
- ⁴⁸ This practice is currently known in the Portuguese language as “coivara”. The word derived, however, from the Tupiguarani expression “cô-y uára”, meaning roughly “planting together with burning”. See T. Sampaio, *O Tupí na Geographia Nacional*, Rio de Janeiro, Editora Nacional, 1901.
- ⁴⁹ Dean, *op. cit.*
- ⁵⁰ McMichael, *et. al.*, *op. cit.*
- ⁵¹ W. M. Denevan, “The Pristine Myth: The Landscape of the America in 1492”, *Annals of the Association of American Geographers*, N° 82, 1992, pp. 369-385; W. M. Denevan, “The ‘Pristine Myth’ Revisited”, *The Geographical Review*, N° 101, 2011, pp. 576-591.
- ⁵² Hemming, *op. cit.*
- ⁵³ T. Pompeu Sobrinho, Povoamento do Nordeste Brasileiro, *Revista do Instituto do Ceará*, N° 51, 1937, pp. 107-162.
- ⁵⁴ IBGE - Instituto Brasileiro de Geografia e Estatística. Base Cartográfica Integrada do Brasil ao Milionésimo Digital - bCIMd. Rio de Janeiro, IBGE, 2010.
- ⁵⁵ Léry, *op. cit.*, p. 183.
- ⁵⁶ Staden, *op. cit.*, p. 91.
- ⁵⁷ D’Abbeville, *op. cit.*, pp. 176-196
- ⁵⁸ Staden, *op. cit.*, pp. 87-125.
- ⁵⁹ Léry, *op. cit.*; Cardim, *op. cit.*
- ⁶⁰ Salvador, *op. cit.*; Staden, *op. cit.*; Gandavo, *op. cit.*, p. 17; Caminha, *op. cit.*, p. 57.
- ⁶¹ Noelli, *op. cit.*
- ⁶² Salvador, *op. cit.*; Gandavo, *op. cit.*; Staden, *op. cit.*; Funari & Noelli, *op. cit.*
- ⁶³ Fernandes, *op. cit.*; Funari & Noelli, *op. cit.*
- ⁶⁴ D’Abbeville, *op. cit.*; Fernandes, *op. cit.*
- ⁶⁵ Metraux, *op. cit.*; D’Abbeville, *op. cit.*
- ⁶⁶ R. E. Horton, “Erosional Development of Streams and their Drainage Basins: Hydrophysical Approach to Quantitative Morphology”, *Geological Society of America Bulletin*, N° 56, 1945, pp. 275-370.
- ⁶⁷ Dean, *op. cit.*
- ⁶⁸ Cardim, *op. cit.*; Fernandes, *op. cit.*; Sousa, *op. cit.*, p. 117; Staden, *op. cit.*
- ⁶⁹ S. W. Miller, *An Environmental History of Latin America*, Cambridge, Cambridge University Press, 2007.
- ⁷⁰ Fernandes, *op. cit.*, p. 99.
- ⁷¹ R. C. Gonçalves, *Guerras e Açúcares: Política e Economia na Capitania da Parayba. 1585-1630*, Bauru, EDUSC, 2007; J. L. Carvalho, “Do império marítimo ao proveito da terra, uma cultura territorial em mutação (Capitania da Paraíba, 1574-1654)”, *Cadernos PPG-AU/UFBA* N° 7, 2008, pp. 13-30.
- ⁷² Steward and Faron, *op. cit.*; Denevan, *op. cit.*; Hemming, *op. cit.*; W. M. Denevan, “The Native Population of Amazonia in 1492 Reconsidered”, *Revista de Índias*, N° 63, 2003, pp. 175-188.
- ⁷³ A. C. S. A. Diegues, *O Mito Moderno da Natureza Intocada*, São Paulo, 2004; G. L. Ribeiro, “Ambientalismo e desenvolvimento sustentado: ideologia e utopia no final do século XX”, *Ci. Inf.*, N° 21, 1992, pp. 23-31; M. Gadgil, F. Berkes, & C. Folke, “Indigenous Knowledge for Biodiversity Conservation”, *Ambio*, N° 22, 1993, pp. 151-156; Corrêa, *op. cit.*; Dean, *op. cit.*; Denevan, *op. cit.*; J. A. Drummond, *Devastação e Preservação Ambiental: os Parques Nacionais do Estado do Rio de Janeiro*, Niterói, Editora da Universidade Federal Fluminense, 1997.
- ⁷⁴ Castro, *op. cit.*; Cabral, *op. cit.*
- ⁷⁵ Drummond, *op. cit.*, p. 42.
- ⁷⁶ Behling Hermann & Raquel R. B. Negrelle, “Vegetation and Pollen Rain Relationship from the Tropical Atlantic Rain Forest in Southern Brazil”, *Braz. arch. biol. technol.*, Vol. 49, N° 4, July 2006, pp. 631-642.
- ⁷⁷ McMichael, *op. cit.*; Drummond, *op. cit.*
- ⁷⁸ W. Cronon, *Changes in the Land*, New York, Hill & Wang, 1986; D. Worster, *Dust Bowl: The Southern Plains in the 1930’s*, Oxford, Oxford University Press, 1982; R. White, *The Organic Machine: The Remaking of the Columbia River*, New York, Hill & Wang, 1995; R. White, *Land Use, Environment and Social Change: The Shaping of Island County*, Seattle, University of Washington Press, 1980.