

# OPEN SPACES AND AFFORESTATION: AN ANALYSIS OF THE SUBURBAN RAILWAY OF RIO DE JANEIRO

*ESPAÇOS LIVRES E ARBORIZAÇÃO:  
UMA ANÁLISE DO SUBÚRBIO FERROVIÁRIO DO RIO DE JANEIRO*

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## ABSTRACT

The Rio de Janeiro railway suburb (Planning area 3 – AP3) has the highest population concentration, number of households and demographic density in the city, as well as the highest number of residents in precarious conditions. Furthermore, this area is negatively marked by intense land occupation, mostly irregular, and subsequent lack of public open spaces. In this context, our research used a multi-method analysis for identifying, quantifying and categorizing the open spaces and afforestation in Rio de Janeiro railway suburb neighborhoods. In a consolidated area such as AP3, which is densely occupied and has high average temperatures, private and public open spaces and their afforestation are important to regulate the microclimate, compensating for the poor local urban infrastructure. The analysis highlights the importance of preserving the vegetation in the open spaces system, showing how those spaces can be used as an important tool for future urban planning actions, in collaboration with public policies for improving the landscape.

Keywords: Open Spaces. Afforestation. Railway Suburbs. Urban Morphology. Rio de Janeiro.

## RESUMO

O subúrbio ferroviário da Cidade do Rio de Janeiro, localizado na Área de Planejamento 3, possui a maior concentração de população, número de domicílios e densidade demográfica dentre as áreas de planejamento da cidade, assim como o maior percentual de residentes em assentamentos precários. Destacam-se ainda, a elevada ocupação do solo e a consequente carência de espaços livres públicos. Este artigo busca apresentar a análise multi-métodos de identificação, quantificação e categorização dos espaços livres e da arborização existentes nos bairros do subúrbio ferroviário carioca. Em uma região consolidada, altamente adensada e caracterizada por elevadas médias de temperatura, o sistema de espaços livres públicos e privados e a arborização se apresentam como importantes elementos para melhoria do microclima, atuando, de maneira compensatória, às deficiências existentes na estrutura urbana local. Espera-se que tal análise possa ser instrumento útil e capaz de evidenciar a relevância da vegetação no sistema de espaços livres, agindo de forma colaborativa com as políticas públicas de gestão do território e de qualificação da paisagem.

Palavras-chave: Espaços Livres. Arborização. Subúrbio Ferroviário. Morfologia Urbana. Rio de Janeiro.

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## 1. RAILWAY SUBURBS IN RIO DE JANEIRO

In the original sense of the suburb, this geographic space is considered a territory located on the margins or in areas peripheral to the city. It is space produced next to the city but, due to its geographical location, types of construction and uses are dissociable from space considered urban (FERNANDES, 2011). In the city of Rio de Janeiro in the 19th century, the suburbs were occupied by large estates of religious or private property, belonging to the orders of the Catholic Church or to the owners of mills and farms, mostly heirs of the hereditary captaincies, determined in the 16th century. After the arrival of the Portuguese Crown in 1808 and the expulsion of the Jesuit priests, who held large parcels of land in the then Province of Rio de Janeiro, control of these lands reverted to the Crown and to wealthy members of the Portuguese Court. Until the late 19th century, suburban regions, far from the center of urban settlement, served as areas of agricultural production and housing for members of the upper and middle classes, who lived on farms and in mansions and who were able to transport themselves to the central regions. It was only in the early 20th century, with population densification and parceling out of lots for residential purposes, that more widespread, affordable occupation occurred on the perimeter of the formal city (FRIDMAN, 1999).

The period between 1870 and 1920, then, was characterized by the first phase of accelerated expansion of the urban network in Rio in qualitatively different directions (Figure 1). The railways and tram lines were potential inducers in the occupation of this territory, which until then was remote and inaccessible to a large part of the population. "In the hundred years from the mid-19th to the mid-20th century, certain areas became familiar with the implementation of technical means, mechanized means, altering the definition of the space and modifying the conditions of its use" (SANTOS, 2008, p. 48).

The trains began to serve areas still poorly integrated into the city, which were then open to those who could afford to live outside the central area, but could not

afford the already high costs of land in Glória, Botafogo or Tijuca; the trams, on the other hand, enabled the increasing exodus of those who could bear the costs, but remained in the center due to the lack of fast, regular means of transport (ABREU, 2013, p. 43).

The birth of the Rio de Janeiro railway suburb was directly influenced by the creation of the Central Railway of Brazil (EFCB), the first stretch of which was inaugurated in 1858. With the steam engine operating and the first surge in manufacturing in Brazil, from 1880, factories which were previously located in more distant regions began to approach the urban area of the city, installed in suburbs, such as Tijuca, São Cristóvão, Engenho Novo and Bangu, along the railroad (ABREU, 2013). The passenger transport service provided by Rio's trains was implemented around 1870 and underwent its greatest period of expansion up until 1930 (LINS, 2010).

As it is the line that initially transported passengers, the D. Pedro II Railway, nowadays known as EFCB (highlighted in yellow in Figure 2), was the most influential on occupation of the territory at that time, being a structuring axis and vector of residential growth of the railway suburb, principally in areas around train stations. According to Abreu (2013), the inauguration of the first stretch of the D. Pedro II Railway, which connected the parish of Santana to Queimados, and the inauguration of Cascadura and Engenho Novo stations, immediately encouraged the occupation of the space between the stations and the city center. The suburbs of the Branch Line, Rio d'Ouro and Leopoldina branches (in orange, blue and red, respectively) were driven by industrial activity and the process of intensifying occupation in these regions was late and therefore differentiated.

The identity between suburb and rail transport is so striking that studying these areas requires very detailed examination. In the city of Rio de Janeiro, in particular, where there is no train, areas are not known as suburbs, even if they are in peripheral areas, endowed with characteristics specific to the term. Such specificity of the idea of a suburb, in Rio de Janeiro, only arose when it began to be defined by three basic notions: "the train as a means

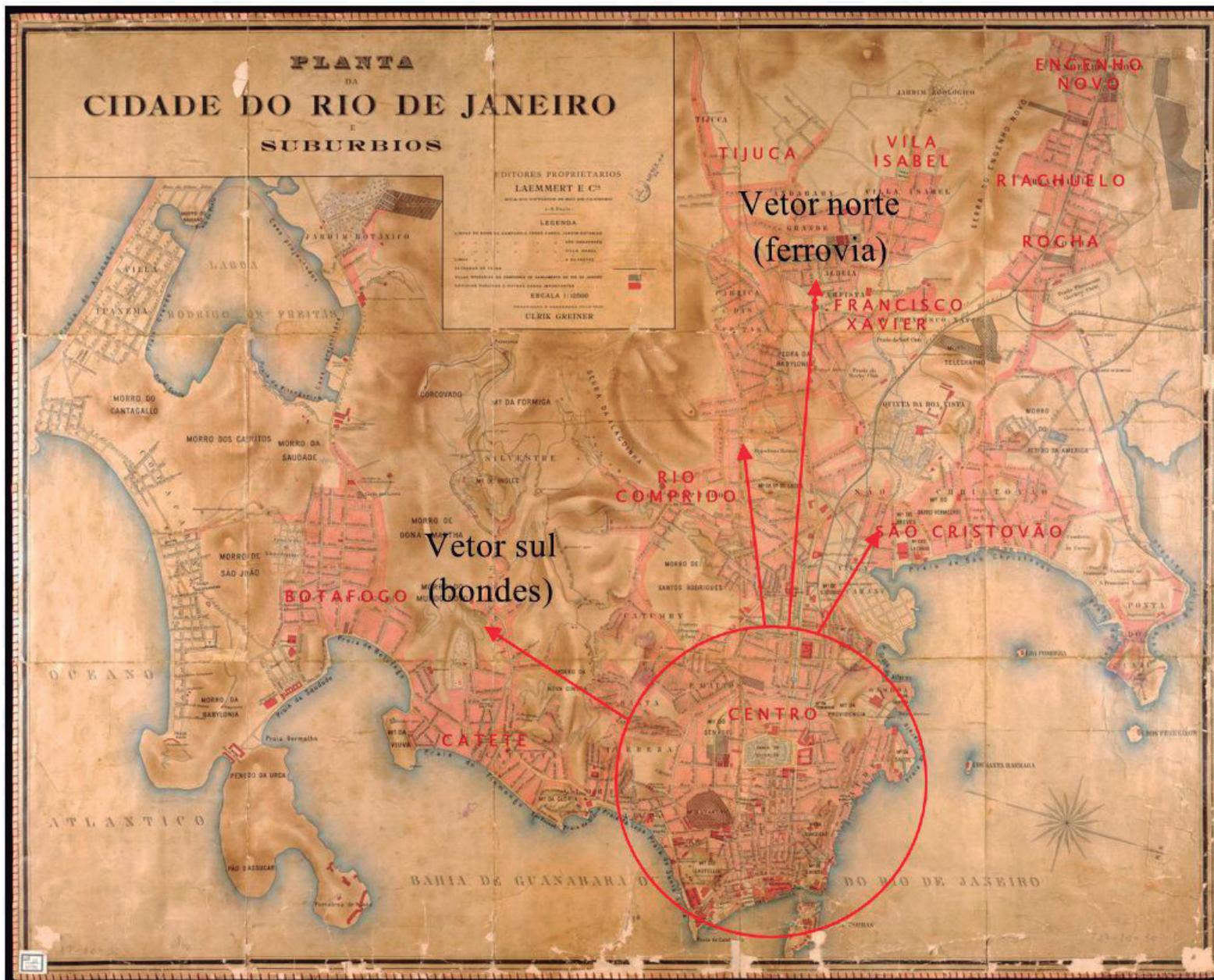


Figure 1 – Plan of the City of Rio de Janeiro and the appearance of the suburbs. Garriga, Antônio José Fausto  
 Source: National Library Digital Collection. Adapted by the author.

