Toiling in Paradise: Knowledge Acquisition in the Context of Colonial Agriculture in Brazil's Atlantic Forest

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ABSTRACT

Four centuries of colonial extraction lead to severe ecological degradation of the forests and soils of the Atlantic region of Brazil. After an overview of the history of colonial plantation agriculture, we discuss the knowledge developed in this context. Over the course of time, several agricultural manuals were published for or in the colony. Landowners recommended agricultural techniques developed for European temperate climates, but also included their local experience. Indigenous knowledge about cultivation was not suitable for the extractive colonial system and therefore played little role in colonial agriculture. Based on agricultural manuals published in Brazil over a period of more than two centuries, we discuss the management of soil fertility and the relationship between agricultural practices and forest stands. The process of acquisition and distribution of agronomic knowledge by Brazilian authors was slow during the colonial period. The strongest point in common among the authors was their concern with the preservation of forests. Their soil classification systems show clear evidence of indigenous influence. The agricultural manuals have not been studied explicitly as sources for the environmental history of Brazil. Therefore, we studied some of the particular ecological circumstances of their writing. The

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Atlantic forest does gain substantial nutrients from rainwater, a fact the authors allude to in their recommendations. At least one author developed plant indicators using native species Although written in a colonial context, Brazilian agronomic literature was full of recommendations for a sustainable use of Brazil's biodiversity, and argued against the devastation wrought by colonial exploitation.

KEYWORDS

Brazilian agronomic manuals, monoculture plantation agriculture, Atlantic Coastal Forest, soil fertility

THE CONTEXT: FIVE CENTURIES OF EXPLOITATION

It is easy to imagine the sense of wonder and excitement of the Portuguese sailors as they set foot on an unknown tropical land after 44 days of sailing, according to the poet Luis de Camões, 'on seas never navigated before'.[1] They had left Lisbon, Portugal, at the end of winter 1499 and had just arrived on a shore of warm and sheltered waters, where numerous rivers flowed into the sea and the dense coastal forest grew almost down to the beach. The impression of this tall forest led the first Europeans to believe that the soil of the land they had discovered was incredibly fertile. Pero Vaz de Caminha, scribe for the fleet of Pedro Álvares Cabral, wrote of this land:

> Em tal maneira é graciosa que, querendo-a aproveitar, dar-se-á nela tudo; por causa das águas que tem! (...). Eles não lavram nem criam. Nem há aqui boi ou vaca, cabra, ovelha ou galinha, ou qualquer outro animal que esteja acostumado ao viver do homem. E não comem senão deste inhame, de que aqui há muito, e dessas sementes e frutos que a terra e as árvores de si deitam. E com isto andam tais e tão rijos e tão nédios que o não somos nós tanto, com quanto trigo e legumes comemos.[2] [It is so gracious, so abundant, (...). They do not farm or raise animals. There are no oxen or cows, goats, sheep or chicken, or any other animal that is accustomed to living with man. They do not eat anything but yams, which are very abundant, and the seeds and fruits of the earth and that which the trees yield to them. And with that diet they are even more vigorous and well-fed than us, with the wheat and vegetable that we eat.] [This and all following translations are by Oliveira.]

As in other instances of Europeans encountering the tropics, the contrast between the landscape of Portugal and that of Brazil, with its profusion of colours and species, lead the colonisers to assume that they had encountered

an extremely productive new land, a true paradise on earth. The concept of a paradise is repeated through much of the Brazilian colonial literature. It can be found as late as 1839.

> Entre todas as regiões do globo, talvez a mais apropriada à agricultura seja o Brasil, pois que na sua vasta extensão acham-se climas, terrenos e exposições de quantas qualidades é possível imaginar, de forma que dificilmente nós poderemos lembrar de uma espécie vegetal, ou de uma sorte de cultura, que não exista já, ou que não possa, para o futuro, introduzir-se neste abençoado país, tão fecundo e variado em produções, ameno em aspectos e ares, tão regado de águas, revestido de matas, e aprazível à vista que os primeiros descobridores não duvidaram avançar que tinham por fim deparado com o paraíso terrestre. [3]
> [Of all of the regions of the world, perhaps the most appropriate for agriculture can be found in Brazil, for in its vast extensions almost unimaginable climates, lands and conditions can be found, to such an extent that it is difficult to think of a plant species or a type of plantation that does not now exist, or could not be introduced in the future into this much blessed country, so fertile and varied in its production, agreeable in aspect and airs, so abundant with waters, clad in forests, so delightful to see that the first discoverers had no doubts at all that they had at last encountered paradise on earth].

Writers like the coffee grower Taunay, from whose work this quote is taken, convey their edenic visions solely in the introductions of their works, not in their recipes and practical descriptions, as will be shown. But as faithful subjects of the Portuguese crown they had to pay reverence to the dominant image to which their sovereign, the king, subscribed and which justified colonial exploitation of biological and mineral resources alike.

While some fine scholarship on the colonial history of Brazil exists, the development of agricultural knowledge in Brazil in the context of colonial exploitation has attracted less scholarly interest.[4] Warren Dean's *With Broadax and Firebrand* (1995), Shawn Miller's *Fruitless Trees* (2000) and Padua's *A Breath of Destruction* (2002) are main texts in the historiography of Brazil's forests.[5] The authors emphasise political and economical processes of appropriation and discuss the use of environmental resources and the progress of landscape transformation. They also introduced readers to the first voices against an agriculture based on destruction of the forest. However, in their narrative, colonial agricultural writers did not play much of a role. We wish to add to this knowledge with a case study on colonial agricultural writings in the Atlantic coastal forest region of Brazil. Figure 1 provides an overview of the original distribution of this biome on the Brazilian coast.

Agriculture was the central pursuit of all societies before the industrial revolution. Human sustenance was based on tapping carefully designed biomass

FIGURE 1. Original distribution of Atlantic Coastal Forest biome in Brazil.
(Map adapted from SOS Mata Atlantica[6])

cycles for energy and food demands.[7] Colonialism was no exception to this pattern. As in other colonies, plantation agriculture played a major role in the exploitation of the riches of Brazil. The knowledge base for this exploitation will be discussed after a brief sketch of the history of colonial extraction in Brazil.

Methods to exploit European colonies in the Americas were developed by trial-and-error in different phases of the colonial enterprise. The first phase of colonial exploitation in Brazil, which began around 1533, involved the harvesting of Brazil-wood (*pau-brasil*), much sought after as a red dye. The main driver

of occupation, colonisation and transformation of the Brazilian territory was sugar production. It had started with the military expedition of Martim Afonso de Souza, sent from Portugal in 1532, which was undertaken to remove French competitors from the coastal areas of Brazil and to promote Portuguese settlement in the region. The fleet brought with it sugarcane plants as well as colonists specialised in the production of sugar.[8]

Sugar production in Brazil had two distinct phases. Up until the seventeenth century, it was the principal colonial activity, with urban areas almost entirely devoted to supporting this industry. The Brazilian sugar economy began to suffer from heavy competition from the Antilles from the mid-seventeenth century onwards, and with the growth of mining in Minas Gerais, the importance of agriculture diminished. Only with the decline of gold production at the beginning of the nineteenth century did the sugar economy regain some of its former intensity.

