Landscape connections – Urban tree planting as a bioconnecting infrasctructure

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Conexões na paisagem – A arborização urbana como infraestrutura bioconectora

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Abstract
Cities' large public spaces, represented by city streets, are presented as a potential support to the vegetation infrastructure, allowing for the continuity and connections between existing green areas, with the capacity to alleviate the climate, reduce air pollution, improve air quality, bring the rich diversity of fauna and flora to the city dwellers, and enrich urban life. Thus, one can take advantage of the existing urban structure so as to enhance urban tree planting initiatives by different stakeholders, think globally to implement locally, boost knowledge about ecosystem relations in urban areas, and provide higher environmental quality for the city as a whole.

Resumo
Apresentamos o grande espaço público urbano, representado pelas ruas da cidade, como potencial para dar suporte a uma infraestrutura de vegetação, que permite a continuidade e conexão dos maciços verdes existentes, com capacidade para amenizar o clima, reduzir a poluição ambiental, melhorar a qualidade do ar e trazer a riqueza da diversidade da fauna e flora para junto dos usuários da cidade, de forma a enriquecer o cotidiano urbano. As vantagens se encontram em aproveitar uma estrutura urbana existente de modo a incrementar as iniciativas referentes à arborização urbana dos vários agentes, pensar global para implantar local, incentivar o conhecimento das relações ecossistêmicas nas áreas urbanas e proporcionar qualidade ambiental para a cidade como um todo.

Introduction

The city is one of our main artifacts, built with elements present in nature, resulting in the place we live, our dwelling, part of our input as agents of transformation, not unlike several other agents whose impact can be felt on different scales and intensities, redefining the very nature we are inserted in. However, in our imagination, being in contact with nature means leaving this environment we have transformed to take refuge in places where human action is camouflaged, or where nature seems to be pristine and untouched. This search for the antithesis of what we have built is a paradox, since we have the technology and knowledge to build a city that is more in line with what we understand to be of high environmental quality, albeit not being what we actually do.

We are aware that vegetation is one of the most characteristic elements in defining this high quality, as it plays an important role in the dynamics of the other elements comprising the environment, by improving the quality and permeability of the soil, filtration, humidity, and air quality. Vegetation is paramount to the water cycle and dynamics, and also to the biotic connections with several species.

However, when reprising the idea of fragmented and/or specialized knowledge, we find that, in general, vegetation is tied to the presence of green reserves, parks and squares. The role played by eventual and extensive vegetation planting and growing is often neglected, regardless of the quality improvements it could afford to areas that direly lack the vegetation element.

Hence, by approaching city streets as public spaces that permeate and connect the whole city and which are characterized as the backbone of urban infrastructure, not to mention its multiple uses and roles, we propose to discuss vegetation as an additional type of infrastructure, crucial to the notion of a city in line with ecosystem services, creating a network-type connection that can support the different biotic relationships fostering their multiplication and the covering of the whole urban space, as a large system, something that presumes the interdisciplinarity and interdependence of knowledge. It is important to highlight that streets and their sidewalks comprise the largest public spaces in the city and that we could potentially take ownership of these spaces from an environmental point of view as well.

The crossing and exchange between different sciences, such as architecture, engineering, urbanism, biology, education and public management could enable such an approach. An interdisciplinary approach and a contextualized view of urban tree planting are necessary, even if the actions are to be local, although globally coordinated.

Urban Tree Planting in São Paulo

Public Authorities are both promoters and fomenters of urban tree planting through norms, legislation and public policies. These are means to expand green areas in neighborhoods, which are microclimate elements that are part of the local ecosystem (Fig. 3) and create nicer, more pleasant paths for the city dwellers.

Figure 3 - Urban tree planting street in Montevideo (A), Uruguay, and Maringá (B), Brazil. Sources: Wellington Tohoru Nagano and Maria Helena Preto, respectively.

Discussing urban tree planting in Brazil is akin to analyzing our cities' sidewalks (Fig. 4). Plagued by issues such as incorrect width, underground and aerial infrastructure interference, unevenness, poor relationship with neighboring properties, among other issues, they are not pedestrian friendly, and become an impediment for those with restricted mobility, be them the elderly, people with disabilities or those with a baby stroller or shopping cart, for example. Despite being of public domain, sidewalk's design and upkeep is the responsibility of property owners, which translates into different types of designs.

Figure 4 - Jerônimo da Mendonça Street (A), in the Mooca District (São Paulo, Brazil), with a wide, tree-lined sidewalk where a person is resting under the shade of a tree. In the Guaianazes District (São Paulo, Brazil), Salvador Gianetti Avenue(B) has narrow sidewalks and light poles that hinder pedestrian circulation. Sources: Wellington Nagano.

In the city of São Paulo, for example, urban tree planting was always treated in a piecemeal fashion, and it wasn't until the 2002 Strategic Master Plan (*Plano Diretor Estratégico*, or PDE) that it started to become more structured with streetside planting, planting on valley-bottom avenues, and school tree planting programs (SÃO PAULO, 2002).

In 1985, the registration of the tree vegetation was an important step for the urban tree inventory. Though it was performed manually, by means of aerial photogrammetry, aided by on-site visits and surveys (SÃO PAULO, 1988), it became an important element in the preservation of the existing city vegetation, pursuant to Decree 30.443/1989. However, there was still no management system in place for monitoring and following-up on this asset over time. More recently, in face of technological developments, the Urban Tree Planting Management System (*Sistema de Gerenciamento de Arborização Urbana*, or SISGAU), created for the Green and Environment Department (*Secretaria do Verde e Meio Ambiente*, or SVMA) by the Technological Research Institute (IPT), includes data on species, location, phytosanitary status, height, and other information pertaining to the existing trees.

Between 2009 and 2012, the city of São Paulo planted over 800,000 trees on streetsides, public areas and in the 50 municipal parks created during that period. The SVMA, through the Decentralized Management Board (*Diretoria de Gestão Descentralizada*, or DGD), carried out urban tree planting programs in public areas, on the street system and at municipal schools.