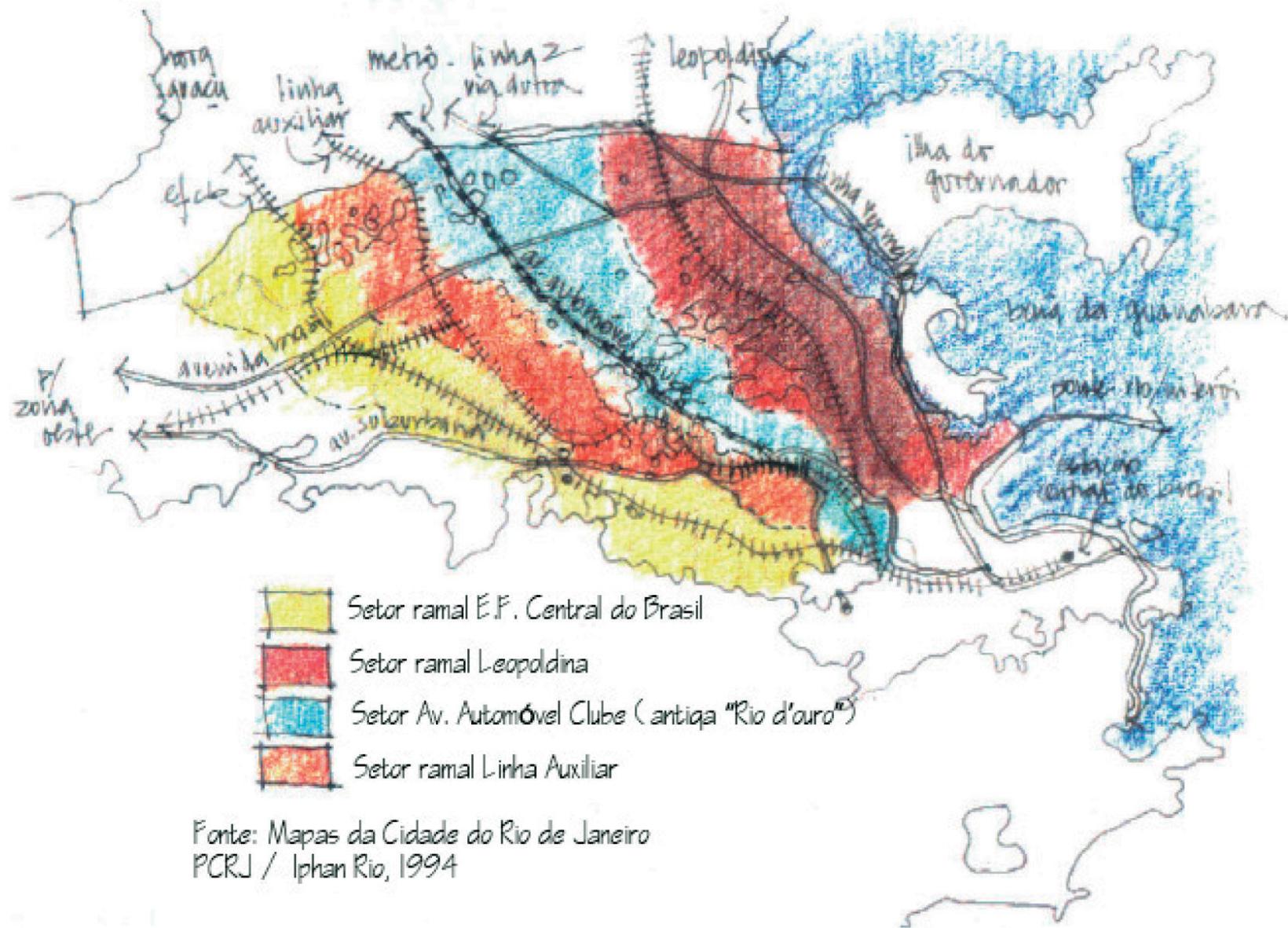


Figure 2 – Sketch of the railway sectors in Rio de Janeiro.  
Source: TÂNGARI, 1999, p. 252.

of transport, the predominance of the disadvantaged population and dependence and close, frequent relations with the City Center” (SOARES, 1960 apud FERNADES, 2011, p. 37). Fernandes (2011) sees in this “ideological kidnapping” justification for the construction of a negative and disqualifying view of the railway suburb, as, according to the author, in the mid-19th century, railway suburbs appeared as wholesome places from the environmental point of view, endowed with atmospheres strongly suited to their occupation, in a city with major infrastructure problems in its urban center.

### 1.1 TRANSFORMATION OF THE SUBURBAN LANDSCAPE

Given the historical account of the conformation of the peripheral territory to the city center of Rio de Janeiro, it is clear that the character of the railway suburb, at its genesis, was completely different than that it presents nowadays. Not only was it perceived differently, but it also had very different land occupation structure and territorial characteristics (Figure 3). It is worth identifying at what point in the city’s history these drastic changes occurred.

Based on the reforms initiated by Pereira Passos in 1903, in the urban molds of the French capital, a new spatial occupation organization emerged that would consolidate and corroborate suburban density. New neighborhoods emerged from settlements occupied by both workers and part of the poor population, now evicted from the old city center, due to the building work installed in that region, which aimed to “beautify” it. Without urbanistic standards and lacking an effective relocation policy, as described by Nestor Goulart dos Reis (1977, p. 53), “a spontaneous configuration of occupation took shape: poorly drawn rough earth streets, without curbs, were appearing everywhere. New constructions were made in inappropriate lots, lacking alignment”.



Figure 3 – Advertisements for the sale of lots in areas close to the railway track revealed the low built density and predominance of open spaces, with land located close to the railways considered a good investment. The image on the left dates from 1938, the images on the right from 1958. Source: [http://www.estacoesferroviarias.com.br/efcb\\_rj\\_linha\\_centro/efcb\\_linhadocentro\\_rj.htm](http://www.estacoesferroviarias.com.br/efcb_rj_linha_centro/efcb_linhadocentro_rj.htm); Accessed on: 18 Mar. 2020.

## MUNICÍPIO DO RIO DE JANEIRO: ZONEAMENTO INDUSTRIAL

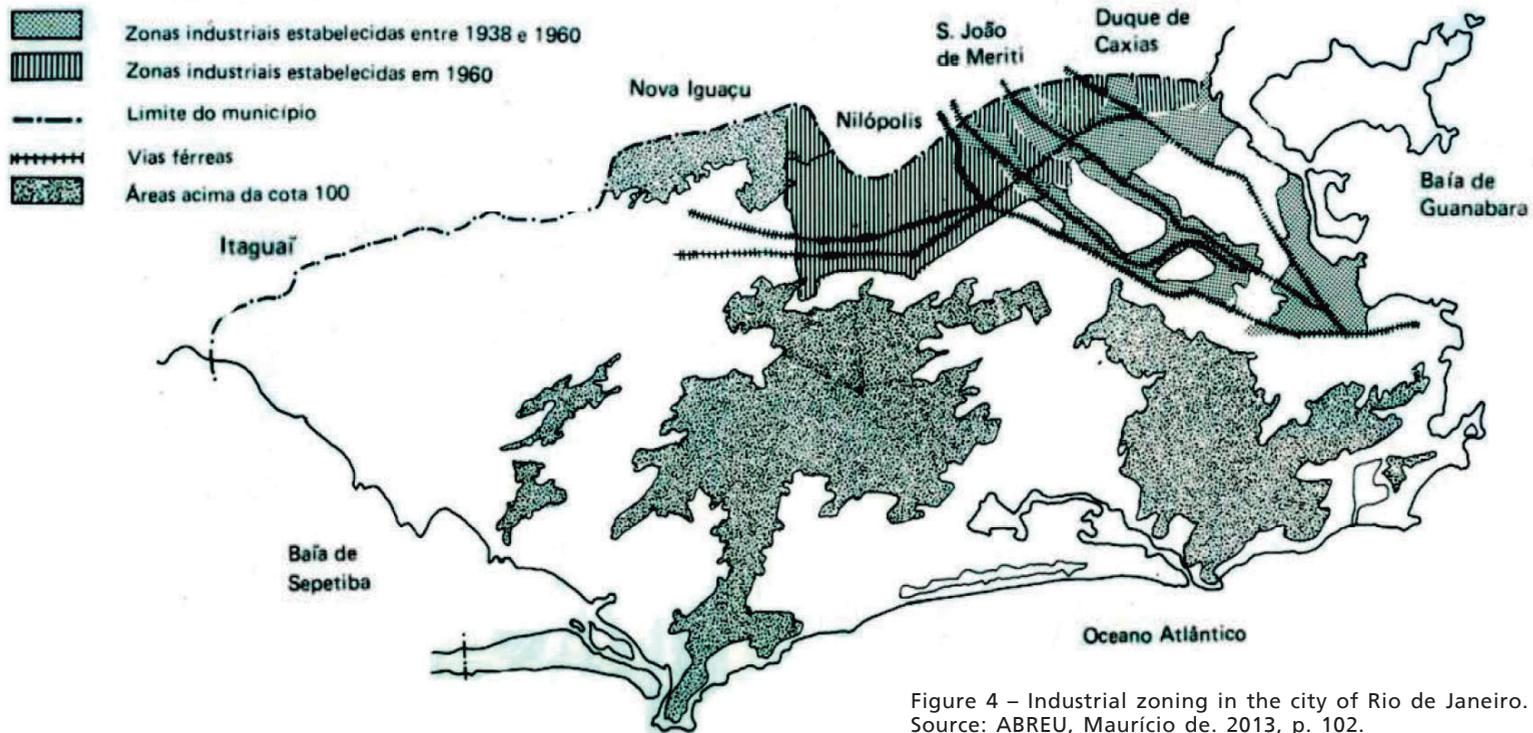


Figure 4 – Industrial zoning in the city of Rio de Janeiro.  
Source: ABREU, Maurício de. 2013, p. 102.

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The functionalist character of the suburbs was also able to influence urban plans developed for the city of Rio de Janeiro, such as the Agache Plan. French architect Alfred Agache, hired by then Mayor Antônio Prado Júnior, in the late 1920s, suggested adopting an urban policy favoring the construction of cheap housing in the suburbs<sup>1</sup>, which would also be endowed with a minimum of basic infrastructure. The plan, although not implemented in practice, made the dichotomy between bourgeoisie x proletariat in the city of Rio de Janeiro

official and in fact advocated the need to control the process of reproduction of the workforce, which would also ensure spatial separation of social classes (ABREU, 2013, p. 87).

<sup>1</sup> Suburbs, named "working-class neighborhoods" in the plan, provided only functional solutions, referring only to the expansion of the railway and subway systems, providing accessibility to employment centers located in the Central Zone of the City

In 1930, as a result of State action on sanitation policies and the ratification of Decree No. 6,000/1937, an industrial occupation process began in the suburban region of Rio de Janeiro. The Decree defined an industrial zone, in the north and northeast areas (Figure 4), excluding such use in the south and central areas of Rio de Janeiro, as these are far from the railway communication routes with São Paulo and Minas Gerais and from the main power lines. Prevented from expanding in these regions, industry then began to subdivide its old land, and settled definitively in the incentivized regions. Based on the industrial zoning, in the following decade the new areas presented vertiginous growth not only of industrial establishments but of population (ABREU, 2013).

## 1.2 PLANNING AREA 3 – AP3

From 1981, the need for sectorial division for coordination and planning in the City arose, leading to its compartmentalization, which became its current administrative base. At this moment, the institutional codification of administrative regions began when, for the first time, the limits of the neighborhoods were made official. In 1992, the Master Plan, created through Supplementary Law 16 of 1992, the so-called Ten-Year Master Plan, divided Rio de Janeiro into five Planning Areas, but continued to denominate a large strip flanking the railway lines as “suburban”. Only in 2011 did the City Hall replace the expression “suburban zone”, naming it Planning Area 3 (AP3), which was then included in one of the Macro-Planning Macro-Zones of the new Master Plan (Figure 5), named Master Plan for Sustainable Urban Development of the Municipality of Rio de Janeiro, ratified through Supplementary Law 111 of February 1, 2011.

AP3 corresponds to 16.6% (INSTITUTO..., 2011) of municipal territory, and is currently subdivided into 13 Administrative Regions (RA) which are sets of neighboring neighborhoods grouped by similarities in terms of their morphological and socio-environmental characteristics (Figure 6 ): Anchieta, Complexo do Alemão, Ilha do Governador, Inhaúma, Irajá, Jacarezinho, Madureira, Maré, Méier, Pavuna, Penha, Ramos and Vigário Geral.

AP3 also has the highest rates of population concentration, households and demographic density compared to other areas of the city. According to data from the 2010 census conducted by the Brazilian Institute of Geography and Statistics (IBGE), the region had 2,440,118 inhabitants (38% of the city’s total inhabitants), distributed among 8,608,310 households (36% of the total households in the city) with a gross population density of 119.91 inhabitants/ha (Figure 7).