The first important Brazilian export had been Brazil-wood, a product of the forests, but the more important second commodity, cane sugar, likewise could not have made its unrivalled contribution to colonial development had the Portuguese encountered a land of fewer trees. To make sugar production possible, large quantities of firewood were needed within easy reach of sugar mill furnaces. Any attempt at sugar production without a ready stockpile of forested land had no chance to succeed no matter how favourable other environmental factors such as climate and soil were.[9]

The negligible costs of forests and land led the planters to abuse wood and soil resources. Originally the planters grew cane in the lowland *várzeas'* rich *massapê* soil, famed for fertility and good water retention. By the nineteenth century, however these plains were mostly in use and the planters were deforesting hillsides.[10] The cultivation of sugarcane in Brazil required large land holdings (*latifundios*) and slave labour.

But colonial exploitation schemes had a pronounced impact on the natural systems upon which they were based. The Atlantic Coastal Forest biome was profoundly changed through these schemes.[11] In addition to the space needed to cultivate sugarcane, land was needed for subsistence farm plots of the slaves, with more forest clearing ensuing. These plots played an important role in keeping friction between owners and their slaves at bay. For the slave owners, these small farms represented a significant reduction in maintenance costs, while for the slaves they represented an opportunity to gain a limited degree of economic independence.[12]

Large areas of forest were needed for construction wood and fuel-wood for the boilers. Sugar mills would grind sugarcane day and night for most of the year. The dependence of sugar manufacturing on the Atlantic Forest was enormous, as fuel-wood was essentially the only available energy source for this agro-industry. Extracted from the property itself, or acquired from nearby lands, fuel-wood was deposited near the furnace and used to feed the fires dur-

ing the long months of sugar production. In addition to fuel-wood to feed the furnaces, other demands for forest products were equally intense, wood was needed for fences, construction, the manufacture and maintenance of ox-carts, and to make crates for shipping sugar. Supplying fuel-wood was always a serious question for the mills, as up to a ton of wood was required for every ton of sugar produced. Generally, eight ox-carts of selected firewood were necessary for twenty cart loads of cut sugarcane; a proportion of 1:2.5. A study based on historical documents about a sugar-mill in Rio de Janeiro that was in operation from 1625 until the end of the nineteenth century gives an estimate of the amount of wood required for sugar production. As this mill processed approximately 6,500 ox-carts of cane per harvest, about 2,600 carts of wood would have been needed for processing. Biomass estimates from neighbouring forests indicate that 10 to 20 hectares of forest were needed per year to supply fuel-wood for a single sugarcane harvest.[13] These numbers all refer to the wood needs of a single mill in a single harvest period. To have an idea of the impact of the sugar industry on the Atlantic Coastal Forest, it must be borne in mind that at the start of the eighteenth century the Capitania of Rio de Janeiro alone had 131 sugar mills in operation.[14]

A new crop was added to the colonial portfolio in the nineteenth century. Around 1830, coffee growers began to alter the landscape in new ways. Coffee beans soon became Brazil's principal agricultural export, economically favouring three south-eastern provinces: Rio de Janeiro, São Paulo and Minas Gerais. In contrast to sugarcane, coffee was generally planted on hill slopes, predominantly in the Paraiba do Sul river valley, the largest drainage basin in south-eastern Brazil.

It is within this spatial and temporal framework of colonial extraction that this paper seeks to analyse the agricultural knowledge of the colonisers and its relation to the Atlantic Coastal Forest. As we will show, indigenous knowledge was ignored whereas the knowledge base of Europe was adapted. While colonial knowledge production was seriously hampered by the political circumstances, several works which survive to date were published, in particular to aid sugarcane and coffee growing. We want to draw attention to contemporary agricultural manuals as a prerequisite for studies of colonial environmental impacts.

INDIGENOUS AGRICULTURAL PRACTICES

The slash-and-burn planting system of Brazil (*roça de toco* or *coivara*) is an Amerindian development. The technique is based on the felling and subsequent burning of the forest, followed by a mixed crop planting regime. Burning is generally performed during the driest months when there is less risk of heavy rain. Ashes are more effectively incorporated into the soil during this dry period, because erosion and leaching would be intense under torrential rains.

An important technique of indigenous agriculture is intercropping up to 15 species together (shrubs, herbs, climbing plants) to reduce plant pathogens and weeds. After a few years – generally three to four – the productivity of the plot will decline due to the exhaustion of soil nutrients by harvesting and erosion. Traditionally, the plots are then abandoned and allowed to rest for at least four years while the farmer cuts another forest area to continue the cultivation cycle. Leaving the land fallow is an integral part of this technique, allowing the growth of a secondary forest that will aid in reincorporating nutrients lost through harvesting and erosion into the soils. The use of fire is fundamental in shifting agriculture, as it sets free phosphorus and other nutrients accumulated in the living biomass.

Although these agricultural systems have often been falsely considered as primitive, inefficient and environmentally inadequate, under appropriate circumstances they can be highly productive, relatively neutral in terms of their long-term ecological effects, and must be considered as a sophisticated adaptation to nutrient-poor soils.[15] A number of studies have indicated that when this agricultural technique is practiced within certain limits, it is ecologically sustainable for an unlimited period of time.[16] Whether applied by Amerindians or by the mixed European/African populations that succeeded them (the *caboclos, caiçaras, quilombolas*, etc.) for subsistence, the sustainability of this type of agriculture is linked to continued mobility and to relatively low population densities, two framework conditions that were not longer available after European colonists had arrived. Almost none of this knowledge was, therefore, used in plantation agriculture.

At the beginning of the period of colonisation, native peoples were seen as a work force that the colonists could count on for opening trails and clearings, cutting and transporting trees, for constructing canoes, homesteads, mills and forts, as well as for hunting and fishing. Without the labour of the Amerindians, the first colonists would have had very little to eat, but this partnership was anything but peaceful. Indigenous labour was used during the early days of the sugar industry, but was progressively substituted, starting in the sixteenth century, by African slaves who arrived in regular commerce across the Atlantic. The Marquis of Abrantes (see below for details on his work) referred to the participation of the Amerindians in colonial agriculture in the following manner:

> Será de nenhum proveito para a Agricultura a colonização dos nossos indígenas. Estes filhos da Natureza e da indiferença, cujas necessidades são tão limitadas, não têm o estímulo necessário para qualquer tipo de trabalho. Inúteis foram, desde os primeiros tempos da América, as tentativas de colonizar ou de chamar os aborígines ao trabalho.[17] [The colonisation of our indigenous peoples will be of no use to agriculture. These children of nature and of indifference, whose necessities are so limited, do not have the necessary stimulus for any sort of work. Any attempts, since the first moments of America, to colonise or call the aboriginals to work have been useless].

The indigenous knowledge of the Amerindians was not ignored by authors of the agricultural manuals, but while they did see the positive results of indigenous methods, they were not willing to adopt and adapt part of the indigenous system:

> A sua indústria agrícola correspondia à sua natural indolência e aos parcos instrumentos que empregavam. Roçam um pedaço de mato, que queimam depois, servindo as cinzas de esterco (...) abandonam as plantações à fecundidade natural do terreno e aos métodos naturais e tiravam ricas colheitas desta terra tão mal preparada, porém vigorosa e forte.[18] [Their agricultural activities correspond to their natural indolence and to the few instruments that they use. They clear a small piece of land, which is then burned, with the ashes serving as fertiliser (….) they abandon the plantations to the natural fertility of the lands and to natural methods, and take rich harvests from this land so badly prepared, although vigorous and strong].