Since then, guidelines, legislation and manuals on urban tree planting have emerged, such as: SVMA Ordinance n. 61/2011, pertaining to the Atlantic Forest native species to be used in environmental compensation procedures; the Technical Manual for Urban Tree Planting (2015), focusing on sidewalk planting, and Article 286 of the 2014 Strategic Master Plan, which established the guidelines for the Municipal Urban Tree Planting Plan (*Plano Municipal de Arborização Urbana*, or PMAU). According to that article, the PMAU should include tree inventories, a vegetation deficit diagnosis by region, the identification of areas for planting, the indicated species, tree planting management, and environmental education programs (SÃO PAULO, 2014).

Urban tree planting actions in São Paulo are not restricted to the city. The State Government, through the Infrastructure and Environment Department (*Secretaria de Infraestrutura e Meio Ambiente*, or SIMA), has passed important legislation regarding vegetation and the restoration of areas in new developments, particularly regarding native vegetation and the preservation of areas along streams and springs, having achieved important results in environmentally degraded locations, such as the recovery of the Villa Lobos Park area, the planting on the banks of the Pinheiros River and the requiring of an Environmental Recovery Project that includes landscaping and tree planting, all within the scope of the Recovery Programs of Social Interest (*Programas de Recuperação de Interesse Social*, or PRIS) in Spring Recovery and Protection Areas that have been taken over by irregular developments lacking in infrastructure.

Moreover, there have also been proposals that use urban tree planting as an element in the redesigning of the streets. In 2015, a pilot project authored by the São Paulo Municipal Government planted yellow ipe trees throughout the Patrocínio Paulista Avenue axis (Figs. 5A and 5B) and at Adelina Tobias de Aguiar Square (Fig. 5C).

Despite benefits such as the slowing down of speeding vehicles and more safety for pedestrians, the pilot project was discontinued due to negative repercussions coming from other areas, that feared that the same would happen on their streets (PAIVA, 2018).

Currently, the trees have grown, and the square has expanded its permeable area, but the project failed to include the creation of a green infrastructure at the site, with

no draining of the surrounding rainwater (Fig. 5D). An opportunity for incorporating green infrastructure to the urban tree planting effort, thus mitigating the effects of climate change, was missed. On the other hand, the pilot project served to show the urban tree planting possibilities in alternative locations, such as corners, between vehicle parking spaces, roundabouts and open areas.

Figure 5 - Patrocínio Paulista Avenue in 2015 (A) and in 2020 (B). Adelina Tobias Square with trees planted around the same time (C). In 2019, the asphalt paving was replaced by vegetation, but the guiding wall prevents the absorption of the rainwater from surrounding streets (D). Photos: Fábio Arantes/SECOM (C) and Google Street View.

Creating urban tree planting plans in a consolidated and heterogeneous city such as São Paulo requires solutions that are adapted to local conditions and often depend on integrated actions to make spaces viable in areas with more restricted infrastructure. Urban groups have been created in the city and they have become agents who act on a local scale. Their association with public agencies could intensify urban tree planting efforts and disseminate their importance due to their greater inclusion in the territory, if compared to Public Authorities, and their liaising and engagement capabilities with the population which could translate into manpower and management volunteers. The Public Authority would then be responsible for the institutional support, technical staff, planning and the supplying of inputs.

The association with urban groups does not exempt the Public Authorities from taking a leading role in urban tree planting efforts, rather it is accepting of new types of public policies. Interdepartmental connections are still needed, with more specific incentives for the planting on sidewalks and better communication about the benefits that urban tree planting could bring to a particular area.

Urban tree planting management

Urban tree planting also involves tree management throughout their life cycle, including growth, maturing and aging. In addition to the risk of disease, which could turn them fragile during weather events, trees can be the target of vandalism or accidents. Constant monitoring of the trees for diseases and external activity is necessary, with their removal and replacement with new and healthier species when needed. Thanks to progress in georeferencing systems and new software, it is possible to create an up-to-date and dynamic tree database.

Urban tree planting management requires the selection of the species to be used from the start, from project design, and should take into consideration aspects such as sidewalk width, interference with infrastructure and type of street, among other things. The manuals and regulations regarding the species to be planted generally consider the city as a whole, generically, not allowing for local particularities. A sibipiruna tree may not be the best suited species for a narrow street whereas a parsley mastic tree may not provide shaded on a wide sidewalk.

Urban tree planting management creates opportunities for partnerships between private agents and the third sector. In São Paulo, the SVMA and the Vila Mariana District Council signed a Cooperation Agreement with a construction company in 2013 for the planting and monitoring of 160 trees on the Vergueiro Street sidewalks and street garden beds between the Paraíso and Vila Mariana subway stations. The partnership had the technical support of governmental agencies, and the planting and monitoring was carried out by the construction company. The cooperation lasted for three years and was able to show how the sum of governmental agencies' technical knowledge with the agility of the private sector can boost urban tree planting and open opportunities with universities, schools, local primary care units, neighborhood associations, non-governmental organizations (NGOs) and collective groups.

Another example of partnership with private agents is the Urban Orchard Project (Projeto Pomar Urbano), which aims at recovering the Pinheiros River riparian vegetation between the Socorro and Vila Leopoldina Districts. Ever since 1999, the state government, through SIMA, has managed to make the tree planting carried out along the river possible and to consolidate it. They have also partnered with companies in vegetation planting and maintenance projects, in exchange for advertising at the site. Throughout the last 20 plus years of project, over 40,000 trees were planted on a 273,000 m² area. The importance of the Urban Orchard is greater due to the ecosystem services that it could provide, rather than due to the landscaping perceptions and its integration with everyday life, since the Marginal Pinheiros expressway is a barrier separating the green area from the surrounding districts and neighborhoods. However, when traveling by car, it is possible to see the difference brought about by that project's implementation and, more recently, with the building of the bike path, this feature can be more closely enjoyed by its users.

