**Hungarian University of Agriculture and Life Sciences**

Institute of Landscape Architecture, Urban Planning and Garden Art

# The role of vegetation in open spaces in urban health and social well-being. Evaluation of greenspaces in Campo Grande and Budapest

Ph.D. dissertation

by

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## LIST OF ABBREVIATIONS

| **Abbreviation** | **Definition** |
|---|---|
| BDA | Biophilic Design Approach |
| BP | Budapest |
| BR | Brazil |
| CG | Campo Grande |
| GSA | Green System Approach |
| HU | Hungary |
| UGS | Urban Greenspace |
| UGSs | Urban Greenspaces |
| UHI | Urban Heat Island |

# 1. INTRODUCTION

*"The more artificial a human environment becomes, the more the word 'natural' becomes a term of value."* - Wendell Berry, environmental activist.

## 1.1 Preamble

Humankind, the *Homo sapiens,* have been living in groups since the dawn of days as shown by countless published research, with safety being pointed as the main reason for it. Back then *Homo sapiens* were nomads, hunters and collectors surviving from what they could gather from nature. Circa 300,000 years ago, humans learned how to create and control fire, which enabled the preparation of hot meals, provided warmth during winter and safety from predators. Afterwards, around 12,000 years ago came the Agricultural Revolution with the domestication of plants and animals, leading to the first permanent settlements (Harari, 2014). Withing this context, it is viable to say that humans went from living and being part of nature to starting the process of stablishing themselves and modifying their surroundings, creating early settlements and later establishing the first kingdoms around 5,000 years ago (Fuller et al., 2019; Mazurowski et al., 2009).

From that point onwards these settlements, or agglomerations, kept evolving and developing into an ever-changing complex organism. From settlements to villages, to roman villas, to cities, to metropolis, megalopolis and so on. Many are the factors that should be considered when analysing how these settlements took shape over time, such as the geographical and geological aspects, natural resources, socio-economic aspects, culture, religion, among others (Ben Salem, 2021). However, in the past decades these changes and growth have been occurring with such an unprecedented pace that cities and communities are losing their essence, character, historical and cultural value, and most importantly their ecological value (Andersson et al., 2007; Bolund & Hunhammar, 1999; Williams et al., 2000). Humankind moved from nature to a highly built environment, leaving little to no space for greenspaces in some cities.

## 1.2 Importance and relevance of the topic

Two historical events can be considered as defining moments for humankind evolution. The first was the domestication of fire and the agricultural revolution, as aforementioned. The second, and perhaps the most drastic one in the context of urban development, was the industrial revolution. During the $19^{th}$ century the Industrial Revolution intensifies urbanization by attracting a larger number of people to the urban centres, a phenomenon known as rural exodus. Amongst demographers and historians, rural exodus is considered to have been one of the key forces behind the development and the urbanization of European economies (Saville, 2013; van der Woude et al., 1995), therefore creating and/or enhancing urban pressure.

The transitional phenomenon of the industrial revolution made significant and irrevocable changes in the socio-economic structure, city morphology, land use, ratio between natural and built spaces, relation to the space and space use and, most importantly population size, aggravating urban pressure (Ben Salem, 2021). This relation is well described by Kasri (2018, p. 21 cited in ben

Salem, 2021) when she writes that "The industrial and technological revolutions of the early 19th century had a considerable impact on the development of societies and the expansion of cities. However, through their all-embracing approach rooted in the spirit of imperialism and globalisation, they have brought out the problem of the context and relation to the place."

Understanding the historical overview is essential in order to better portray the relevance of greenspaces in urban landscapes, especially in a world where less and less greenspaces are present in big urban centres (Hutyra et al., 2011; Seto et al., 2012). In present times, the growth crisis can be related to societies incapable of perceiving different solutions rather than capitalism and productivism, considered key causing factors. Hence this is reflected in today's economic and political structures, in the environment, energetic resources management and socio-cultural identity (Ben Salem, 2021; Liegey et al., 2013). Additionally, the aforementioned can be considered influences on urban greenspaces and how people interact with such as well, reinforcing Rogers' (2019) claim that humans have an innate connection and need for nature. This appreciation is often invoked as evidence of biophilia, and it can be seen as a growing movement or design/planning trend where its purpose is to bring nature back to the urban environment, increasing the greenery and biodiversity level in a sustainable and active way.