The paradoxical image held by the European colonisers was that the new continent was a paradise inhabited by people unfit to use it. As these native populations were oriented towards a system of common lands and self-sufficiency, their agriculture was incompatible with the monocultural model directed towards external markets that the empire sought to establish.

AGRONOMIC KNOWLEDGE IN A COLONIAL CONTEXT

The transition from shifting to permanent agriculture was a consequence of European colonisation. Permanent agriculture in Brazil was introduced in form of mono-cultural sugarcane plantations. As we have detailed above, this development did not lead to reduced forest use; it rather intensified the demand on forest resources. Since sugarcane is a fast-growing grass, it could be left in the ground for multiple cuttings and burned periodically in order to boost production. But because no thought was given to replenishing soil fertility, yields declined over time. When yields decreased, fields were abandoned and given over to pasture in a cycle that took between 12 and 15 years, a type of long rotation that proved unable to sustain soil fertility. New areas would be cleared and cultivation moved on, destroying more forest. Erosion on steeper slopes was also a major problem and contributed to declining yields. Sugar production has been termed a system of profligate use, based on abundant resources of land, forests and labour.[19] The overall ecological effect of this massive change was a conversion of biologically diverse coastal ecosystems into systems favouring a limited number of cultivated and/or exotic plant species, many of which came to be considered agricultural weeds. This same phenomenon occurred also in many other countries under colonial rule, e.g. in Australia.[20]

When land ceased to be used exclusively for subsistence agriculture and regions were transformed into agro-industrial landscapes, new practices had to be

adopted to compensate for the rapid exhaustion of soils. Subsistence agriculture had relied on shifting populations and agricultural areas. Permanent agriculture was based on the availability of immense reserves of forested land that were used as sources of wood and bio-fuel, and to substitute the lands damaged by erosion and/or having reduced fertility. The continuation of sugar cultivation and later that of coffee both depended on the availability of new forest areas as the easiest way to overcome the reduction of soil fertility due to depletion of soil nutrients. In this situation, colonial estate owners started to codify their knowledge in order to sustain, if not their soils, so at least their income basis.

Although colonial sugarcane production was exploitative, colonisers were not oblivious to the effects of nutrients and can be assumed to having principally been interested in remedies that could boost their production. Agronomic knowledge was organised and systematised to adapt it to the tropical characteristics of Brazil, but with a long delay. The first Brazilian agricultural manual appeared three centuries after the introduction of sugarcane cultivation. All information available to the farmers up until that time was based on oral transmission among colonisers, on personal experience, or on imported European manuals. The oral tradition of indigenous peoples was ignored in the process of knowledge acquisition and adaptation, as it would not have been useful for sugarcane plantations. There were no positive references in agricultural manuals from the colonial period to any of the techniques employed by the Amerindians, and the dominant vision adopted by Europeans was that the coastal forest soils were rich and that the agricultural knowledge of the indigenous peoples was primitive and rudimentary, according at least to one manual writer, the Marques de Abrantes.[21]

Most European agricultural manuals contain extensive references to earlier works, building a sizeable body of (sometimes contradictory) knowledge which was available at least partially to literate landowners all over Europe.[22] Not all information was actively applied. To give but one example, the technique of planting leguminous crops to add nitrogen to the soil was known to the Ancient Romans but, like crop rotation, was not regularly practised by farmers in the Middle Ages.[23] One is left with speculation as to the reasons for such 'forgetting', but it should be borne in mind how much the organisation of agricultural operations mattered for the applicability of agricultural knowledge. Some methods might simply have ceased to be feasible for economic and labour reasons.

The processes of acquisition and distribution of agronomic knowledge by Brazilian authors were very slow during the colonial period, although the number of published works was significant – especially considering that the country's first printing press was only installed in 1808, approximately 280 years after the start of sugarcane cultivation. It is also true that Brazilian literary production circulated very slowly in the country, and openly communicating and exchanging ideas was no habit among the colonial agricultural authors. References to Brazilian authors were rarely made. Emphasis was being put almost exclusively on foreign writers. A good example of this attitude is the aforementioned manual

written by Miguel Du Pin de Almeida, the Marquis of Abrantes, in 1834. The author, an estate owner himself, demonstrated considerable knowledge of the classical writers and provided extensive descriptions of state-of-the-art agriculture in various European countries (like France, Germany, Austria, Switzerland, Italy, Spain, Sweden and Great Britain) and the United States. His work contains extensive reviews of the principal agronomic writers from each of these countries. But the Marquis of Abrantes referred only superficially to information produced by Brazilian authors, in general limiting himself to referring to a periodical he had founded, the *Annals of the Agricultural Society*.[24] There are exceptions to this pattern, but in general, locally acquired knowledge was not valued as much as written expertise from Europe, at least not in the production of written knowledge. It is also probable that some Brazilian landowners had access to agricultural manuals written in Portugal, 'learned' agriculture in Brazil was dominated by knowledge written for vastly different ecological systems.

THE EIGHTEENTH CENTURY: AGRICULTURAL ENCYCLOPAEDIAS

Nevertheless, there are books discussing subjects closely related to tropical soils. A good example is the work entitled *Memórias de agricultura premiadas em 1787 e 1788*, published by the Royal Academy of Sciences of Portugal. This book is a collection of treatises on various agronomic topics and they were not addressed to tropical agriculture. Although it largely concerned crops that were rarely cultivated in Brazil at that time, such as wheat and grapes, there is evidence that it had been used in Brazil.[25] In it, numerous references concerning soil management by classical authors such as Virgil and Columella are reproduced. Various articles recommend techniques for replenishing soil nutrients through incorporating animal or plant wastes into the soil, and describe alternative fertilisation techniques for localities where animal manure might not be available. One author stressed the use of ashes and of 'exposing the soil to the atmosphere numerous times, which is sufficient to fertilise it'.

Most soils of the Atlantic Coastal Forest are acidic and usually deficient in potassium. The use of ashes would, therefore, have resulted in significant benefits to the crops, had this technique been used, but this cannot be ascertained. In one of the chapters of the manual, the author lists arguments against the use of fallowing as a technique of recuperating soil fertility. According to this treatise, the farmer who uses fallowing will not produce large harvests and could even promote the progressive sterilisation of his lands: 'to leave the soil fallow is an abuse, which is detrimental to the farmer and to the state'.[26] No references were made in nineteenth-century manuals to the use of fallowing in Brazil, which may well be a reflection of the influence of this concept. The stock of virgin soils is another reason which made the use of fallowing unnecessary.

The first Brazilian agricultural manual, *Cultura e Opulência do Brasil* (Culture and Opulence in Brazil), was written in 1711 by the Jesuit André João Antonil, predating the Portuguese collection.[27] But two weeks after its publication the entire edition (except for three or four books) was confiscated and burned by order of the crown, in an attempt to keep the riches of the colony secret. Only in 1798 (that is, 87 years after its first publication) was Frei José Mariano da Conceição Velloso able to produce a partial edition of the book.