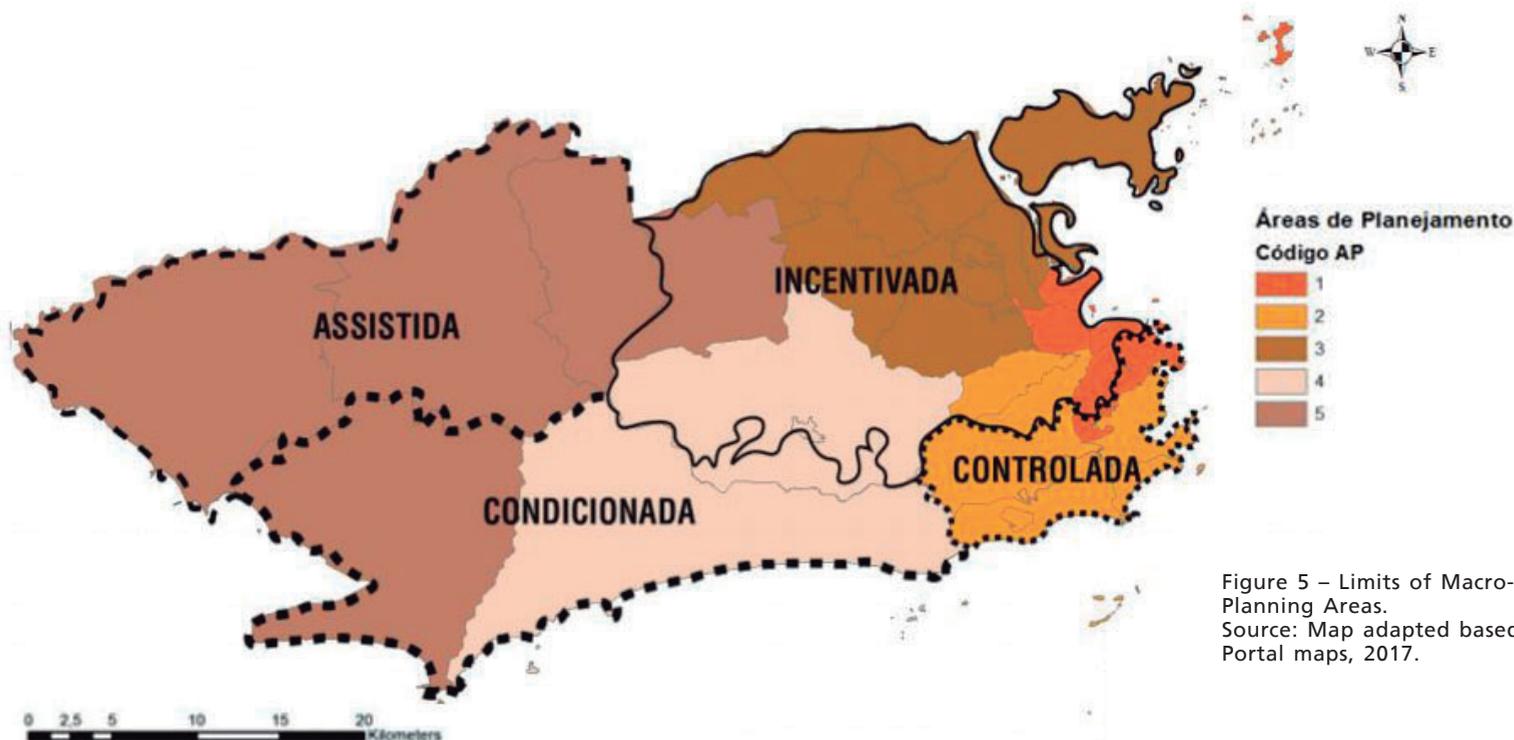


Figure 5 – Limits of Macro-zoning and Planning Areas.  
Source: Map adapted based on GeoRio Portal maps, 2017.

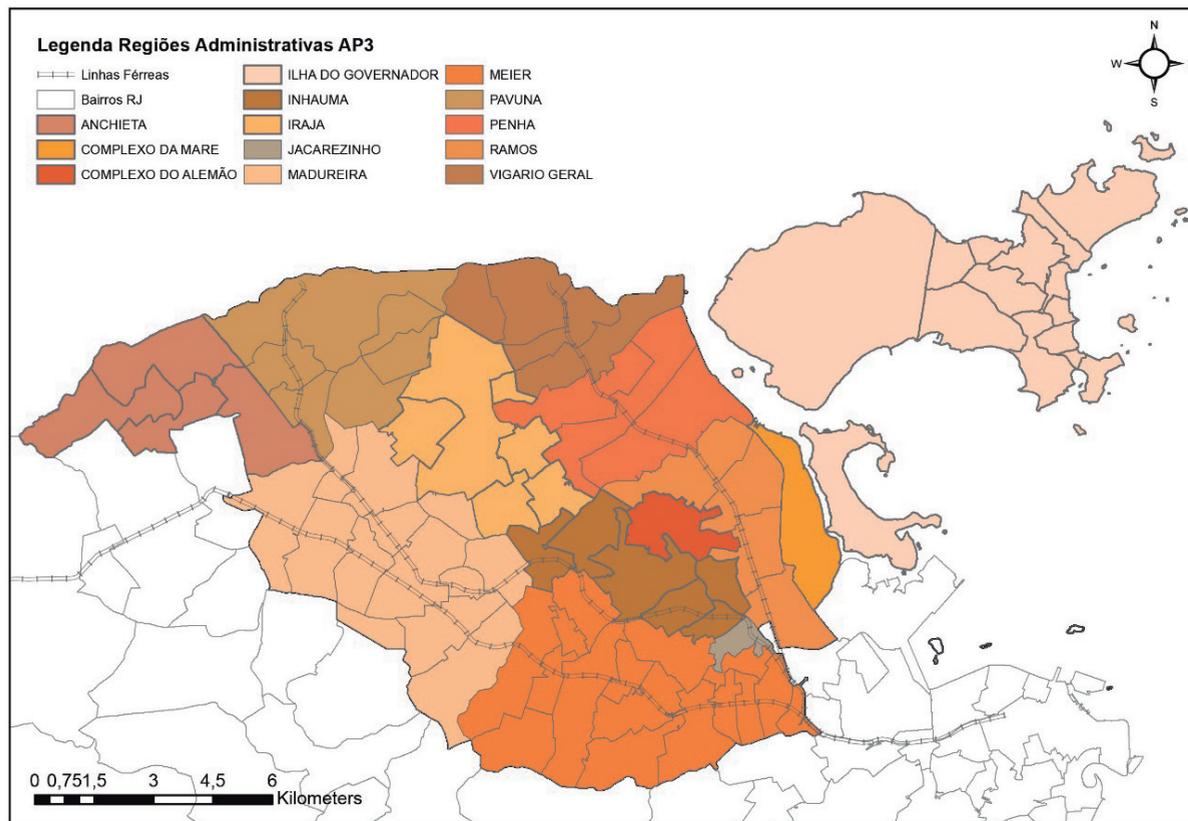


Figure 6 – Administrative Regions of AP3.  
Source: Map adapted based on Geo-Rio Portal maps, 2017.

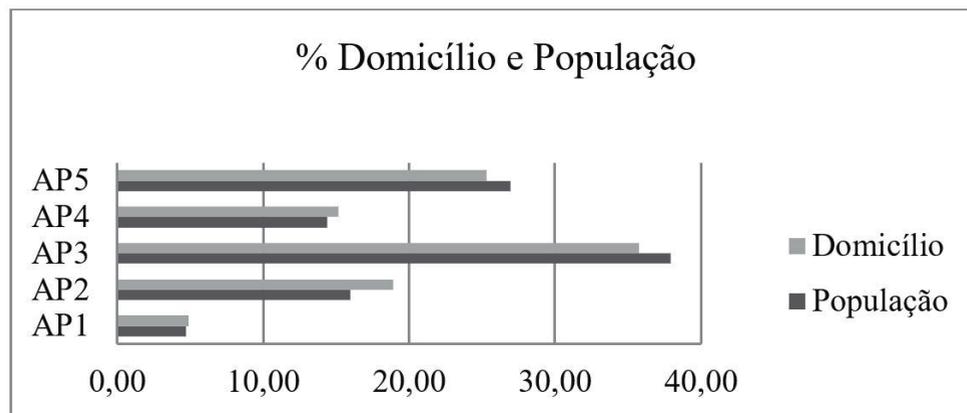


Figure 7 – Percentage of households and population by planning area .  
Source: Graph based on IBGE data (2011).

2 Percentage calculated by AP on the total value of households and population

The areas occupied by slums and illegal subdivisions are also evident. Regarding the proportion of the population living in slums, compared to the rest of the population, AP3 has the highest rate of residents in precarious settlements in relation to the total in the City - 45% (Table 1).

## 2. PROBLEM AND OBJECTIVE

Over the past 15 years, major territorial and social transformations have taken place in the city of Rio de Janeiro, as a result of cultural and sporting mega-events, such as the Pan American Games in 2007, World Youth Day in 2013, the Football World Cup in 2014 and the Olympic Games in 2016. In this context, significant urban and architectural reformulations, such as the implementation of express bus lanes, were responsible for transforming the landscape of the railway suburb (AP3), without, however, systematically taking into account the consequences of such changes and the wishes of the local population. Urban open space has been relegated to dealing with issues related to the circulation of vehicles and pedestrians, compromising the social and environmental character of this space, developing a landscape devoid of identity (SILVA, 2004 apud TANGARI et al., 2009, p. 21).

It is also noteworthy that, based on the premises of the urban legislation defined by the Macro-zoning of the Master Plan of the City of Rio de Janeiro, approved in 2011, AP3 was defined as an Incentivized Macro-zone, with incentives from the Municipal Government for verticalization. It is estimated that this morphological transformation of the urban fabric will take place through the replacement of single-family, one to two floor houses with backyards or wooded gardens, with multifamily buildings of more than three floors, which will in turn be established in lots where the residual open space can be gradually paved over for parking and leisure areas for the developments. Based on previous studies that proved changes in urban microclimate, driven by changes in urban legislation (BUENO et al., 2012; MONTEZUMA et al., 2014; TÂNGARI; CARDEMAN, 2016), the same effect is expected for AP3, accentuating the worsening of microclimate conditions related to increased temperatures and decreased humidity, in addition to the creation of new waterproof surfaces, already excessive in this region.

In view of the lack of studies portraying and qualitatively and quantitatively addressing the topic of open spaces and the presence of afforestation in this territory, this article seeks to introduce the multi-method analysis of identifying, quantifying and

Table 1 – Resident population in slums in the city of Rio de Janeiro. AP3 highlighted.

Áreas de Planejamento	População Residente			
	Cidade	Proporção	Favela	Proporção
Total	6.320.446	100%	1.443.773	100%
AP1 - Central	297.976	5%	103.296	7%
AP2 - Zona Sul	1.009.170	16%	174.149	12%
AP3 - Zona Norte	2.399.159	38%	654.755	45%
AP4 - Barra/Jacarepaguá	909.368	14%	236.834	16%
AP5 - Zona Oeste	1.704.773	27%	274.739	19%

Source: IBGE, 2011.

categorizing open spaces and afforestation in the railway suburbs in the city of Rio de Janeiro.