Street redesign – expansion of the planting possibilities

As a one-time activity, urban tree planting can be thought of as a component that brings diversity to the urban space, since it is possible to create and install habitat mix patches or large connections between existing habitats which are able to introduce or enhance the day-to-day spaces and, over time, become very close to the population.

In order for that to happen, the assessment of the existing street system and the hierarchization of its use for automotive traveling is essential, so the existing infrastructure can be used without harming flows, as demonstrated by the "Whole Streets" (Ruas Completas) initiatives, fostered by WRI Brasil (World Resources Institute) and the street redesigns proposed by the National Association of City Transportation Officials (NACTO), which value space ownership by the people and other travel possibilities. The inclusion of rain gardens would make it possible to expand the permeable areas that provide support for the vegetation and, therefore, to increase water absorption possibilities. The inclusion of shrubs and lining would allow the enrichment of the soil, making it more permeable and prone to the development of microorganisms, improving the quality of the water that reaches the conventional drainage system.

In order to illustrate the idea of bioconnecting streets in an existing urban infrastructure, we propose that a first approach would be working with streets following the characteristics that we describe below (Fig. 6):

- Shared streets, without connections, featuring local access for residents, with the space shared by cars, cyclists and pedestrians and without a level difference between the sidewalk and street, with controlled speed limits and priority for pedestrians;
- Local streets characterized by local neighborhood traffic connections only, with reduced street width, widened sidewalks, winding design, and a shorter radius of concordance at the corners to reduce speed;
- Connecting streets would suffer no changes to their layout, but would expand the garden areas, using lot access as a reference and, finally;
- Streets with a central gardens and with sidewalks similar to those of the connecting streets.

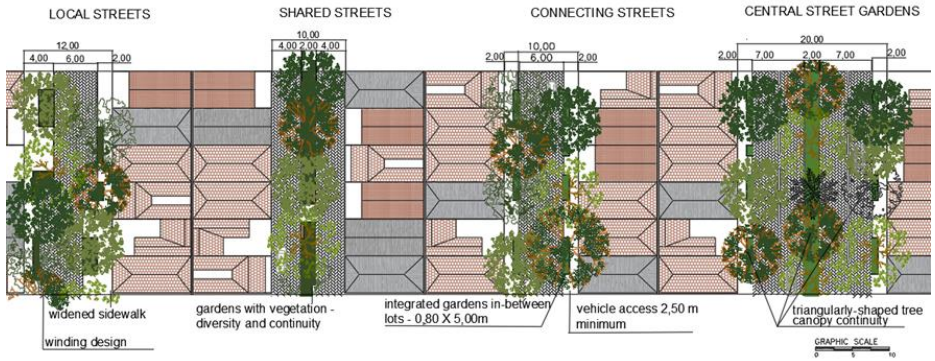


Figure 6 – Plans for the proposed streets. Source: GEP Camboatã Collection – designed by Annie B.C. da Silveira

In order to create more generous spaces for the planting of vegetation, when considering shared and local streets, we started with the worst-case scenario with streets

that are 10.0 m wide and have 5.0 m lot fronts. Thus, more favorable scenarios, when existing, both in terms of the street width and lot fronts, could yield greater breadth to the proposal.

For the connecting streets, we propose a 2.5 m lowering of the street guides for vehicle access to each lot, so that the rain gardens can group together and be 1.0 m x 5.0 m, providing a larger infiltration area and greater soil possibilities for planting trees, maintaining a street width of at least 6.0 m. We generally use a minimum distance of 10.0 m between planted trees, so that the tree canopies can touch and provide aerial continuity in the environment.

The following illustrations (Fig. 7) show the proposals for each type of street, without lot closures segregating public and private spaces, and, in the long term, we have the expectation that through environmental education, space ownership, and raising awareness, there would be a possibility of integrating small gardens in the private spaces with the public areas' sidewalk space, including a larger permeable area in the lots and the planting of vegetation in this private area integrated to the public areas.

For local streets it would be possible to maintain the dimensions described here through street redesigning, including a winding roadway aimed at reducing vehicles' speed and, whenever possible, with the widening of sidewalks (for streets that are over 10.0 m wide).

Shared streets presume access to real estate property only, with no distinction between the street and the sidewalk, since the priority is the pedestrians, with lanes at least 4.0 meters wide for access to lots, a central area with rain gardens at least 2.0 meters wide along the entire length of the street, intercepted by interspersed walkways. For streets longer than 40 m, it is necessary to provide fire hydrants or a minimum width of 6.0m for fire safety. Thus, it is assumed that the tree planting effort will be able to count on a larger area of permeable soil, in addition to being integrated with the shrub and bedding strata, bringing greater diversity and fauna association possibilities.

Figure 7 - Illustration of the proposed streets, with treetop continuity and greater integration of garden areas. Source: GEP Camboatã Collection - designed by Annie BC da Silveira

By altering the public spaces on the street, it is possible to intensify the planting of vegetation, the proximity between tree canopies, the arrangement of the various tree, shrub, and lining strata, and to bring the residents closer to a much wider range of biotic activities in urban life, as a means of encouraging these public areas to connect to gardens on the private areas of the lot, expanding the permeable and vegetated/connected areas.

Bioclimatic considerations

The bioclimatic considerations in face of the loss of green areas has been highlighted by several authors in studies about the city of São Paulo, in the sense that there are clarifying data that point to the urgency of actions to contain the average increase in temperature within the urban environment. This can be observed in more than one scale, be it within the scope of the metropolis, the city of São Paulo, or within the public health issues of the peripheral neighborhoods in the city. There is a direct

relationship between the heat islands and the problems related to the increase in the historical average temperature, especially in areas that traditionally have a full urban infrastructure and minimal vegetation cover.