Antonil must have been aware of the habits of sugarcane planters, as he offers information on how planters valued different types of land. In the early chapters of his book, Antonil demonstrated an understanding of Brazilian soils and set up a classification system to match crops with different soil types. He considered dark types of clay, *massapê*, 'strong dark soils', as ideal for the cultivation of sugarcane. The *massapê* is a dark soil derived from cretaceous sediments; a heavy clay that can retain a great deal of water. Under heavy rains this material forms a compact mud capable of bogging down the ox carts used to transport sugar or sugarcane. These thick clays made ploughing impractical in cane fields, for it was very difficult for the draft animals to turn this viscous mud.[28] Antonil next refers to sandy/clay soils, called *salões*, 'suitable only for short cultivation, as it soon becomes weak', followed by *areiscas*, 'a mixture of sand with salão that is suitable for manioc and vegetables, but not for sugarcane'.[29] The *salões* is a reddish substrate derived from the decomposition of crystalline rocks; a lighter soil, but one with a lower water retention capacity. In rainy years the *salões* was better for planting sugarcane than *massapê*, but sugarcane

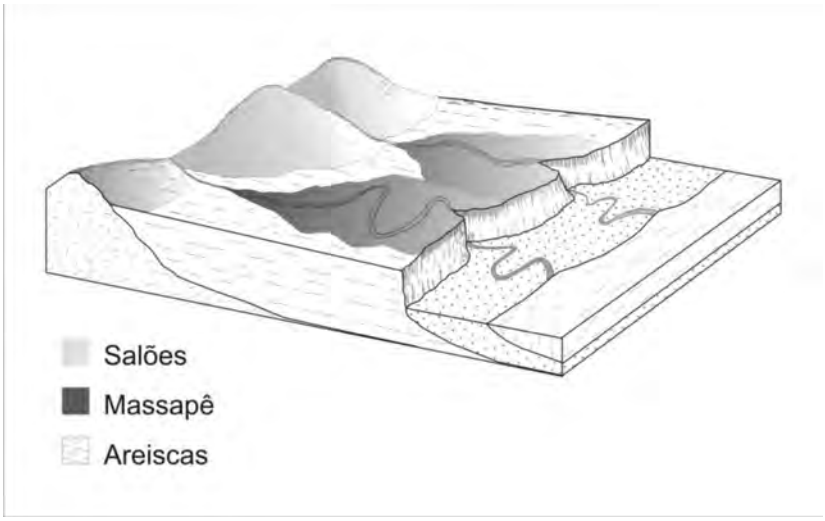

FIGURE 2. The scheme of soil classification system used by the Jesuit André João Antonil as a geomorphological soil classification [Drawing by Marcelo Motta]

growers in general seem to have valued it less than the thicker clay. Figure 2 shows a geomorphologic scheme of this soil classification system, showing that Antonil's way of describing the soils he encountered is consistent with the basic geomorphological situation in the Atlantic coastal region of Brazil.

According to Antonil, 'new' lands (where forests had been cut only recently) would produce a thick crop of sugarcane for the first and second harvest, but this harvest would not be suitable for making sugar as the cane would be very 'watery'. Antonil recommended the use of animal manure, but only for cultivating tobacco. To fertilise the sugarcane plantations, plant wastes should be burned on the land: 'burning should be done either in the early morning or at night when the wind is calmer and better serves to make the land more fertile'.[30]

When Antonil's book was written, sugarcane cultivation was at its apogee, covering a large part of the Atlantic Forest biome and leading to drastic alterations in the extension and structure of this forest. In contrast to later writers, Antonil viewed this resource as inexhaustible:

> O alimento do fogo é a lenha, e só o Brasil, com a imensidade dos matos que tem, podia fartar, como fartou por tantos anos, e fartará nos tempos vindouros, a tantas fornalhas, quantas são as que se contam nos engenhos da Bahia, Pernambuco e Rio de Janeiro, que comumente moem de dia e de noite, seis, sete, oito e nove meses do ano. [The fires are stocked by fuelwood, and Brazil, with the immensity of the forests that it contains, can count on abundance, abundance in the future, for all its furnaces, as many as there are sugar-mills in Bahia, Pernambuco and Rio de Janeiro, that commonly grind cane day and night for six, seven, eight, nine months a year].[31]

Generally, during early colonial times, the sentiment was that the Brazilian forest was of little intrinsic value, although Brazilian native plants like cashews, papayas, passion fruits and pineapples were quickly adopted and spread throughout the world.[32] But the view of Brazil's forests changed substantially over time. Between 1798 and 1806 Frei José Mariano da Conceição Velloso produced (as writer, coordinator and translator) an important edition of works specifically oriented towards scientific, agricultural and industrial development in Brazil[33]. His eleven volume encyclopaedia *O Fazendeiro do Brasil (…) segundo o melhor que se tem escrito a este assunto* - ['The Brazilian Farmer (...) according to the best that has been written about this subject'] boldly claimed to cover new ground. He covered subjects ranging from the manufacture of sugar, the cultivation of numerous species, including vegetable dye sources, coffee and cocoa, to the preparation of milk and its derivatives.[34] This publication, compiled by Velloso with articles by more than forty foreign authors, was specifically designed to instruct Brazilian farmers. He used most of the space of the first book of his encyclopaedia to convince the Emperor of the damage wrought by the destruction of forests. Frei Velloso also, as a secondary goal, advocated the introduction of new crops in the country. Another author, Baltasar da Silva

Lisboa, was one of the first to explicitly denounce the destruction of the Atlantic Coastal Forest in 1786. In fact, most of these agricultural publications contained expressive accusations against the predatory techniques used by the farmers.

In the preface of Tome I, Velloso clearly addresses the non-sustainability of a cultivation system based on the heavy exploitation of the Atlantic Coastal Forest:

> Mas porventura a Natureza será tão liberal na produção destas matas preciosas, que suposta a sua abundância nos reais domínios de Vossa Alteza, possam satisfazer as nossas necessidades presentes e à dos vindouros, sem economia alguma e sem o receio de virem a faltar no futuro? Certamente a devemos recear, pela continuação do presente sistema praticado no Brasil, onde no futuro pode tornar-se difícil este caro e precioso donativo da Natureza. [...] A pobre Natureza vigente, que supre a todas as nossas necessidades é anualmente assassinada nestas máquinas açucareiras, pela indiferença de seus donos. [...] Não há a abundância de matas que se apresenta à primeira vista.[35] [Is it possible that nature was so liberal in the production of these precious forests, which grace with abundance the royal dominions of your Majesty, that it can satisfy our present needs and those to come, without any economy of their use and without fear of scarcity in the future? We must certainly fear, with the continuation of the present system practised in Brazil, a future where this rich and precious gift of nature will become scarce. […] Poor nature, which supplies all our needs but is regularly assassinated by these sugar-machines, by the indifference of their owners. […] There is no longer the abundance of these forests as we have seen at first glance.]