### 3. OPEN SPACES

Urban open spaces (EL) stand out in the city landscape and are closely related with the quality of life and the dynamics of occupation of the territory. According to Tângari (1999, p. 184), "by forming through the action of public and private agents, the city combines built on spaces and open spaces [...] both built and building-free spaces confer character and identify the city landscape." Queiroga and Benfatti (2007, p. 86) add the concept of open spaces as systems, emphasizing the character of connectivity and complementarity even though they were not thought of as such:

Urban open spaces constitute a complex system, given the interrelationship with other urban systems that can overlap with the open space system (built object system and its corresponding system of actions) or overlap, totally or partially, with regards action systems. In the latter case, it is particularly interesting to investigate the main interrelationships between the open space system and the public space system in Brazilian urban areas, to what extent the open space systems contribute to the production of the contemporary public sphere.

We can illustrate the most common free spaces in the urban environment, as defined by Magnoli (1982), as: backyards, public or private gardens, streets, avenues, squares, parks, rivers, forests, mangroves and urban beaches, or simple urban voids, which constitute a complex system with categories and types that vary in quantity and quality depending on the urban sector in which they are located in each city.

With regard to the city of Rio de Janeiro and, more precisely, the region of the railway suburb, the lack of open spaces becomes evident, especially those of a public nature (squares, parks and spaces for leisure and recreation in general), mainly as a result of

the high rate of land occupation and privatization (Figure 8). In 1999, in his doctoral research, Tângari found that only 8% of the total official public open spaces in the city of Rio de Janeiro were located in the northern part of the city, and their surface was less than 100 ha, while in the central and southern regions this approached 1,000 ha (TÂNGARI, 1999). Currently, the percentage of distribution of public open spaces in AP3 is 36%, in an area of 20,350 ha, lower than the percentage found in Planning Area 1 - 37%, the lowest of the planning areas of the City, approximately 3,440 hectares (Figure 9).

% Private Open Spaces x Territorial Size (ha)

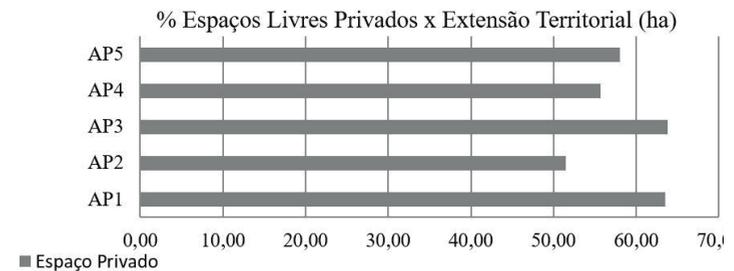


Figure 8 – Percentage of private open spaces by planning area. Source: Open Space Systems in Rio de Janeiro (SEL-RJ), 2017.

% Public Open Spaces xC Territorial Size (ha)

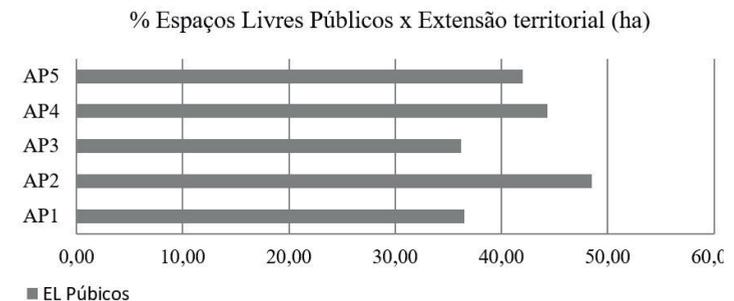


Figure 9 – Percentage of public open spaces by planning area. Source: Open Space Systems in Rio de Janeiro (SEL-RJ), 2017.

#### 4. URBAN AFFORESTATION

The term afforestation defines the act or effect of afforestation, which, in turn, represents the action of planting or decorating with trees and the word afforested is understood as a planted space or one full of trees (FERREIRA, 2010). It is also understood as the result of planting and maintaining trees, whether individually or in groups. Urban afforestation, on the other hand, is understood as the set of all trees and associated vegetation within a given urban area, be it a small populated nucleus or a large metropolis (MILLER, 2015). This category includes the tree mass found on streets, avenues, squares and parks; conservation and preservation units, as well as in private areas, remnants of natural or planted ecosystems.

The role played by afforestation in the configuration of urban spaces, is undoubtedly a point of great importance. Initially, aesthetic and beauty-related issues became more frequent with the conscious inclusion of afforestation in urban areas in 17th century Europe (PITT et al, 1979 apud FARAH, 1997). The styles that marked the history of open space projects, French in the 17th century and English in the 18th century, directly influenced not only the way of including the tree element in cities but also the design of open spaces, mainly from the 18th century onward, emphasizing the connection between landscaping and urban design (KOSTOF, 1991).

However, the true function of the tree element goes beyond the aesthetic issues originating in the 17th century or the hygienist



Figure 10 - High soil waterproofing and absence of afforestation in a section of the AP3 neighborhood. Source: SEL-RJ Archive, 2017.

policies of the 19th century, which highlighted the importance of the tree element, mainly responsible for the oxygenation of air in cities. Several authors attest to the importance of the plant element in an urban environment, in its geo-biophysical, cultural and environmental spheres, according to a recent publication on the role of native vegetation in landscape planning and design (BARRA et al, 2015). From the mid-19th century onwards, the importance of the presence of afforestation in cities started to be emphasized by several professionals and theorists in urbanism and landscaping, such as Sitte (1900 apud COLLINS; COLLINS, 2006), Lynch (1972) and Cullen (1999), which sought to portray not only the aesthetic benefits of afforestation, but also symbolic, psychological and emotional issues related to natural contributions to the urban landscape.

In this context, observing the climatic and geo-biophysical issues of the suburban region to the northwest of the city of Rio de Janeiro, where, in the summer, average maximum temperatures reach around 32.6°C<sup>3</sup>, the plant element gains prominence, together with other morphological elements of the urban space, due to its low incidence (Figure 10).

## 5. STUDY AREA AND METHODS

In view of the complexity of the suburban railway territory and its extensive geographic boundary, the research in question limited the analysis to only the neighborhoods included in the AP3 geographic boundary and which are characterized by more consolidated occupation, originally crossed by the EFCB, as illustrated in Figure 11. The study area selected for the research is traversed by approximately 17 km of the Central do Brasil railway line, and is subdivided into 16 neighborhoods. They are the neighborhoods of Marechal Hermes, Bento Ribeiro, Osvaldo Cruz, Madureira, Cascadura, Quintino, Piedade, Encantado, Engenho de Dentro, Todos os Santos, Meier, Engenho Novo Sampaio, Riachuelo, Rocha and São Francisco Xavier.

<sup>3</sup> Average maximum temperatures recorded between 20/12/2017 and 20/03/2018. Data collected at the Realengo station/Rio de Janeiro-RJ. Source: Data from the Network of the National Meteorological Institute (Inmet). Available at <http://tempo.inmet.gov.br/Graficos/83801>. Accessed on: 10 Mar. 2020.

The study is based on the methodology used by the Brazil National Landscape Research Network - Open Spaces System (QUAPÁ-SEL) and by the Open Spaces Systems Laboratory in Rio de Janeiro (SEL-RJ), linked to the Postgraduate Program in Architecture at the Universidade Federal do Rio de Janeiro (PROARQ-UFRJ) to identify and characterize open space systems (CAMPOS et al, 2011, 2012). The quality of the studies developed on the theme of open spaces by the highlighted research groups was taken into consideration when choosing the methodology to be used, as well as the abundant research material produced and made available for consultation by the City of Rio. of January.

To analyze the public and private open spaces in the city of Rio Janeiro, the reference used in the research was the mapping carried out by the SEL-RJ Group where public and private free spaces were identified and classified according to a predetermined categorization (TÂNGARI, 2018).

When mapping private open spaces, the percentage of occupation of the surface of the blocks was taken into consideration, thus establishing the patterns of occupation and incidence of private open spaces: "up to 30%", "from 30% to 50%" and "over 50%" of building-free spaces on the blocks. As for the identification of open spaces of a public nature, reference was made to the categorization of open spaces and their respective types:

Category: environmental open space, where leisure and recreation activities can also take place:

– Conservation unit - Corresponding, in this research, to the areas covered by the mountains, defined according to decree, and the Tijuca, Pedra Branca and Gericinó Massifs

– Shore - Continental Coastal Zone, corresponding to open space of permanent preservation adjacent to bodies of water with vegetation, sand, stone and the like. Includes beaches and other marginal strips

Category: urban open space, related to the circulation of vehicles or pedestrians, where recreation, commerce, sports, culture, education, political activities and festivities can also take place:

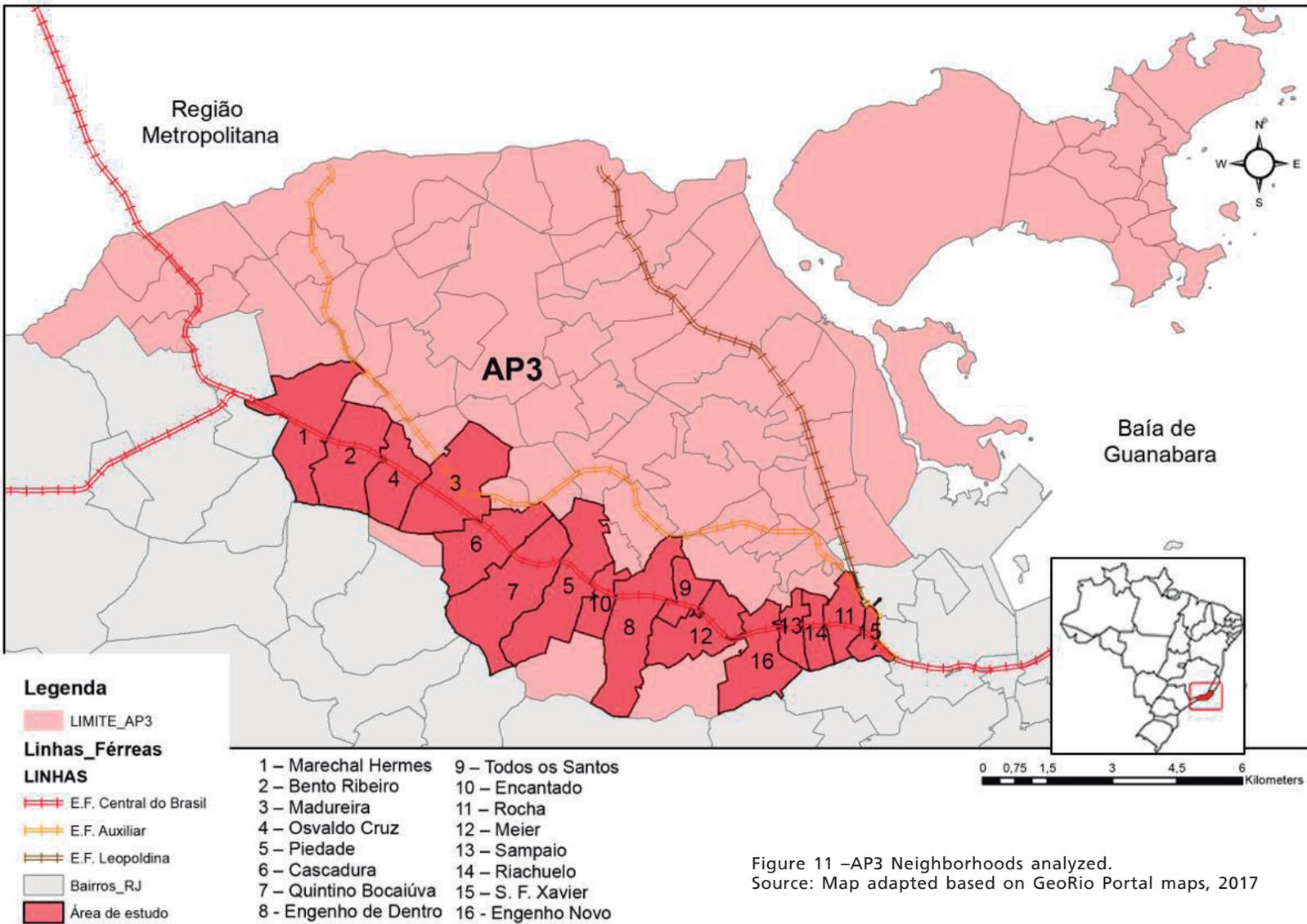


Figure 11 –AP3 Neighborhoods analyzed.  
Source: Map adapted based on GeoRio Portal maps, 2017