Climate

Global policy-making entities, such as the Food and Agriculture Organization of the United Nations (FAO), are key to establishing concepts for future reversals of the climate change scenario based on the experience in cities in different countries, particularly those under development:

> Urban areas are major contributors to climate change: although they cover only 2 percent of the earth's surface, they produce more than 70 percent of global carbon dioxide emissions as well as significant quantities of other greenhouse gases. Urban areas are also highly vulnerable to climate change (FAO, 2017 p. 55).

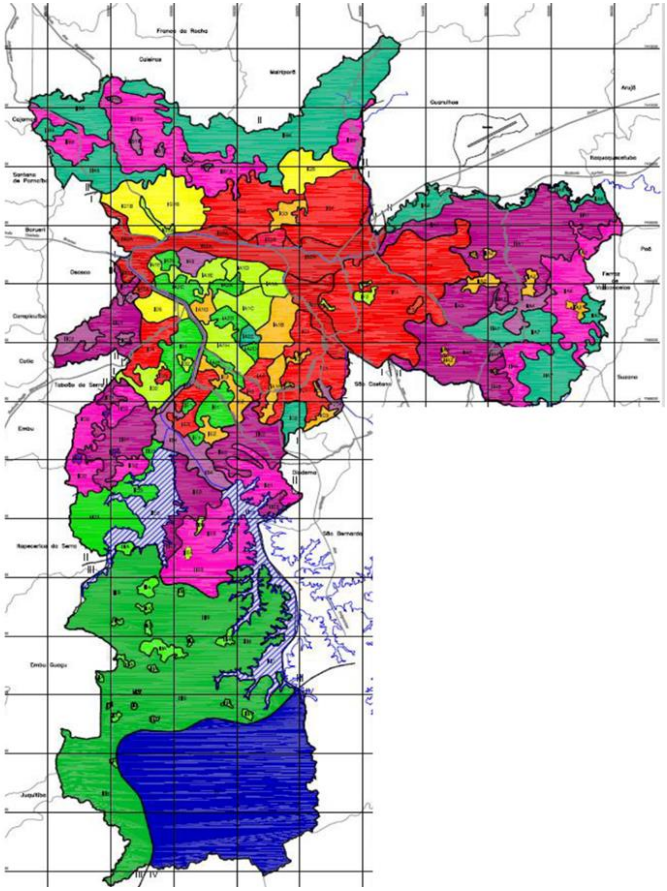
According to Romero (1988) *apud* Rossetti et al (2009), the definition of local climatic factors states that they are those conditioned by topography, vegetation, natural and built soil surface. Vegetation, specifically, stabilizes the climate effects on its immediate surroundings by reducing extreme environmental variations.

He classifies as climate elements those representing the values of each climate type, namely: temperature, air humidity, precipitation, and atmospheric movements.

The Central Urban Climate Unit presents the first urbanization process from the founding core of the city of São Paulo, and its interactions with other units described by the authors:

> The first level established is the transition from local urban climates to Urban Mesoclimate Units. The extension of the metropolitan phenomenon goes beyond the local level, encompassing the sub-regional level, involving, modifying and transporting energy, pollutants and its urban atmosphere to other local climates in the Upper Tietê basin (TARIFA & ARMANI, 2001, p. 48, our translation).

Therefore, an important factor raised by the studies presented is the transport to neighboring areas, that is, the influences that expand in the atmospheric environment by changes in air quality, temperature increases, and the action of other pollutants and particulate matter.



Climate control		Climate control												
Predominant soil usage	% of green areas	Pollution									Apparent surface temperature (target) estimated by LANDSAT 7 Satellite Thermal Band Processing (° C)			
		Part. Mat. (ug/m3)		NO (ug/m3)	O3 (ug/m3)	SO2 (ug/m3)		Smoke (ug/m3)		CO (ppm)	Sept 3, 1999 – 9:57 AM		Apr. 30, 2000 – 9:57 AM	
		Annual mean	Max (24h)	Max hour	Max (1h)	Annual mean	Max (24h)	Annual mean	Max (24h)	Max (8h)	Predominant temperature (°C)	Temperature range (°C)	Predominant temperature (°C)	Temperature range (°C)
Verticalized/ administrative (downtown)	Non-existent	54	185	851	249	17	63	61	183	10,4	28	28 – 32	28	28 – 31
Res. green district (Pinheiros)	Large	41	76	1.163	247	17	66	98	182	-	28	28 – 31	29	28 – 31

Figure 8 - The color patches show the building blocks of urban climate units. The result of these aggregates is closely linked to the green areas coverage status – on a scale ranging from non-existent (light green) to large coverage (Dark green). Of the dozens of cores, we cut out two for a brief comparison. The data also includes air pollution. Source: Atlas Ambiental de São Paulo, 2000.

Despite the little difference in average temperatures between the two chosen cores, data such as "Particulate matter and photochemical pollution (NO and O3)" show a relationship between the low green area ratio and the concentration of these pollutants.

The assessments also suggest a combined benefit of the larger vegetated area in Pinheiros, and the lower verticalization rate, in contrast with the low dispersion in the central region.

It is important to remember that this study is always presented together with the Map of natural climate units. However, in this case, the focus is on urban tree planting and its possibilities as related to the Urban Climate.

Temperature

Since it is one of the questions raised – the status of public policies applied to urban revegetation – it is important to review some concepts used here. Such an approach seeks to show methodologies for analysis (climate change reversal) of the abiotic sphere in large urban settlements, and the commitment of cities, such as the São Paulo Municipal Government, and their respective plans to reduce the effects on local microclimates.