Velloso had realised the inadequacy of the sugar-mill system and called attention to the very real possibility of production coming to an end if the forests were indiscriminately felled. He also refers to the idea of paradise comparing it to the richness of nature using terms like 'lost paradise' and 'there's no country in the world with a flora like Brazil'.[36] On the other hand, he paints with strong colours the destruction of the 'paradise', that is, the wrong use of natural resources by the farmers:

> As matas são finitas. Quantos engenhos de açúcar não têm deixado de existir pela falta deste combustível? A Ilha do Governador, no Rio de Janeiro, foi chamada antigamente de sete engenhos; hoje tem apenas um, insignificante. Quantas fazendas se acham reduzidas a taperas, porque seus matos se converteram em sapezais e setais, pelo errado princípio da sua agricultura? [...] Cartago e Tróia não viram certamente maiores montes de cinzas quando foram arrasadas do que se vê nas roças do Brasil e com que se destroem essas importantíssimas e belíssimas matas atualmente.[37] [The forests are finite. How many sugar mills have not disappeared because they ran out of fuel-wood? The community of Ilha do Governador, in Rio de Janeiro, used to be called Seven Mills; but today there is only one insignificant mill left. How many farms have been reduced to abandoned manors because their forests were converted into *sapezais* and *setaes*, by the errors of their agriculture?[38] [...] Carthage and Troy did not turn into larger

> mounds of ash when pillaged than those you can see in the farms of Brazil, where they destroy these important and beautiful forests even today].

Velloso demonstrated a clear concern about felling forests to fulfil the energetic needs of the sugar-mills:

> Não há outra lavoura, outro cultivo no Brasil senão derrubar matos. Que extensão de terra não tem sido descortinada por proprietários de engenhos para a construção das suas fábricas, para a plantação das suas canas, para a combustão das fornalhas de caldeiras e para a fabricação de suas caixas? Quantos lenhos preciosos não foram vítimas de suas mal construídas fornalhas?[39] [There is no farming, no cultivation in Brazil without cutting down the forests. What extensions of land have not been cleared by the owners of sugar plantations in order to run their mills, plant their sugarcane, to supply fuelwood for their furnaces and to build their packing crates? How much wood has been wasted heating their badly constructed furnaces?]

Realising the necessity of increasing productivity without destroying the forests, Velloso proposed a number of alterations to the productive chain: '[…] instead of axes and machetes, the plough; instead of the ashes of the precious and necessary woods, dung and all other types of fertilisers should be used'.[40]

He also linked the preservation of the forests to the restoration of soil fertility, with direct benefits for the cane fields:

> Que proveitos não resultariam dessa mudança sábia e prudente? (...) Os campos vastíssimos até aqui reputados como infecundos se voltariam fertilíssimos; as terras que se dizem cansadas e estão reduzidas a sapezais e setais tornariam a dar copiosas searas e ótimos frutos: não se precisaria de tanta extensão de terra para se fundarem fazendas lucrativas.[41] [What benefit would not result from this wise and prudent change? The vast fields that are considered infertile would return to fertility; the lands that are considered worn out and reduced to grasslands and scrub would go back to yielding copious harvests and wonderful fruit: one does not need huge extensions of land to have lucrative farms].

Many of the texts concerning sugarcane production translated by Velloso in the two volumes of his encyclopaedia *O Fazendeiro do Brasil* make reference to the use of fertilisers, linking soil fertility restoration and forest conservation. Bryan Edwards (in his chapter 'Civil and Commercial History of the English Colonies' in the encyclopaedia) discusses fertilising through the addition of ashes, vegetable substances, garbage, lime, cane leaves, etc. to the soil. For his encyclopaedia Velloso selected and translated more than forty studies from various countries, the majority from English or American authors and from the Antilles. The texts show commonalities in terms of their concern about the loss of productivity due to soil exhaustion, their efforts to promote fertiliser use, and their calls for preservation of forest lands. In this collection, Velloso's objective was to present alternatives to forest destruction for Brazilian farmers. As

a botanist, he was familiar with the botanical tradition to include the study of the soil into plant descriptions, which is already found in Theophrastus' *Causis Plantarum*, the oldest botanical work of Europe.

THE NINETEENTH CENTURY: AGRICULTURAL MANUALS

During the period from around 1800 to 1860, many agricultural manuals became available in Brazil.[42] This burst in agricultural publications was related to economic growth in the country, and to the expansion of coffee cultivation, but also reflects the worldwide increase in book production during this period. Manuals had to compete in a market. In order to be interesting for readers, they chose different approaches. One can find different motivations, goals, various degrees of in-depth coverage of issues, sets of techniques covered and so on. Each editorial production was sold as 'unique' and 'novel'. The manuals drew attention to different problems. For instance, Taunay's manual focuses particularly on the administration of slaves and related problems. This seems to him a more important issue than the technical information about cropping or grazing. He strongly favours what he considers a more 'rational' way of administrating the slaves. Slavery was an important topic in Brazilian manuals. Jean-Baptiste Alban Imbert and Frei José Mariano da Conceição Velloso both wrote manuals about the medical treatment of slaves under the title of 'agriculture manual'. The manuals of João Rodrigues de Brito and Marques de Abrantes try to convince their readers with mathematical arguments of the necessity of using new techniques and equipments in sugar cane mills. The manual by Baron of Pati do Alferes is very rich in things concerning practical aspects of farming administration.

Carlos Taunay (1791–1867) was the son of Nicolas Taunay, an important member of the French Artistic Mission brought to Rio de Janeiro by D. João VI. Coming from a military background, Taunay wrote a *Manual for the Brazilian Farmer* in 1839. His experience in agricultural affairs was derived from his managing a coffee plantation in the mountains near Rio de Janeiro. Although this book was largely directed towards the administration of slaves, he also proposed innovative techniques capable of increasing productivity of rural properties and dealt with the cultivation of numerous crops, such as coffee, sugarcane and plants used in dyeing, as well as teas and other crops. Taunay expressed his belief that the fertility and abundance of Brazil only needed a rational approach in order to reach their full development. Taunay, echoing Velloso's earlier conviction, considered the plough the principal and most admirable of all agricultural machines, although neither the plough nor manure were regularly used in colonial agriculture. As we have seen, ploughing on *massapê* soils was not feasible, the esteem of the plough hence cannot be considered as stemming from practical experience but is rather a claim founded on the appreciation of the European agricultural model.

Taunay attributed the absence of the plough to 'the facility and simplicity of cutting down virgin forests in Brazil and abandoning the tired land again until the forests grow back'.[43] In terms of the continued use of the land, Taunay affirms that: 'the difference in the quality of the lands influences only the longer or shorter time it can be cultivated. With the exception of very privileged lands, which can give yields for seventy or eighty years in equal abundance, cultivated lands are soon abandoned for newly cleared plots. Only near the larger cities, where the land is greatly sub-divided, is the farmer obliged to use the same plot continuously. As the use of fertiliser is little known or practised, the results are much inferior to the almost spontaneous production from recently cleared forest land'.[44]

Like Antonil, Taunay attempted to classify the soil types found in Brazil, dividing them into three basic classes: heavy clays (*massapê*), sandy/clay (*salões*) and sandy soils, and he remarked that the sugar-mill owners considered the latter soil to be very weak.

Taunay wrote that the sandy soils 'produced almost nothing, but under the influence of the '*meteoros*' and of the atmosphere, vegetation could progressively cover these lands and make them appropriate for cultivation'.