- Shoulder - Area located on the right side of a highway or urban road;
- Sidewalk - Sidewalk designed with a specific project or resulting from significant changes with dimensions above the standards

- Beds - road, central, lateral or residual from road setting located on roads or adjacent to public roads, with or without vegetation;
- Cycle lane - Road intended for the exclusive circulation of bicycles and non-motorized vehicles and closed to motor vehicles;

- Deck - Surface suspended over a water body, includes piers and marinas;
- Parking - Public vehicle parking area – parking spaces or similar - does not refer to street parking spaces;
- Footbridge - Elevated road for preferential pedestrian circulation, closed to motor vehicles;
- Roundabout - Island, usually circular in shape, surrounded by return roads and intersections, with or without vegetation;
- Street and avenue - Between building alignments, generally includes side sidewalks;
- Bus terminal - Set of bus bays located outside the street lane with stop and shelters for pedestrian protection;
- Viaduct - Elevated vehicle lane visually marked from beginning to end of the ramp;
- Pedestrian street - Road intended for the preferential circulation of pedestrians and closed to motor vehicles;

Category: urban open space, related to the permanence of pedestrians, with the possibility of recreational activities, commerce, sports, culture, education, political actions and festivities:

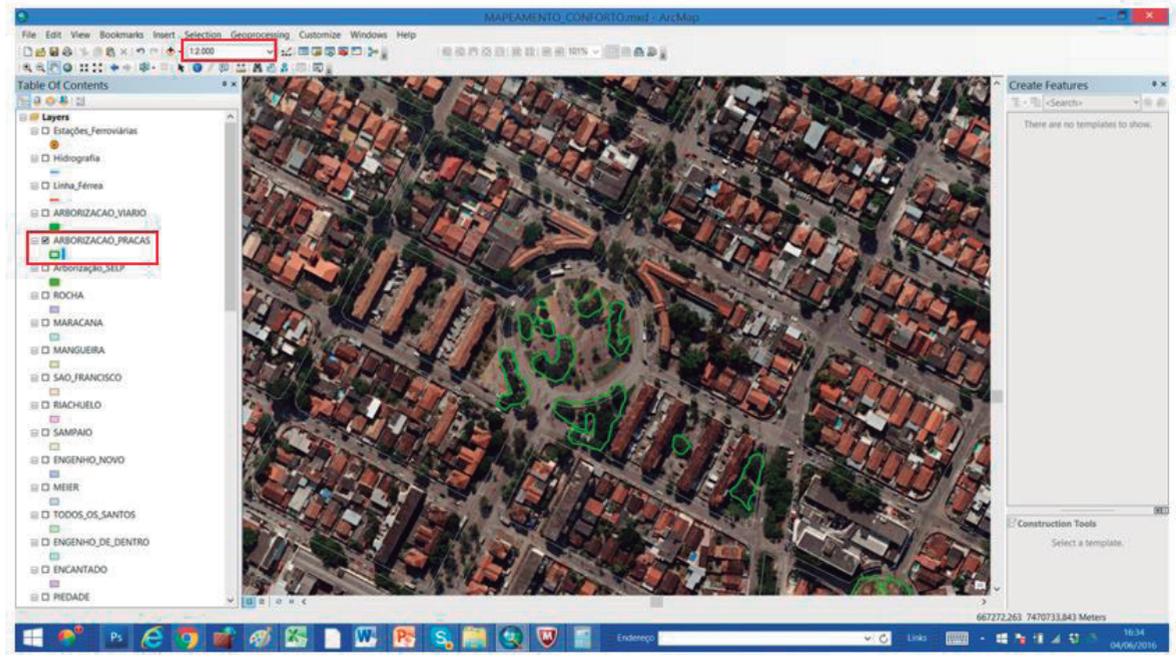
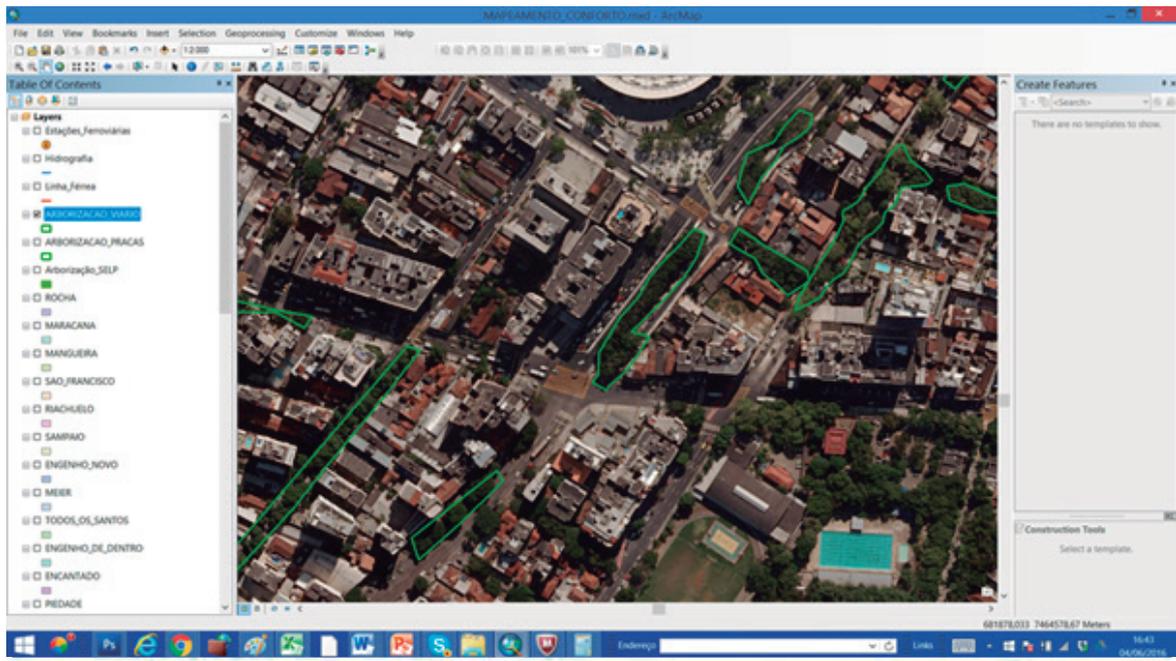
- Park - Public open space, especially designated as a park;
- Square - Area determined in a subdivision project as a public open space for recreational activities;
- Non-implanted square - Area determined as a public open space for recreational activities in a subdivision project that was not executed;
- Occupied square - Area determined as a public open space for recreational activities in a subdivision project which was set apart (above 50%) for the construction of health, education or residential equipment;
- Football field - Isolated informal open space where ball is played;

Category: urban open space, related to administrative, transport, sanitation, educational, cultural infrastructure, where trade, services, recreation, sports, culture, education activities can also take place:

- Space for special/dominical use - Unbuilt spaces owned by the public and granted for special uses - railways, ports, airports, university campus, etc.;

Urban vegetation with tree species was evaluated based on mapping the existing tree mass, in open public and private spaces. Such mapping was made possible by the use of ArcGis software, based on satellite image (orthophoto), of the City of Rio de Janeiro, in the year 2015, made available by the City Hall of Rio de Janeiro. The methodology consisted then, in identifying and mapping tree patches evident in the urban space, based on images in a predetermined scale of 1:2,000, as shown in Figures 12 and 13. Subsequently, field work complemented the analysis of the difficult to detect patches.

It is important to clarify that the tree vegetation is not present only in the areas demarcated in the study, however, the existing vegetation, which becomes irrelevant in relation to the determined scale, was disregarded. In the study, tree patches at high levels where occupation is often unfeasible from a structural and environmental point of view, or prohibited by law, and patches in irregular residential settlements, represented by slums and irregular subdivisions, were not evaluated as it was considered that these territories present a peculiar and singular conformation of land occupation and that they deserve specific study. It is also worth mentioning that the definitions of public and private properties specified in the Brazilian Civil Code in effect since 2003 are considered here, where private properties are classified as those strictly for private use and public properties divided into: common use of the people (squares, streets, parks, beaches, etc.), of special use (the properties of specific use of public entities such as the Army, public schools, public hospitals, etc.) and dominical or dominical use (disposable public properties without disaffection, as they no public destination).



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Figures 12 and 13 – View of the working screen of the ARCGIS 10.3.1 software with emphasis on the marking of the tree mass.

Despite taking as a base the definitions of property mentioned above, for the analysis in question it is understood that the population's access to open spaces of properties of special and dominical use is restricted and for this reason the vegetation present in these environments acts indirectly to the environment in which it is located in a similar way to the vegetation present in private spaces. For this reason and, in particular, in evaluating the arboreal patches, the vegetation in public spaces of common use is distinguished here from the rest of the arboreal mass belonging to the other private or semi-private spaces.

## 6. RESULTS AND DISCUSSION

### 6.1. PRIVATE OPEN SPACES

As can be seen in the map in Figure 14, the greatest incidence of open spaces in the neighborhoods of Cascadura, Quintino and Engenho de Dentro is explained by the existence of residual areas bordering the Tijuca Massif. Most of them correspond to areas with a steep slope and high levels where, in general, occupation is restricted through environmental decrees and laws (non aedificandi) or in lots belonging to private equipment or institutions such as schools, gymnasiums and stadiums. In the neighborhood of Marechal Hermes and in Rocha, this greater incidence is explained by the presence of large military institutional areas.

On the municipal scale, it is interesting to observe the representative data of private open spaces from each Administrative Region (RA): through comparative analysis between the planning areas, shown in Figure 15, the reduced percentage of private open spaces in the region of AP3 becomes clear, mainly characterized by an incidence of up to 30% of open space within the blocks, which also highlights the high density of the built area in the suburb (Figures 16 and 17).

Due to the complexity and scale of the analysis, it was not possible to detail and quantify private open spaces lot by lot. In the study, the incidence of these spaces was considered in a block-by-block analysis alone, determining the percentage of open spaces observed on the surface of the blocks.