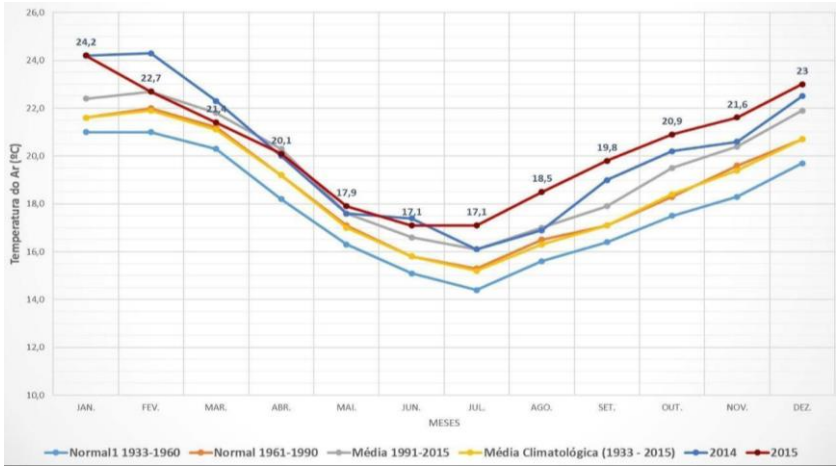


Figure 9 – Comparison of the annual mean air temperature in the city of São Paulo. Source: Astronomical and Geophysical Institute of the University of São Paulo.

Heat islands and tree planting

Spangenberg (2019) updated the concept of heat islands, comparing them to the (opposing) concept of summer oases. A few conventional building materials that are heat absorbent overheat some areas of the city more than others. Other features within the city may undergo worsening processes. According to the author:

> Particularly in low-height building neighborhoods with sky view factors (SVF), with little vegetative shade, heat islands tend to develop on sunny days, retaining and emitting absorbed energy until late at night, leading to a hot and dry (desert) urban climate" (SPANGENBERG, 2019, p. 73, our translation).

The author describes the summer oasis climate as more comfortable, typical of areas near bodies of water and significant green areas patches (parks, densely forested streets), resulting in shaded and therefore relatively cool surfaces.

Comparing temperatures between the rural outskirts of the metropolis and the densely populated city center, Spangenberg states that the differences between heat islands and summer oases can present differences between 10º C and 12º C. On the scale between urban neighborhoods, he cites such a difference would be between 1º C and 5º C, particularly when comparing parks and streets with sparse trees.

In the central and some peripheral areas, one can list: contaminated soil and groundwater, under-inhabited buildings, intense heat generation increasing the average temperature of the surroundings by reflectance and materials absorption, air aridity and dryness, and little or virtually no green areas.

Use of native species – using ecosystem services in urban tree planting

Green public spaces are the closest urban components we have to the natural habitat in which humans originated and on which they will always depend. The urban human habitat built for centuries has created problems that could be mitigated and/or healed through a design and action approach involving an analysis of the ecosystem services provided.

Complementary to ecosystem services, which are society's services to the environment, and termed by the Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária*, or EMBRAPA) as "environmental benefits resulting from intentional society interventions in the dynamics of ecosystems, such as

human activities for the maintenance or recovery of ecosystem components" (EMBRAPA, 2015, our translation), the ecosystem services we are talking about here also include benefits to humans from the management of natural ecosystems, that is, as characterized by Constanza et al. (1997), they are "functions or processes that contribute directly or indirectly to human welfare," benefits that people can derive from the functioning of healthy ecosystems.

In the Millennium Ecosystem Assessment (MEA), organized by Kofi Annan, Secretary-General of the United Nations, ecosystem services can be classified into four categories: provisioning, regulating, supporting, and cultural. The supporting service is the only one that is directly linked to the other three because it offers, as the name suggests, support for the others to happen, including the maintenance of the supply environment, such as soil quality, biodiversity assurance, pollination. The provisioning service involves the supply of basic raw materials and supplies such as food and water. The regulation service deals with climate quality (temperature, air, rain) while the cultural service offers leisure, mental and physical health, and culture (MEA, 2003).

According to Bolund and Hunhammar (1999), at least six ecosystem services are provided in green spaces, they are: air filtration, microclimate regulation, noise regulation, rainwater drainage, sewage treatment, recreation and culture, these defined pursuant to Figure 10:

HUMAN WELFARE BENEFITS	ECOSYSTEM SERVICE PROVIDED
AIR FILTRATION	Plants have high capacity to remove particulate pollutants from the air
MICROCLIMATE REGULATION	By means of evapotranspiration, it cools the temperature down and the projected shade of canopies decreases ambient temperature
NOISE REDUCTION	Capacity to absorb noise and slow wind movements
RAINWATER DRAINAGE	Potential to absorb rainwater, decreasing the proportions and quantity of floods and erosion
SEWAGE TREATMENT	Capacity to retain nitrogen and phosphorous
RECREATION AND CULTURE	Stress reduction, physical and emotional well-being

Figure 10 - Relationship between ecosystem services and human welfare benefits. Source: BOLUND and HUNHAMMAR (1999).

In general, landscape ecology also means relationships between the populations in the landscape. In an urban environment, inspired by nature, it is about driving populations to a state of balance such that the system supports all species' niches in their habitats. In the city, therefore, the challenge is to come up with similar support (resources), in a scenario of reduced territory, significant changes in the average temperature, reduction in air humidity levels (Flora), and shelter for Fauna, among other factors. If in parks with their areas of native forest these processes already exist, it is a matter of bringing such biotic relationships to (an essentially linear) urban tree planting.

Therefore, it is also clear that in tree-planting processes on streets devoid of vegetation, with a tendency to arid microclimates, the citizen-activists and the developed environmental recovery programs are the ones who play the support providing role, or resources providing support to the local flora and fauna, at first, for the tree-planted strips (management during the childhood and youth of the planted species).

Actions already mentioned such as: management projects, correct use of tree species seeking their maximum potential within the ecosystem services: individually – (aesthetic attributes such as flowering, fruits, structure), shelter for fauna – and collectively – microclimatic improvements, identification with the regional geography, suitability to the environment, among other qualities already mentioned above – are what will rise tree-lined streets to the level of biconnected streets.