Studying Taunay's Manual I: The role of atmospheric nutrients in tropical agriculture

The colonial literature frequently alludes to fertility derived from the '*meteoros*' and the '*adubos meteóricos*'. Taunay is no exception. The terms 'meteoros' and 'adubos atmosféricos' (atmospheric fertilisers) appear in the pages of his book as a source of renewed fertility for the soil. That the rains make soil fertile is an old conviction. Such lore can be found in many of the Portuguese and European manuals of Early Modern times and are also documented for Classical antiquity, e.g. in the works of Columella (first century C.E.). In a section of the previously mentioned book *Memórias de agricultura premiadas em 1787 e 1788*, the role of nutrients derived from the atmosphere is emphasised: 'rainwater is best for the soils as it gathers all the atmospheric fertilisers (adubos atmosféricos), especially those that originate from lightning'.[45] The Marquis of Abrantes recommended planting trees in pits opened a full month before planting, so that they could 'receive during that interval the benefits derived from the atmosphere'.[46]

The beneficial influence of atmospheric precipitation can be attributed to nutrients deposited in the form of dust, aerosols and above all rainfall that, in tropical systems with very poor soils, can represent a significant source of nutrients. One study undertaken in an area of Atlantic Coastal Forest (situated near the farm plots of a traditional population) compared the uptake of nutrients into that ecosystem by way of two vectors: a) the production of leaf litter; and b) by rainfall and dry deposition.[47] In this study, rain and litter production were monitored over one year, and samples were collected for chemical analyses. The

total input amount of these nutrients is shown in Table 1; Figure 3 compares the percentages of nutrient input from leaf litter and from the atmosphere.

Table 1. Total input of nutrients from leaf litter and from atmospheric sources at Ilha Grande, Rio de Janeiro (values in $kg.ha^{-1}yr^{-1}$). [45]

	N	P	K	Na	Ca	Mg
leaf litter input	105,0	1,5	25,1	17,6	269,9	49,7
atmospheric input	3,6	6,6	100,1	115,1	13,0	97,2

Figure 3 shows that these atmospheric inputs are quite significant for the nutrient balance within the ecosystem, whether for native forests or for any type of agriculture practiced there. In situations of low soil fertility, as in the majority of the soils in the Atlantic Coastal Forest, these inputs mattered for agricultural production. An old claim by agricultural writers proves to be particularly true under tropical circumstances. We have no means to tell if the Brazilian writers emphasised the importance of rainfall due to practical experience or due to adherence to tradition, but in their agro-systems, rainfall did indeed have measurable effects.

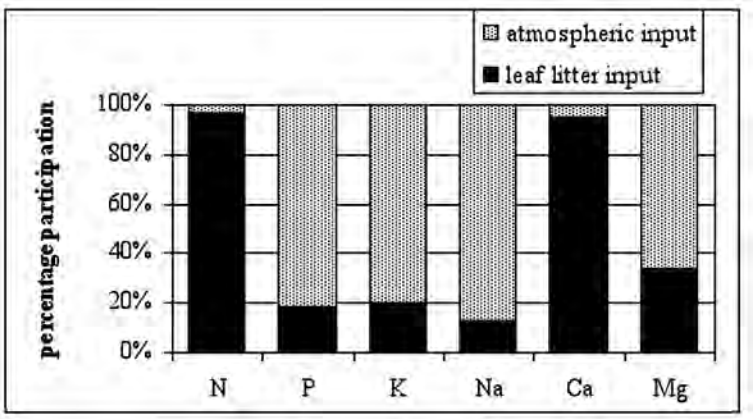

FIGURE 3. Distribution of the percentage of nutrient input from leaf litter and from atmospheric sources in the Atlantic Coastal Forest ecosystem for the elements Nitrogen, Phosphorus, Potassium, Sodium, Calcium and Magnesium. All but Sodium are among the seven main plant nutrients. [45]

Studying Taunay's Manual II: Soil erosion

Taunay was also intimately familiar with the problem of soil erosion in coffee plantations. His plantation was situated in the Maciço da Tijuca, Rio de Janeiro, a very steep landscape, with topographic gradients varying between 30 and 50 per cent.[48] According to him, the loss of humus in unprotected soils was responsible for transforming the soil in *caput mortuum*. Taunay was the first author to recommend planting coffee along hill contours, which was due to an influence, he revealed, of Dutch farming technology at their Asian colonies. Up until that time coffee had been planted in vertical lines on hillsides, a technique that increased erosion but was favoured because it allowed better oversight of the slaves. According to Taunay in some plantations where coffee bushes had been planted randomly, the erosion was avoided. Those farmers who did not plant their coffee plants in regular spacing and alignment did so to avoid having the soil washed off the roots by the rains. But this was an exception. A new front was opened up for the occupation and alteration of the Atlantic Coastal Forest biome. In contrast to sugarcane, coffee was generally planted on hill slopes, principally in the extensive Paraíba do Sul river valley (the largest drainage basin in southeastern Brazil), thus initiating an erosion cycle of enormous proportions. A study on sedimentation in an auxiliary water shed region of the Paraíba River, for example, indicated that during the Pleistocene-Holocene transition (13,000 to 8,000 B.P.) the sedimentation rate there was approximately 300 m^3/year; but

FIGURE 4. Gully and sheet erosion in a slope of Rio de Janeiro State where coffee plantations were established in the nineteenth century. [Photo R.R.Oliveira.]

during just 100 years of coffee cultivation (from 1830 to 1930) the deposition rate in the same location had more than doubled, to almost 750 m^3/year.[49] This cycle of deforestation and erosion on an enormous scale created entire landscapes of infertile and eroded lands without any forest cover. The lack of erosion control in colonial coffee farming had led to a regional landscape of eroded lands with severe gully and sheet erosion problems (Figure 4).

THE MANUAL OF PATI DO ALFERES: THE USE OF INDICATOR PLANT SPECIES

The extent to which the agricultural manuals were acquired and read by contemporary plantation owners is hard to ascertain. But at least one manual, written by the Baron of Pati do Alferes in 1847 could be considered a best-seller of its time. The first edition was sold out in less than a year and it was followed by four other editions. This work explained how a plantation should be established and administered. It covered techniques useful for cultivating a large number of crops, and provided information concerning animal husbandry. At the end of the book there are some studies from different authors concerning the characteristics and methods of cultivation of a number of crops, such as tea, indigo, cotton and coffee. This was the first agricultural manual derived from experiences accumulated during the boom in coffee cultivation. As in the case of sugarcane, the coffee plantation owners depended on the continuous availability of workers and on virgin lands that could be incorporated into the production process. The Baron was also worried about soils and was the first author to recommend the use of intercropping of coffee with other species like castor oil plant (*Ricinus communis* L.) or *melão de S. Caetano* (*Momordica charantia* L.) as a protection against long dry spells. [50]

In comparison with earlier authors he also demonstrated considerable knowledge of the Atlantic Coastal Forest.[51] In one of the book's chapters he offered a list of the native species and their farm uses (fashioning struts, roof wood, water wheels, planks for doors and windows, etc.). Although he did not have the botanical knowledge of Velloso, he had a great deal of practical experience. This empirical bent is noticeable in the way this author recognised the quality of the soils and the species that grew on them:

> O conhecimento das terras boas ou más é sem dúvida um grande alcance em que está o lavrador a outro meio que as não conhece. As terras apreciam-se avistando as suas florestas ao longe, e principalmente nos meses da primavera. A folhagem de seus arbustos, a configuração de seus galhos, a altura deles, faz distinguir a sua qualidade nessa distância. Entrando em suas matas, ao primeiro golpe de vista conhece-se pela madeira a qualidade da terra, se boa, se média ou má. [Recognising good or poor soils is without doubt a great advantage to the farmer who can, in relation to one who cannot. The lands reveal themselves through their