However, based on the total quantification of urban blocks, it is possible to establish a relationship between the extent of each planning area and the total area of private open spaces, understanding surfaces that encompass both built and non-built areas as private spaces. The result becomes relevant, as it proves the high rate of land occupation in the region of the railway suburb, mostly belonging to AP3, where approximately 64% of the territory is composed of occupied land, with the highest rate of land occupation by planning area.

In the individualized analysis of the Administrative Regions of Méier and Madureira the values of land occupation are even higher as shown in Figure 18.

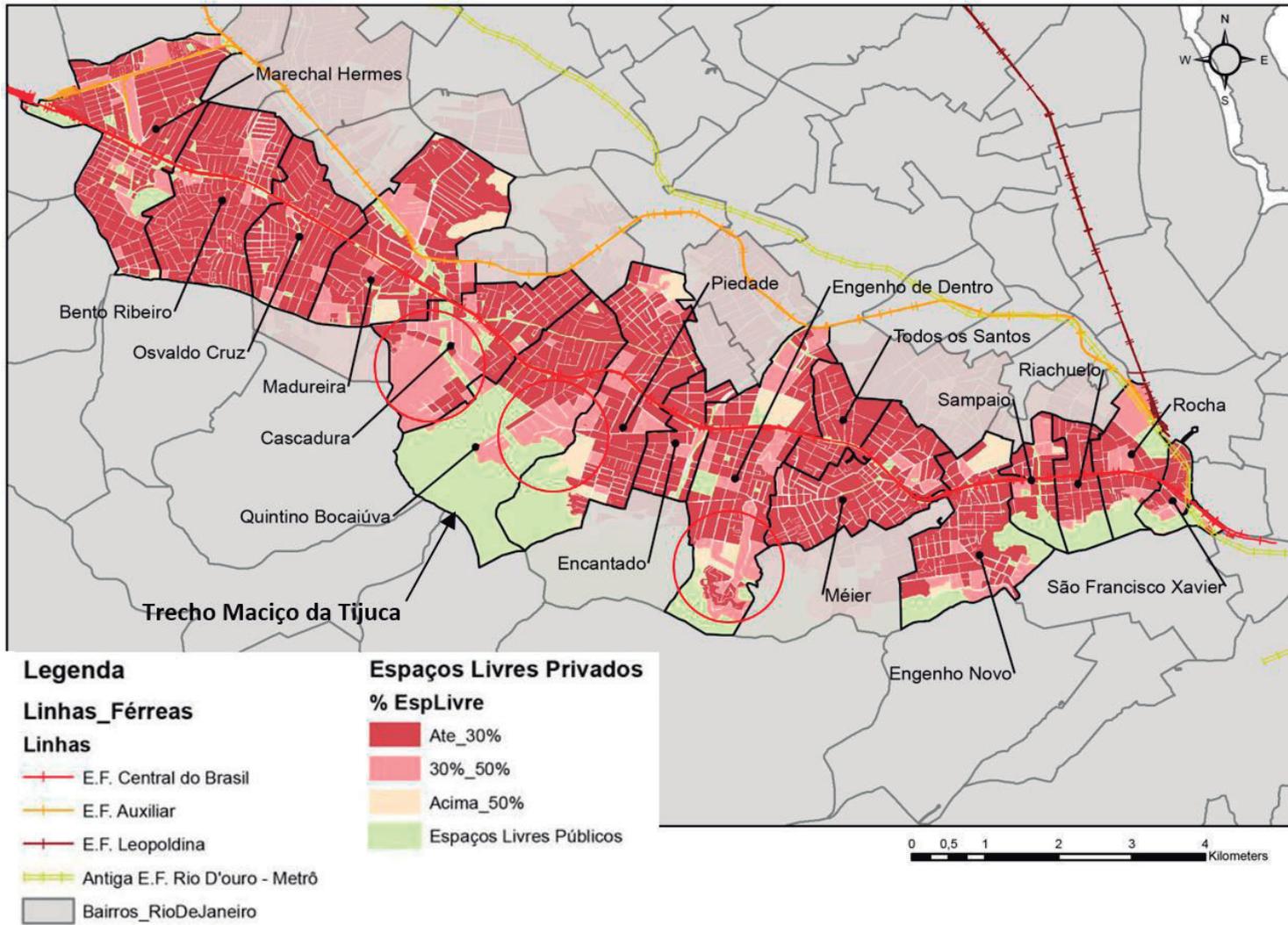


Figure 14 – Analysis of private open spaces by blocks.  
Source: Map adapted from the SEL-RJ database, 2017.

Private Open Spaces (Hectare) x Planning Area  
Espaços Livres Privados (Hectare) x Área de Planejamento

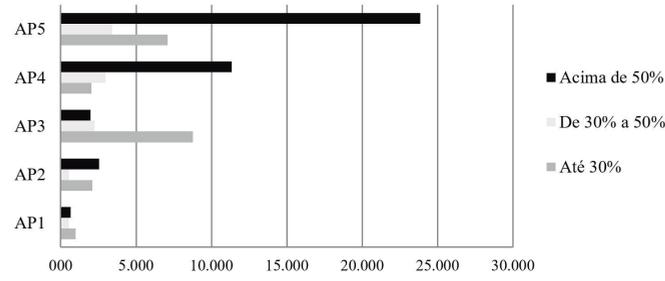


Figure 15 – Mapping of private open spaces by RA.  
Source: SEL-RJ, 2017.

% Private Open Spaces –RA Madureira (Hectare)

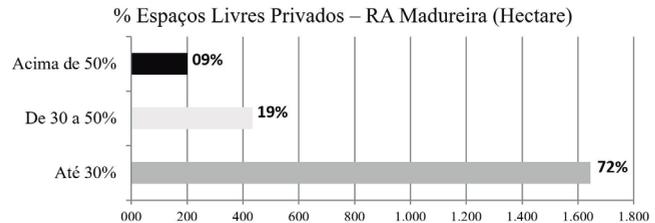


Figure 16 – Percentage of private open spaces per block in RA Madureira.  
Source: SEL-RJ, 2017.

% Private Open Spaces –RA Meier (Hectare)

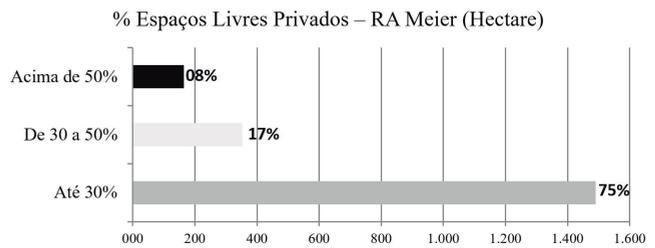


Figure 17 – Percentage of private open spaces per block in RA Meier.  
Source: SEL-RJ, 2017.

% Private Open Spaces x Territory  
% Espaços Livres Privados x Ext. Territorial

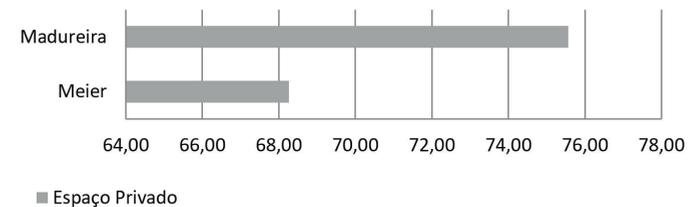


Figure 18 –Private Spaces per RA.  
Source: SEL-RJ, 2017.

### 6.2. PUBLIC OPEN SPACES

Regarding the occupied area, the most representative public open spaces include: spaces for the circulation of vehicles or pedestrians, formed by streets and avenues; open spaces of an environmental nature, mostly without public access or restricted access due to irregular occupation of slums and informal subdivisions and spaces for dominant use given to military forces or service concessionaires (lighting, water supply, rail transport, etc.) (Figure 19). It can be seen that the total area of open spaces is directly proportional to the extent of the planning areas: the greater the AP, the greater the area of public open spaces (Figure 20). However, when considering the relationship between open spaces and the territorial extent of the planning areas, AP3 has the lowest rate of open space distribution per hectare in the City (Figure 21).

#### 6.2.1 SQUARES IN THE SUBURB

The individualized assessment of public spaces represented by squares, in the suburb, reveals a particular issue that deserves to be highlighted in the material presented here: such places, which are already scarce in this region, are still sometimes suppressed, for the implementation of education and health equipment. The practice of occupying public open spaces for leisure to imple-

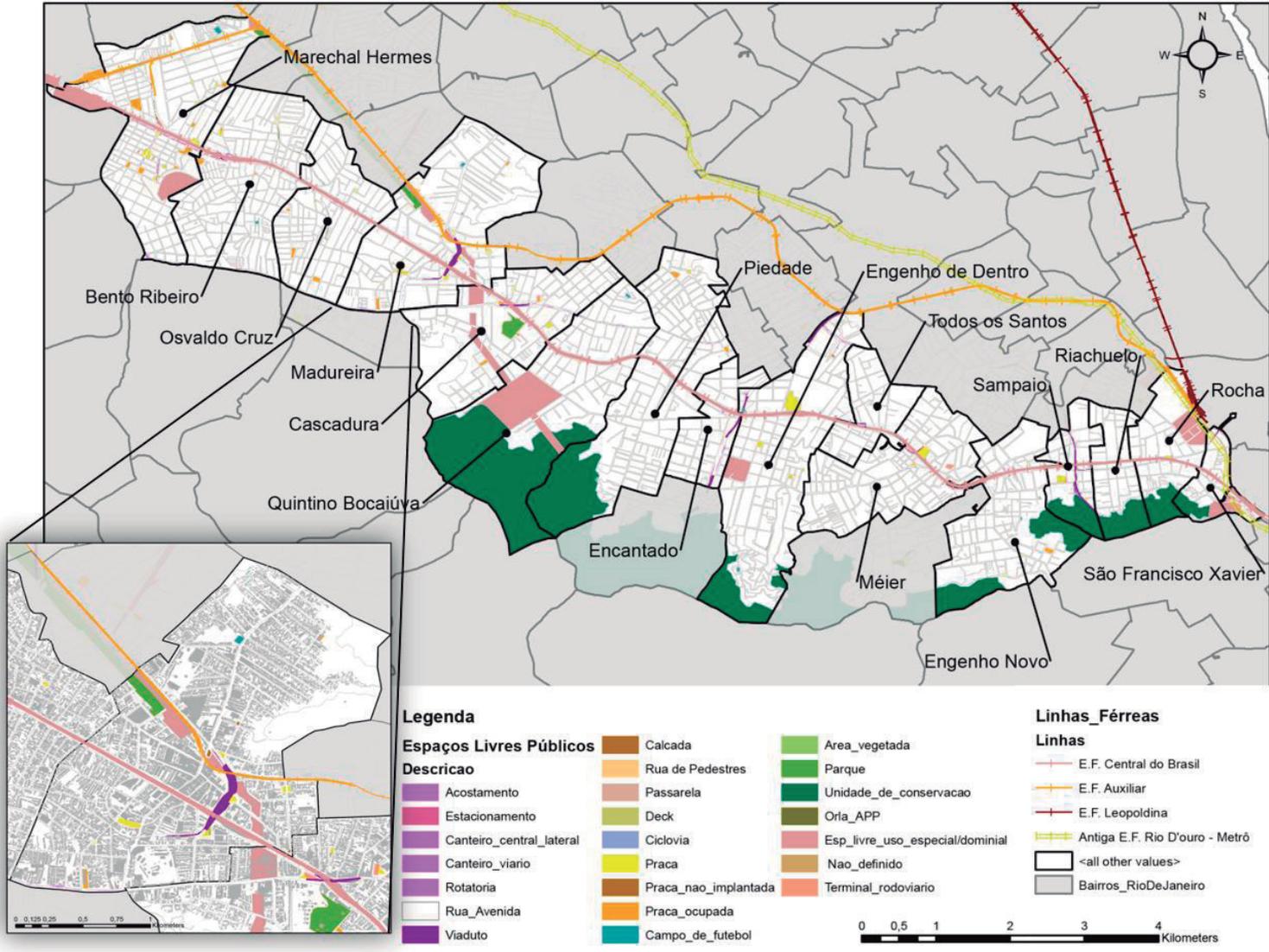


Figure 19 – Analysis of public open spaces with expansion in the Madureira neighborhood  
Source: Map adapted from the SEL-RJ database, 2017.