We have known for some decades now that it is possible to go beyond the urban forest considered an extension of the public space gardens that provide shade and leisure, containing mostly exotic species, and basically aimed at aesthetic appreciation, (no less important ecologically speaking).

We have learned that a systemic view ensures the efficient management of information needed by the planner, and we have realized that municipal urban tree planting programs and processes of shared management with society are under the umbrella of international protocols and guidelines, linked to agencies and NGOs that promote environmental programs.

Considering Planning, Design, and Management, aimed exclusively at the implementation, promotion, and recovery of Urban Forests, organizations such as the Food and Agriculture Organization of the United Nations (FAO) have transformed a whole collection of experiences into principles and guidelines for connected cities.

FAO guidelines for urban forest management

According to FAO (2017), among the several functions of urban forests, it is worth noting the forest patch management cycle and carbon sequestration maintaining and enriching the biodiversity of forest formations in cities (Fig. 11).

Figure 11 – The urban forest management cycle. Source: FAO, 2017.

In this regard, FAO (2017) establishes three guidelines for urban forests: promotion of native species to create layers of canopy that can increase carbon sequestration; assessing existing green spaces from the perspective of ecosystem services, benefits, natural and human capital; and full, partial or sample inventory of trees in existing green spaces.

The analyses converge on the most important term for the tree planting of streets, from the viewpoint of landscape ecology: connectivity. As an example of connectivity, a bioconnecting street (Fig. 12) may have trees at 4-to-6-meter intervals for vehicle access to the lots. This distance between them makes it possible for birds to use them as a feeding corridor or pathway.

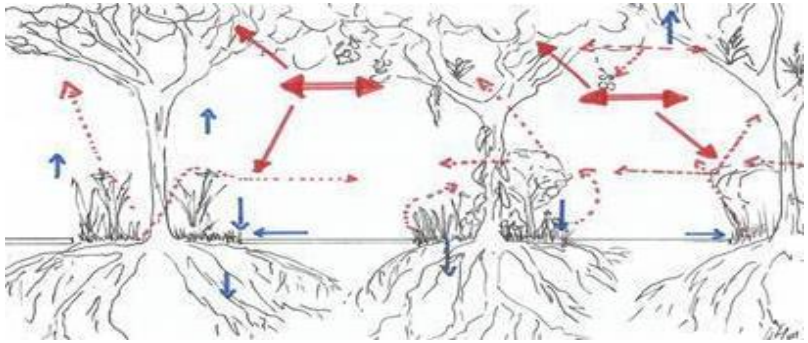


Figure 12 - Depiction of tree planting in streets. Thick red arrows indicate the path, usual height, and feeding corridor of the bird species. The thinner red arrows indicate the predation paths of insectivorous birds from the trees. The dotted red arrows are paths of the pollinating insects between the herbaceous, shrub and tree layers. Blue arrows represent the water cycle. Drafting: Sidney Carneiro Mendonça Fernandes.

This possibility of street redesign allows for more continuous spaces of inclusion of gardened areas, expanding permeable areas, creating more space for roots, and intensifying the relationships between the tree, shrub, and forage strata with the microorganisms present in the soil.

The idea is to connect existing vegetated areas and intensify the tree planting of streets re-signified as bioconnectors, taking into consideration central issues related to the Landscape Ecology present there: local biomes (Atlantic Forest Domain), soil and its biochemical cycles, vegetation (trees, shrubs, herbaceous plants) with associated microfauna and resulting organic matter, water cycle (in the subsoil, in association with vegetation, in air humidity, as a public health factor), always considering the existing urban morphology and Socio-Environmental Programs to be fostered.

The Public Authorities, together with other entities involved in this topic, have the means to carry out assessments and projections on a macro scale, so as to set actions, priorities, and targets to be pursued, such as physical and biotic characterization, diversity to be obtained in each region or city compartment, desired connections between existing massifs, fauna and flora species to be stimulated. Thus, by means of incentive programs, it is possible to incorporate local actions that will conspire to obtain results and, in the long run, will transform our understanding of a city and the involvement of each element with the whole.

Creating the possibility of collectively cultivating an urban forest that leads to landscape recovery, with the possibility of rehearsing the planning of street sidewalks use in a systemic way – in an immediate action scenario, with the optimization of urban tree planting as part of a kind of diffuse park where neighborhoods are transformed from this type of action and, later, the possibility of an expansion of the vegetated areas in the scope of the streets, winning over parking areas in the name of a renewed urban vegetation vision as green infrastructure, with valued ecosystem services and leading to a regenerative condition.

Education on different scales

Education is a paramount factor in the redesigning of the streets and the qualification of their spaces, particularly when considering that the maintenance and control of these spaces depends basically on their agents taking ownership of them.

This education includes different scales of intervention and the understanding that the importance of improving urban quality depends on everyone. Currently, there is a shared notion about the need to maintain and preserve green areas and vegetation remnants, but in a way this understanding is very much based on regulating the activities of "someone else", as if we had to stick to fighting for what has not been completely degraded, without considering that the change of attitude towards the urban space can build new forms of biotic relationships, which can be quite interesting. The current generations in general have little contact with the land, the diversity and identification of species, whether of flora or fauna, in a distant understanding of reality, but very aware of the theme of preservation of everything that is far removed from their daily lives. How many criticize deforestation without ever having planted or cared for a single tree, or worse, not noticing those that are in their daily path? What about the endless possibilities that are latent and ready to be incorporated into the urban routine?

Biodiversity education should not be restricted to the most preserved habitats but should rather include everyday life and the possibility of environmental quality whether in the school space, on the streets, or at home. Creating conditions for biotic interactions in everyday life can create possibilities and a generation that is more connected to its individual potential for intervention and family re-education, just as it already happens to a certain degree regarding water consumption and waste recycling.