TABLE 2. Indicator species for land quality according to the Baron of Pati do Alferes (list compiled and correlated to modern scientific names by R.R.O.).

old vernacular name	scientific name	family	habitus
good soils			
óleo vermelho**	*Myroxylon peruiferum* L.f.	Leguminosae	arboreal
jacarandatã *	*Machaerium pedicelatus* Vogel	Leguminosae	arboreal
guarabú	*Goniorrhachis* sp	Leguminosae	arboreal
guararema *	*Gallesia integrifolia* (Spreng.) Harms	Phytolaccaceae	arboreal
guarapoca *	*Raputia magnifica* Engl.	Rutaceae	shrub
canela-sassafrás*	*Ocotea pretiosa* (Nees) Mez	Lauraceae	arboreal
cedro	*Cederela fissilis* Vell.	Meliaceae	arboreal
jequitibá *	*Cariniana legalis* (Mart.) Kuntze and *C. estrelensis* (Raddi) Kuntze	Lecythidaceae	arboreal
laranjeira *	*Sloanea monosperma* Vell.	Elaeocarpaceae	arboreal
arco de pipa **	*Erythroxylum pulchrum* A. St.-Hil.	Erythroxylaceae	shrub
pau-paraíba **	*Schizolobium parahyba* (Vell.) S.F. Blake	Leguminosae	arboreal
canela de veado **	*Senepheldera multiflora* Mart.	Euphorbiaceae	arboreal
sucupira	*Boldichia* sp	Leguminosae	arboreal
tenguassiba **	*Zanthoxylum rhoifolium* Lam.	Rutaceae	arboreal
medium soils			
peroba *	*Aspidosperma polyneuron* Müll. Arg.	Apocynaceae	arboreal
cabiúna *	*Machaerium incorruptibile* Allemão	Leguminosae	arboreal
canjerana **	*Cabralea canjerana* (Vell.) Mart.	Meliaceae	arboreal
canela de brejo **	*Nectandra lanceolata* Nees	Lauraceae	arboreal
canela preta **	*Nectandra membranaceae* (Sw.) Griseb.	Lauraceae	arboreal
canela cheirosa *	*Ocotea corymbosa* (Meisn.) Mez	Lauraceae	arboreal
ipê	*Tabebuia* sp	Bignoniaceae	arboreal
taquaracaú **	*Guadua tagoara* (Nees) Kunth	Poaceae	herbaceous
taquarapoca **	*Merostachys riedeliana* Rupr.	Poaceae	herbaceous
poor soils			
tapinhoã *	*Mezilaurus navalium* (Allemão) Taubert ex Mez	Lauraceae	arboreal
bicupari *	*Garcinia gardneriana* (Planch. & Triana) Zappi	Guttiferae	arboreal
milho-cozido	*Licania* sp		arboreal
negro-mina **	*Siparuna apiosyce* (Mart. ex Tul.) A. DC.	Monimiaceae	shrub
caeté	*Calathea* sp	Marantaceae	herbaceous
taqura-de-lixa	*Merostachys* sp	Poaceae	herbaceous

* species normally associated with climax forests

** species that occur in secondary forests

> forests when seen from afar, principally in the months of spring. The foliage of the shrubs, the configuration of the branches, their height, all reflect their quality even from a distance. Entering into the woods, at first glance one can recognise in the trees the quality of the land, whether it is good, medium, or poor.][52]

By examining the common plant names published in the Baron of Pati do Alferes' book, it was possible to gain a fair idea of the tree species to which he referred, although one has to take into account that popular names change over time and are different in different regions. Based on published studies of the modern flora in the region of the mid-Paraiba valley, it was possible to identify with some precision the modern species designation of the Baron's list. A large majority of the references are to trees, followed by shrubs and herbs. It was not possible to detect a pattern of successional classification among these plants, as the species mentioned as soil indicators by the Baron of Pati do Alferes can occur in both climax and secondary forests.[53] It is not frequent to find quotations or direct references to particular species of plants in the colonial and post-colonial agronomic literature and Baron of Pati do Alferes shows a great familiarity with the Brazilian flora. He describes also the best woods to be used as furniture, houses and rural machines. Even a botanist like Velloso did not make such association (flora and quality of soils) and referred to the plants in an unspecific way in his treatise of agronomy. Probably the use of this association is an appropriation of native knowledge. But more than a simple list of bioindicators or useful species, Baron of Pati do Alferes refers to them as values to be preserved from destruction.

The use of indicator plants to judge soil quality adapts, for the first time in Brazilian agricultural manuals, a tradition that reaches back to ancient Rome. Columella, as well as Pliny and Cato presented lists of plants useful for this purpose.[54] In their work, as in Pati do Alferes, many species that occur in pristine environments were used to distinguish between fertile and infertile soils.

CONCLUSION

To sum our findings up, the writers presented here are in agreement with regard to the threatened fertility of Brazilian soils, in spite of the recurrent topical invocation of the new world being a green paradise. As all the works were written in the context of colonial politics, such statements of concern about soil fertility, which differed from the official perception, have to be evaluated as departures from it, and hence as inherently political.

A majority of the authors attempted to establish classification systems for the foreign soils they encountered. Most of them were using the system that the Jesuit Antonil had developed or taken from native informants. Later, many authors used systems of soil classification based on this threefold system (*massapê*, *salão* and *areisca*) or similar to it. [55] It is important to note that this system

of soil classification does not in any way resemble European classifications. A number of authors tried to understand the natural and artificial processes involved in soil fertility and prescribed procedures to increase it. The use of cattle manure, ashes, marl, the influence of the 'meteoros' and the 'atmospheric fertilisers' appears recurrently in most colonial manuals.

Colonial plantation agriculture, both for sugarcane in the earlier days and later for coffee, had detrimental effects on Brazilian ecosystems. In contrast to a dire reality, viewing the tropical land as paradisiacal was deeply engrained in the coloniser's perception, and was in compliance with the wishes of the crown. Most of the agricultural authors of the colonial period, such as Velloso, the Marquis of Abrantes, Taunay, and the Baron of Pati de Alferes are good examples of the ambivalence between edenic pretension and the requirements of practical recommendation. Local, if not indigenous, knowledge did permeate the coloniser's view of the world. The threefold distinction of soils which Antonil had first presented was obviously developed not through recourse to classical European agricultural literature, but inferred from local experience. Although the introductions of many works reproduce the colonial ideal, the main body of the texts does not. All of them were very concerned with the preservation of forests. The authors clearly perceived that the production systems of sugar or coffee cultivation could not be maintained indefinitely if the forests were destroyed. While claiming erudition and making recourse to European knowledge, the authors – out of their practical experience – understood that there was a clear relationship between forest conservation, soil fertility, and the maintenance of water resources. In this respect, the Brazilian colonial agronomic literature constitutes a first instance of insight into the need of preservation of Brazil's biodiversity against the devastation wrought by colonial exploitation.

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[3] Carlos Augusto Taunay, *Manual do Agricultor brasileiro*; ed. Rafael de Bivar Marquese (São Paulo: Companhia das Letras, 2001), 33 (original edition 1839).