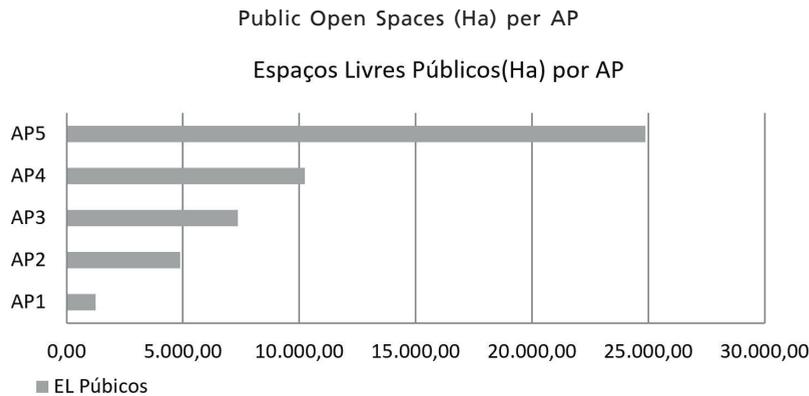


Figure 20 – Public Open Spaces per Planning Area.  
Source: SEL-RJ, 2017.

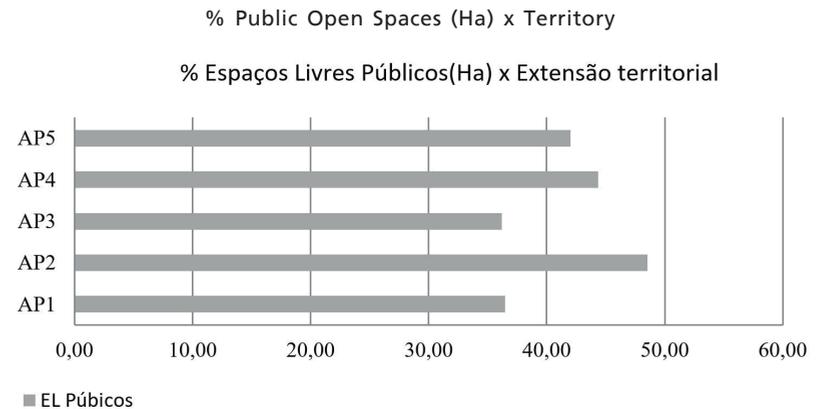


Figure 21 – Percentage of Public Open Spaces x Territorial Extent of AP.  
Source: SEL-RJ, 2017.

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ment other essential services is not recent in the history of the City. Back in 1960, in the election of the first administration of the newly created State of Guanabara, Carlos Lacerda promoted his candidacy with the promise of ending the deficit of places in the state's primary schools. By the end of that year, 78 schools had been opened and many of them were located in the suburbs of Rio de Janeiro. Between 1960 and 1965, about 200 primary schools were built (PEREZ, 2005). Two important premises were adopted at that time by the government to streamline the construction process of schools and reduce implementation costs: the first established an architectural standard based on the standardization of the materials used and the second was the implementation of buildings in public squares (Figure 22).

Through a legal maneuver implemented by decree and supported by the Brazilian Civil Code, the government can use common use goods of the people to meet the needs of the entity itself. According to these decrees, squares cease to belong to the category of "common use goods" and become "special use goods" subject to disaffection or alteration of affect, legitimizing the

implementation of public buildings in the square. The change can be partial or total. In many cases observed, the information in the database of the City of Rio de Janeiro itself is conflicting and does not correspond to reality: despite being classified as a public square, the entire area of the lot is occupied by a school. In this specific case, as well as in others identified, it was not possible to locate the decree that legitimized the new use for the site.

Based on this history of suppression of squares, the research sought to make the areas of squares and parks compatible, as well as their current conditions, based on the database of the City of Rio de Janeiro<sup>4</sup>. Of the 114 squares identified in the study, only 58 (51%) were identified and can in fact be characterized as squares or parks. Of the remainder, 13 (12%) are decreed as a square according to the survey, however, by changing the partial or total affectation of public space, they are mostly occupied by schools or public clinics. The remaining 43 (37%) are areas indi-

<sup>4</sup> File in shapefile format (.shp) referring to the demarcation on a map of land uses in the city of Rio de Janeiro in 2017. Available through the link <https://bit.ly/3boJYJ0>. Accessed on: 18 Mar. 2020



Figure 22 – School installed in a former square in the Osvaldo Cruz neighborhood.  
Source: Google Earth, 2017.

cated as squares, but in reality, they are privatized open spaces (undue appropriation of public space), or open spaces that have ceased to exist due to road changes and redesign of urban layouts in general.

The survey carried out gave rise to the map represented by Figure 23 and the graph in Figure 24 that elucidate the information provided.

The neighborhoods of Madureira and Marechal Hermes stand out as the neighborhoods with the largest number of squares.

Marshal Hermes also has the largest number of non-existent squares, where many spaces demarcated as squares are actually flowerbeds and parking lots for residential condominiums. The Engenho de Dentro neighborhood also stands out for the number of non-existent squares: the demarcated areas to the north of the railway are currently occupied by residential buildings, and to the south, the incorrectly demarcated spaces are large areas occupied by informal dwellings on the fringes of the Tijuca Massif. Marshal Hermes also has the largest number of occupied squares, along with the Osvaldo Cruz neighborhood.

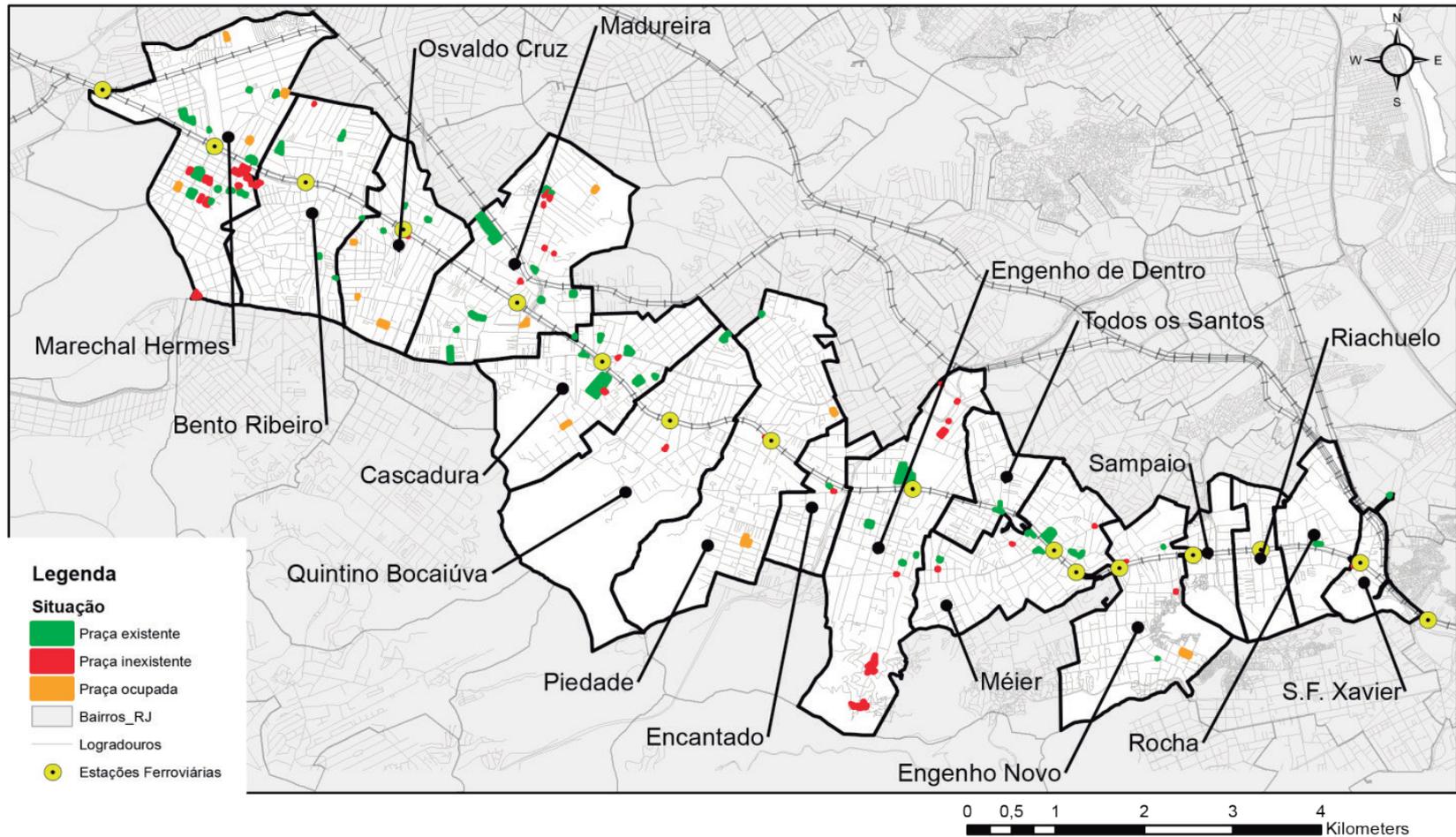


Figure 23 – Location and analysis of squares and parks.