In landscape design courses at architecture school, for example, it is common for students to be fascinated by the discovery, in their course, of potential elements that they had not been educated to see, such as textures, colors, and the dynamics of the vegetation present in the urban environment. It is also clear how this inability to see removes the possibility of qualifying their living spaces, by observing the differences regarding the presence of vegetation in different areas of the city, failing to find incentives for transformation, even though there are several studies on the quality of the climate and temperature in the more forested areas. It is imperative that the various disciplines, whether of architecture or engineering, incorporate the presence of vegetation in the design as an element of urban infrastructure in a more consistent way, together with other areas of knowledge, such as biology, botany, and geology, so these can become more of an element in the project's conceptions. Interdisciplinarity needs to be present in everyday life as well.

In general, the engineering or architecture professionals who intervene directly in urban spaces have an absolutely secondary knowledge of vegetation and that is not consistently present in their projects, in order not to compromise the look, or not to damage buildings, or even due to the lack of knowledge on specific characteristics, dimensions, and needs, which generally ends up consigning the topic to complementary projects that do not go hand in hand with the initial concept and are often limited to a work’s finishing touch.

Hence, the agencies comprising the Public Authorities, in addition to their competencies of regulation and control, play a key role as promoters of quality and could be more committed as proposing agents. The Public Authority has trained technical staff and the mechanisms for contracting interdisciplinary projects, and is able to propose viable long-term scenarios, so that there is a sectored plan of species and diversity which are desirable for each region of the city, appropriate to the ecosystemic interweaving between urban life, fauna, and flora. This desirable scenario or scenarios can serve as a guide for local actions, whether by the Public Authority itself, or by agents of private companies, associations or collective groups, or even by local residents.

The implementation and maintenance of urban tree planting also carries the issue of the boundaries between the public and the private spheres, just as it happens with sidewalks, which are everywhere: rich, poor, sophisticated, or common

neighborhoods, next to monuments, large buildings or the self-built houses, always keeping with the human scale in the city. Both have the Public Authority as the regulator of quality, but because of their nature, always linked to the property owner, they also allow group or private movements, since each person can collaborate in a simple and low-cost way by planting in front of his or her property, for example. Educational movements could possibly engage the population to act towards improving urban quality. Let us think about the large urban areas that lack tree planting and could be the object of planting movements in their desert streets. Urban tree planting can be linked to an implementation and awareness program, which uses the city dwellers as agents in programs such as "adopt a tree," which was an experiment in the 1970s in the city of São Paulo and that currently has ongoing initiatives in several cities. The idea of bringing the responsibility for a qualified urban environment closer to the people, along with education, would bring the population closer to environmental issues and can bring back the relationship that once existed with backyards. This type of initiative can enhance the quality of extremely arid regions of the city, through the work of local agents.

However, education at the different levels is essential, so that legislation is more than just rules to be followed, but rather, content discussed in schools at all levels, which will raise awareness for the different public and private agents.

Final considerations

The tree planting of streets and sidewalks – the public spaces in a city's everyday life – spotlights the possibility that these spaces have in playing a leading role in the intrinsic relationship between city use/enjoyment and the elements of nature, in the connection with other forested spaces or with remnants of vegetation, and all the life species around us, as well as in the role we play as agents who impact and are impacted in a more virtuous way, whether by planning and designing or simply by leading our local lives. Imagining the amount and variety of knowledge consolidated on people's doorsteps, bringing in health, purer and breathable air, amidst the dynamics of life exploding in colors, smells, and textures, is reminiscent of the city as a big garden, or perhaps of the countryside and backyards of the past, which used to be a part of people's daily lives.

Bringing the knowledge accrued on ecosystem services to urban tree planting means including in the fabric of everyday life the possibility of a more connected life in line with the environmental qualification of the urban space and the engagement of the local population with the role that each one can play for a friendlier and more pleasant city.

The possibility of using the incredible number of species present in our surroundings can lend a different infrastructure perspective to urban tree planting, one that is connected through ramifications of a system that carries the life and diversity that is so desired, permeating the entire city, sometimes with more structural and compact connections, sometimes with less pretentious and more ethereal possibilities, but all playing a role in the greater mosaic of life.

Including urban tree planting as an element of education and awareness can inform new generations to make them more connected to their role as active agents in the improvement and rebuilding of the urban environment, aware that it is not enough to preserve areas of existing or remaining vegetation, but to understand their role as builders of the environment they want to live in and bequeath as a legacy.

Being able to count on a more proactive Public Authority at the planning stage, which defines large patches of diversity and connections, can guide the local scale implementation of tree planting and revegetation policies so that they can be implemented in public work interventions, communities and even at the individual level. This close intervention in the city can bring a greater understanding of the role that each one plays in the building of our space, be it in public areas or in the privacy of the lot.

The city is the consolidation of several disciplines, and urban tree planting is an example of that. It is one of the many interfaces between architecture, engineering, and biology, where the sum of these disciplines can rescue nature as an integral part of the city and not an antagonistic element. Hence, it is necessary to understand urban tree planting as a global structure, where the small parts in the concerted local actions make up its totality.

The Public Authority, in the form of the municipal administrations, has the ideal conditions in terms of quality and quantity of information to be the Planner/Proposer of policies that will permeate the coordination of the afforested spaces, or those to be afforested, in order to propose the ecology to be applied to the urban environment as a overarching theme, capable of encompassing the large variety of activist movements and keeping in close contact with the local organized communities,

reaching out to the citizens day after day, through methodologies in line with the multiple realities of the São Paulo city universe, in a clear and objective way.

This is the moment to simplify the scientific language, making it accessible to everyone, indiscriminately, in order to create an easy and efficient reading code that turns the urban environment, from regional to local, into a friendly environment to the trees of the Atlantic Forest Biome, repairing a historical gap in the cultural repertoire of the City's population. Its succession system should be an inspiring element of clear, efficient and educational objectives for the participants of tree planting programs. In time, the transforming Culture universe may come – a universe that, indeed, brings together the best expectations.