[4] See e.g. Warren Dean, *A ferro e fogo: a história e a devastação da Mata Atlântica brasileira* (São Paulo, Companhia das Letras, 1996). The original edition of this book is Warren Dean, *With Broadax and Firebrand: The Destruction of the Brazilian Atlantic Forest* (Berkeley: University of California Press, 1995).

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[29] Antonil, *Cultura e opulência do Brasil,* 101 – 2.

[30] Antonil, *Cultura e opulência do Brasil,* 105 – 7.

[31] Antonil, *Cultura e opulência do Brasil,* 115.

[32] Williams, *Deforesting the earth*, 350–1.

[33] Velloso was also an important botanist and the director of the publishing house *Regia Officina Typographica, chalcographica, tipoplastica e Litteraria do Arco do Cego* in Lisbon. His most famous scientific work is the *Flora Fluminensis* (1825), a substantial publication with three volumes of text and fifteen volumes of copper plates. This publication comprises descriptions of seventeen hundred species, many of them previously unknown to science.

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[35] Velloso, *O Fazendeiro do Brazil*, tome 1, 16-9.

[36] Velloso, *O Fazendeiro do Brazil*, tome 1, 10-2.

[37] Velloso, *O Fazendeiro do Brazil*, tome 1, 22.

[38] Velloso is refering to these two exotic Graminae (=Poaceae): *Imperata brasiliensis* Trin. (sapê) and *Tristachya leiostachya* Nees. (capim seta), species that are typical for degraded lands.

[39] Velloso, *O Fazendeiro do Brazil*, tome 1, 28.

[40] Velloso, *O Fazendeiro do Brazil*, tome 1, 27–8.

[41] Velloso, *O Fazendeiro do Brazil*, tome 1, 37.

[42] They are: André João Antonil, *Cultura e opulência do Brasil*. (Rio de Janeiro: Typ. Imp. e Const. de J. Villeneuve, 1711. (Velloso's 1837 edition of this book); Frei José Mariano da Conceição Velloso, *O Fazendeiro do Brazil – melhorado na economia rural dos gêneros cultivados e de outros, que se pode introduzir, e nas fábricas que lhe são próprias, segundo o melhor que se tem escrito a este assumpto* (Lisboa: Regia Officina Typografica, 1743); Baltazar da Silva Lisboa, *Discurso histórico, político e econômico, e estado atual da filosofia natural em Portugal, acompanhado de algumas reflexões sobre o Estado do Brasil*. (Lisboa 1786); João Rodrigues de Brito, *Cartas econômico-políticas sobre a agricultura e comércio na Bahia*. (1st. ed.: 1821, Salvador, 1985); Miguel Calmon Du Pin de Almeida (Marquês de Abrantes), *Ensaio sobre o fabrico do açúcar* (Salvador: Tipografia do Diário, 1834); Jean-Baptiste Alban Imbert, *Manual do fazendeiro ou tratado doméstico sobre as enfermidades dos negros* (Rio de Janeiro: Typ. Nacional e Const. De Seignot-Plancher e Cia., 1834); João Joaquim Ferreira de Aguiar, *Pequena Memória sobre a Plantação, Cultura e Colheita do Café* (Rio de Janeiro: Imprensa Americana, 1836); Carlos Augusto Taunay, *Manual do agricultor brasileiro*; organização Rafael de Bivar Marquese (1839) (São Paulo: Companhia das Letras, 2001); Agostinho Rodrigues Cunha, *Arte da Cultura e Preparação do Café* (Rio de Janeiro, Typ. Universal de Laemmert, 1844; Francisco Peixoto de Lacerda Werneck (Barão de Pati do Alferes), *Memória sobre a fundação de uma fazenda na província do Rio de Janeiro* (Rio de Janeiro: Fundação Casa de Rui Barbosa. Original edition: 1847); Carlos Augusto Taunay and Antônio Caetano da Fonseca, *Tratado da cultura do algodoeiro ou arte de tirar vantagens dessa plantação* (Rio de Janeiro, 1862); Frederico Leopoldo Cesar Burlamaqui, *Monographia do Cafeeiro e do Café* (Rio de Janeiro, Typ. N. L. Vianna e Filhos, 1860); Antônio Caetano da Fonseca, *Manual do agricultor de gêneros alimentícios* (Rio de Janeiro: Ed. Eduardo & Henrique Laemmert, 1863).

[43] Taunay, *Manual do agricultor brasileiro*, 44.

[44] Taunay, *Manual do agricultor brasileiro*, 44–5

[45] Constantino Botelho de Lacerda Lobo, 'Quais são os meios mais convenientes de suprir a falta de estrumes animais nos lugares onde é difícil havê-los', in *Memórias de agricultura premiadas em 1787 e 1788, Academia Real de Ciências* (Lisboa: Oficina da Academia Real de Ciências, 1788).

[46] Almeida, *Ensaio sobre o fabrico do açúcar*, 97.

[47] Rogério Ribeiro de Oliveira and Ana Luiza Coelho Netto, 'Captura de nutrientes atmosféricos pela vegetação na Ilha Grande, RJ', *Revista Pesquisas* (2001): 31–49.

[48] Manoel do Couto Fernandes; André de Souza Avelar and Ana Luiza Coelho Netto, 'Domínios Geo-Hidroecológicos do Maciço da Tijuca, RJ: Subsídios ao Entendimento dos Processos Hidrológicos e Erosivos', *Anuário do Instituto de Geociências – UFRJ* 29 (2006): 120–146.

[49] Marcelo Dantas and Ana Luiza Coelho Netto, 'O Impacto do Ciclo Cafeeiro na Evolução da Paisagem Geomorfológica do Médio Vale do Rio Paraíba do Sul', *Cadernos de Geociências*, 15 (1995): 65–72.

[50] Barão de Pati do Alferes / Luiz Peixoto de Lacerda Werneck, *Memoria sobre a fundação e costeio de uma fazenda na província do Rio de Janeiro* (Rio de Janeiro: Eduardo & Henrique Laemmert, 1878): 201–2.

[51] José Augusto Pádua, '"Cultura esgotadora": agricultura e destruição ambiental nas últimas décadas do Brasill Império', *Estudos Sociedade e Agricultura* (1998): 134–63.

[52] Barão de Pati do Alferes, *Memória sobre a fundação de uma fazenda*, 96–8.

[53] Gilson Roberto de Souza, *Florística do estrato arbustivo-arbóreo em um trecho de floresta atlântica, no médio Paraíba do Sul, município de Volta Redonda, Rio de Janeiro* (Rio de Janeiro: Universidade Federal Rural do Rio de Janeiro, 2002).

[54] Verena Winiwarter, 'Prolegomena to a History of soil knowledge in Europe', in John McNeill and Verena Winiwarter (eds.), *Soil and Societies: Perspectives from Environmental History* (Cambridge: White Horse Press, 2006): 177–215.

[55] The authors that used this or a similar system were: Taunay, *Manual do Agricultor brasileiro,* 1839; Barão de Pati do Alferes, *Memória sobre a fundação de uma fazenda*, 1847; Almeida, Ensaio sobre o fabrico do açúcar, 1834; Taunay and Fonseca, *Tratado da cultura do algodoeiro,* 1862.