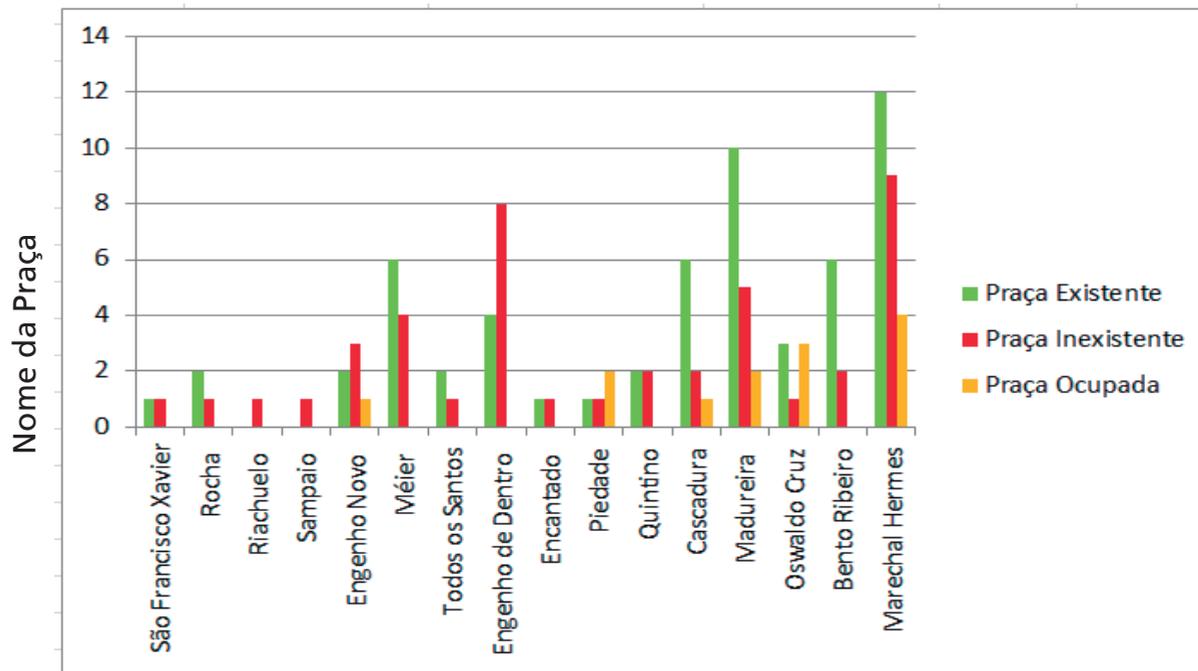


Figure 24 – Situation of squares and parks by neighborhood.

### 6.3 AFFORESTATION

Based on the proposed methodology, it was possible to identify and map the existing tree mass in the study area (Figure 25). Based on the comparison between public and private spaces, it was possible to attest that, the latter comprise 83% of the entire wooded area considered, in contrast to the 17% incident in public spaces (Table 2).

As elucidated in the table, the percentage of afforestation of private open spaces in the evaluated neighborhoods was significantly higher than that in public spaces (Figure 26). In addition to the military areas, other factors are determinant to the existence of the tree mass in private spaces:

- Significant amount of private land that houses power transmission towers
- Incorporation of residual areas adjacent to water bodies, to residential lots;
- Predominance of single-family homes with backyards and garden areas, responsible for the formation of arboreal corridors at the back of the lots
- Good afforestation of the common use areas of some multi-family housing estates;

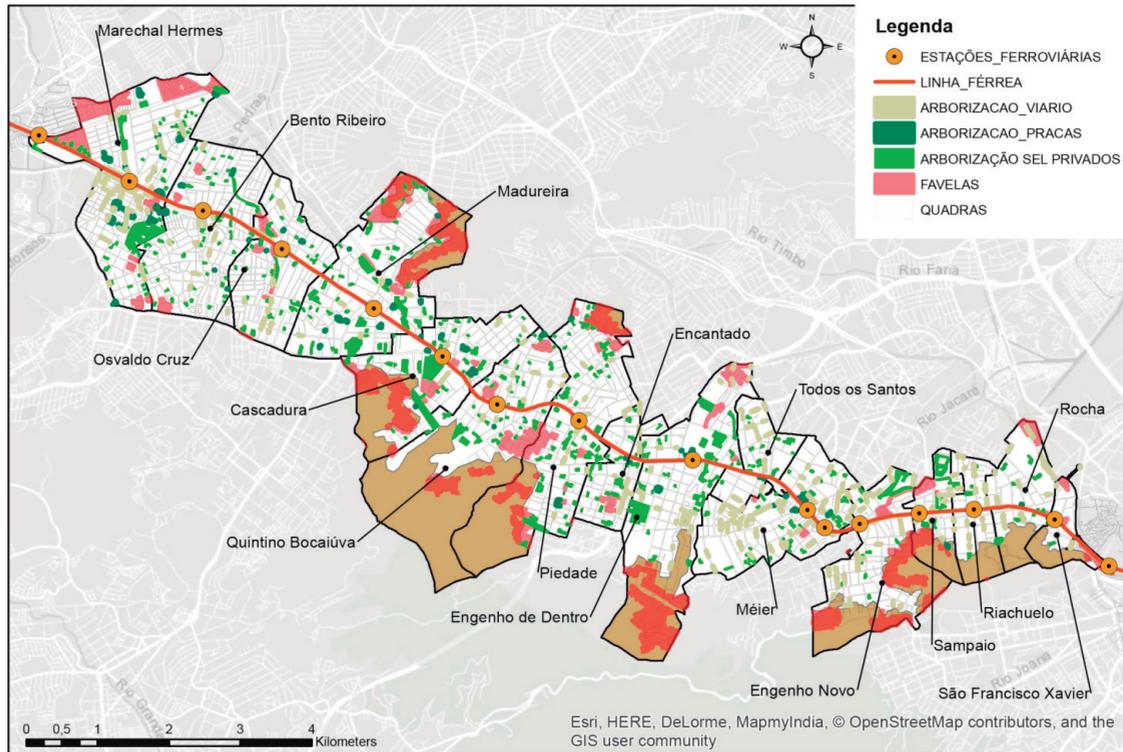


Figure 25 – Mapping the tree mass of private space systems.

TABELA QUANTITATIVA MASSA ARBÓREA BAIRRO A BAIRRO										
BAIROS	ÁREA(ha)	HABITANTES	DENS.POP. (Hab./ha)	PRAÇAS / PARQUES E LARGOS (ha)	%	VIÁRIO (ha)	%	SEL PRIVADOS (ha)	%	
MARECHAL HERMES	388,00	48061,00	123,80	2,27	9	4,29	17	18,23	74	
BENTO RIBEIRO	303,00	43707,00	144,25	0,22	3	0,97	14	5,62	83	
OSVALDO CRUZ	207,00	34040,00	164,44	0,06	< 1	0,95	15	5,32	84	
MADUREIRA	378,00	50106,00	132,56	0,46	2	0,33	1	19,19	97	
CASCADURA	284,00	34456,00	121,32	0,43	2	0,37	2	14,46	96	
QUINTINO	432,00	31185,00	72,19	0,12	1	0,44	5	8,53	94	
PIEDADE	388,00	43378,00	111,80	0,23	1	0,62	4	14,11	95	
ENCANTADO	106,00	15021,00	141,71	0,02	< 1	0,88	17	4,15	82	
ENGENHO DE DENTRO	392,00	45540,00	116,17	0,64	3	1,3	6	18,27	91	
TODOS OS SANTOS	101,00	24646,00	244,02	0,08	2	0,97	31	2,04	67	
MÉIER	247,00	49828,00	201,73	0,93	9	4,09	39	5,26	52	
ENGENHO NOVO	264,00	42172,00	159,74	0	0	2,57	33	5,2	67	
SAMPAIO	88,00	10895,00	123,81	0,06	1	0,46	8	4,87	91	
RIACHUELO	93,00	12653,00	136,05	0	0	1,2	57	0,88	43	
ROCHA	131,00	8766,00	66,92	0,03	< 1	1,43	37	2,38	63	
SÃO FRANCISCO XAVIER	65,00	8343,00	128,35	0,01	1	0,33	61	0,2	39	
<b>TOTAL</b>	<b>3867,00</b>	<b>502797,00</b>	<b>121,61</b>	<b>5,56</b>	<b>3,5</b>	<b>21,2</b>	<b>13,5</b>	<b>128,71</b>	<b>83</b>	

Table 2 – Synthesis table generated from the mapping of afforestation of open space systems.



Figure 26 – Maintenance of afforestation on private lots.  
Source: SEL-RJ Archive, 2017.

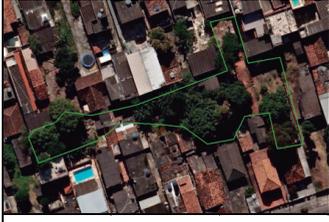
- Large lots belonging to educational or health institutions that are largely wooded;
- Considerable amount of undeveloped lots that preserve existing afforestation.

Based on the factors considered for the mapping of the wooded areas of the private spaces, eight main categories were defined for the most representative spaces that preserve considerable tree mass, as can be seen in Chart 1:

## 7. CONCLUSION

This article sought, through an in-depth analysis of open spaces and their treatment with vegetation, to demonstrate that, in the city of Rio de Janeiro, it is still possible to find a considerable area of private open spaces in the railway suburb and that such areas retain a significant percentage of afforestation, representing an important characteristic to be observed. Within this context, these spaces become identified for contributing to the neighborhoods to which they belong, being an alternative

Chart 1 – Categorization of private open spaces based on the mapping of existing afforestation.

	Áreas militares		Linhas de transmissão
	Áreas residuais		Margem de rios
	Conjuntos habitacionais		Lotes vazios
	Fundo de lotes		Associações (fundo de lotes, áreas residuais e terreno vazio)
	Instituições de ensino / saúde		

of permeable spaces capable of contributing to improving social and environmental conditions and an important heritage to be preserved.

The analysis of open spaces in the study area shows that the patterns observed by Macedo et al (2009) about the system of open spaces, whether public or private, in Brazilian cities, are, in fact, clearly identified in the suburb of the city of Rio de Janeiro: the first standard highlights the scarcity of properly identified public open spaces, referring as much to sidewalks and streets as to the structures of squares and parks. The second pattern concerns the reduced size of private unbuilt or unpaved spaces.

In the particular case of occupation of the squares in the suburbs, it is clear that the power game of public management at different times and the lack of legal depth in the field of urbanism and its real needs end up enabling loopholes that allow the municipal administration to use decrees and thereby supplant the urban guidelines contained in the Master Plan, which are the legal tools capable of ensuring the preservation and maintenance of public spaces. In this way, the few existing spaces end up being superseded so that other emergency demands such as education and health services and equipment can be met.

In addition to highlighting the lack of structured public recreation spaces capable of meeting the demand for leisure in the suburbs, the tree mapping carried out in this study highlights the importance of maintaining private spaces, despite their sometimes reduced dimensions, and their afforestation, which contribute to compensating the lack of public wooded areas. The analysis can also be an important instrument in the individualized assessment of the conformation of each neighborhood studied, making it possible, through the correlation of the areas presented, to identify potentialities and deficiencies, with regard to the afforestation of these regions.

With the advance of discussions and the appreciation of envi-

ronmental issues, it becomes appropriate to consider all significantly vegetated areas as green areas, whether public or private. This statement intends to enable, in this way, the valorization of public interest in environmental protection that also applies to private properties. In this context, based on the results obtained, the importance of private open spaces for maintaining vegetation in the spatial section of the railway suburb analyzed is proven.

The data generated in this research can also be compared with new mappings that could be performed, based on maps and orthophoto in following years. This comparison could assess the increase or suppression of vegetation, both in public and private open spaces. Likewise, the information and data obtained through this analysis can be considered in the formulation of urban laws regulating the use and occupation of land in private and public spaces in the neighborhoods located in the studied region: such as preservation of a proportion of, at least, 50% of the lot's occupation area for afforestation purposes, even if the construction typology is modified. It is also urgent to recommend increasing afforestation in public spaces as well as to create new spaces, such as squares and parks that contain at least 50% of wooded areas inside, including in circulations, even in cases where there are built elements for shade (VASCONCELLOS, 2006).

In climates with temperature and humidity characteristics such as those of the City of Rio de Janeiro, the incidence of afforestation is constituted in demand for comfort and well-being, justifying extending studies such as those shown in this article to other districts and regions of the City.

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