Among the many urgent issues linked to educational practices in urban tree planting, the breaking down of barriers that limit the perception of how we use inhabited spaces (currently aseptic, "private", compartmentalized and surveilled in the worst sense of the word) is expected. To that end, it should be something like a system that dissolves the differences between City and Nature through a continuum of life, that is, a guiding principle for the ailing spaces in the city.

Spotlighting the nature that surrounds us in our daily lives allows many people to understand that it is not hundreds or thousands of kilometers away, but all around us, yielding the best benefits to the microclimate, air quality and the fauna and flora within of our cities. Showcasing the nature in the city means promoting environmental awareness and the perception that each one is a part of the whole.

Referências

BOLUND, P. HUNHAMMAR, S. Ecosystem Services in Urban Areas. **Ecological Economics**, no. 29, 293-301. 1999. Available at: http://www.fao.org/uploads/media/Ecosystem_services_in_urban_areas.pdf. Accessed 07/25/2021.

COSTANZA, R., D'ARGE, R., DE GROOT, R., FARBER, S., GRASSON, M., HANNON, B., LIMBURG, K., NAEEM, S., O'NEILL, R., PARUELO, J., RASKIN, R., SUTTON, P., VAN DEN BELT, M., 1997. **The value of the world's ecosystem services and natural capital**. Nature Magazine 387 (15), 253–260.

EMBRAPA, **Serviços Ambientais em Sistemas Agrícolas e Florestais do Bioma Mata Atlântica**. Distrito Federal, Brasilia, 2015.

FAO (Food and Agriculture Organization of the United Nations), 2016. **Directrices para la silvicultura urbana y periurbana**, por Salbitano, F., Borelli, S., Conigliaro, M. y. Chen, Y. 2017. FAO Studio: Montes No. 178, Rome, Italy; Available at: http://www.fao.org. Accessed on: 07/15/2021.

MEA. **Millennium Ecosystem Assessment**. Ecosystem and Human Well-Being: a framework for assessment. Washington: Island Press, 2003.

NACTO. **National Association of City Transportation Officials**, Available at: https://nacto.org. Accessed: 07/15/2021.

PAIVA, L. Afastar pedras do caminho e plantar árvores no asfalto. Quando Fernando Haddad adotou solução urbanística de baixo custo. **Minha Cidade**, São Paulo, year 18, n. 212.03, Vitruvius, mar. 2018. Available at: https://vitruvius.com.br/revistas/read/minhacidade/18.212/6919. Accessed: 07/05/2021.

ROSSETTI, A. I. N. PELLEGRINO, P. R. M. TAVARES, A. R**.; O Espaço na Cidade de São Paulo e sua interface com a arborização: aspectos da transformação socioeconômica do sítio físico e da proteção de vegetais de porte arbóreo.** Article: Revista da sociedade brasileira de arborização urbana - REVSBAU, Piracicaba – SP, v.4, n.1, p.21-38, 2009. (received on 09.03.2008 and accepted for publication on 03.19.2009). Available at: https://www.researchgate.net/publication/332822348. Accessed: 07/20/2021.

SAO PAULO (City). **Atlas ambiental do município de São Paulo.** Fase I: diagnósticos e bases para a definição de políticas públicas para as áreas verdes do Município de São Paulo**.** Administered by: Harmi Takiya. Final report, July / 2002, Prefeitura do Município de São Paulo. Available at: https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/meio_ambiente/ATLAS%20AMBIENTAL-compactado.pdf. Accessed: 07/28/2021.

SÃO PAULO (City). Law 13.430, of September 13, 2002. Plano Diretor Estratégico. **Diário Oficial do Município de São Paulo**. São Paulo, SP, September 14, 2002. p. 1.

SÃO PAULO (City). Law 16.050, of July 31, 2014. Aprova a política de Desenvolvimento Urbano e o Plano Diretor Estratégico do Município de São Paulo e revoga a Lei nº 13.430/2002. **Diário Oficial do Município de São Paulo.** São Paulo, SP, August 1, 2014. Supplement.

SÃO PAULO (State). **Vegetação Significativa do Município de São Paulo**. São Paulo: Secretaria do Meio Ambiente/Secretaria Municipal de Planejamento, 1988, 560p.

SPANGENBERG, J. **Natureza em Megacidades: Serviços Ambientais da Floresta Urbana.** São Paulo - Editora da Universidade de São Paulo, 2019.

TARIFA, J.R & ARMANI, G. in TARIFA, J.R. & AZEVEDO, T.R. de (Org.). **Os climas na Cidade de São Paulo – teoria e prática**. São Paulo GEOUSP - Coleção Novos Caminhos - 4, FFLCH USP; 2001.

WRI Brazil - **World Resources Institute**. Available at: https://wribrasil.org.br/pt/o-que-fazemos/projetos/ruas-completas. Accessed: 07/18/2021.SÃO PAULO (Cidade). Lei 16.050, de 31 de julho de 2014. Aprova a política de Desenvolvimento Urbano e o Plano Diretor Estratégico do Município de São Paulo e revoga a Lei nº 13.430/2002. **Diário Oficial do Município de São Paulo. São Paulo**. São Paulo, SP, 01 de agosto de 2014. Suplemento.

SÃO PAULO (Estado). **Vegetação Significativa do Município de São Paulo**. São Paulo: Secretaria do Meio Ambiente/Secretaria Municipal de Planejamento, 1988, 560p.

SPANGENBERG, J. **Natureza em Megacidades: Serviços Ambientais da Floresta Urbana.** São Paulo - Editora da Universidade de São Paulo, 2019;

TARIFA, J.R & ARMANI, G. in TARIFA, J.R. & AZEVEDO, T.R. de (Org..). **Os climas na Cidade de São Paulo – teoria e prática**. São Paulo GEOUSP - Coleção Novos Caminhos - 4, FFLCH USP;2001

WRI Brasil - **World Resources Institute**. Disponível em: https://wribrasil.org.br/pt/o-que-fazemos/projetos/ruas-completas. Acesso em: 18/07/2021