### 1.3 Problematic

Identifying and factoring the relevant problems of a specific topic is of extreme importance and urgency, thus for this research is the lack of properly planned and maintained greenspaces in urban environments, focusing on the vegetation. Nowadays cities are becoming congested and polluted in an ever-increasing pace (Blanco et al., 2009) due to the unremitting and disorganized urbanization processes. According to the study published by the United Nations' Department of Economic and Social Affairs (UN DESA), in 2018 an estimate of 55.3% of the world's population lived in urban areas, a proportion that is expected to increase to 60% by 2030 and 68% by 2050 (United Nations, 2019). Whilst these statistics are growing, considerable research attention has been drawn towards the issue of urban greenery i.e., greenspaces, urban forests, greenways, promenades, vegetation in general - provided their fundamental role in the cityscape and urban health (Endreny et al., 2017; Lohr et al., 2004).

Due to these reasons, environmental and social problems are presenting themselves every day owing to the increased urban pressure. Further factors of utmost importance to be accounted for are climate change and other climatic and environmental challenges independent, although related to climate change, such as: urban heat island effect, air pollution and existing climate extremes, such as hurricanes and typhoons. Furthermore, the radical socio-economic changes related to the pandemic that started in 2020 worldwide and which deeply affected not only society's behaviours and customs, but humans' relation and/or desire for nature, need to be accounted for.

Focusing on the Brazilian case study chosen for this research, by observing and analysing the urban context of Campo Grande city in search of the problematics, four main issues could be defined: the ever-increasing and disorganized urban sprawl alongside the negative effects imprinted on the urban health, the knowledge gap on national and local literature, the lack of landscape architectural design in most urban greenspaces, and the lack and/or minimal available information on endemic and applicable species. These factors together can create a hazardous scenario for local communities, the cityscape, and all inhabitants, hence the need to research for solutions to minimize them.

### 1.4 Research aims and questions

It has already been proven that urban greenspaces can impact the environment and well-being in urban centres, such as with the improvement of air quality, decrease in temperature and the hability to provide an overall positive impact to daily life and wildlife habitat (Nowak & Dwyer, 2007; Scott, 2015). Furthermore, some research shows that greater biodiversity in such spaces can greatly increase the psychological benefits provided by greenspaces (Fuller et al., 2007).

In this perspective, the two main objectives of this study are to better understand how urban transformation and urban greenspaces affect urban health and social well-being; Strategize how to improve and/or create new urban greenspaces adapted to contemporary social needs and environmental challenges, for increased optimal benefits enhancing urban resilience. The main aim consists on addressing these issues with a planting design approach focusing on the vegetation, seeking to understand the negative effects of negligent or non-existing planting design as well. Additionally, it searches for ways to disseminate the acquired knowledge to all stakeholders.

Based on the above dilemmas and queries, this study presents the following hypothesis:

*Greenery alone is not enough.* Urban greenspaces need careful and thoughtful planning, with a multidisciplinary strategy. A probable and efficient approach could be to *direct more attention and greater importance to planting design and maintenance, increasing biodiversity and aesthetics.*

In order to address and confirm the hypotheses, this study puts forth four main research questions (and their sub-questions). These were formulated to be both theoretical and practical questions, the latter being related to the case studies of urban greenspaces in Campo Grande and Budapest:

1. **How do urban greenspaces affect urban health and social well-being?**
    a. What are the aspects of a healthy greenspace?
    b. Is the current design functional and biodiverse or merely aesthetical?
    c. Which factors should be excluded and modified to create valuable and stable greenspaces?
2. **What to consider when analysing urban greenspaces from a planting design perspective?**
    a. What is the character of the applied taxon?
    b. What are the maintenance situation and requirements?
    c. What are the direct and indirect effects of vegetation on UGS?

3. **What methods and strategies can be adopted in order to improve the urban greenspaces?**
    a. Which species can be more introduced to increase biodiversity?
    b. Which species should not be considered for city usage?
    c. How to plan the upgrading of UGS into a healthier space?
4. **Are there any methods, practices and identified species that can be transferable from one city to the other?**
    a. Why is it important to sample areas in both cities?
    b. What are the similarities and differences expected?
    c. Why does a negative or positive evaluation from one city might be of value to the other?

On the whole, this research is a step towards enhancing the understanding of planting design in the sites of the case study and their implications, therefore enabling the elaboration of proposals and guidelines on how to improve such open spaces, focusing on the greenspaces in Campo Grande. As a result, possibly contributing to the increase of urban greenery in the future, in a city level further, moving towards greener, more liveable and resilient cities.

# 2. LITERATURE REVIEW

*"Landscape is a spectrum, from intangible subjective nature related cognition to tangible human-altered nature."* - Feng Han, landscape studies professor.

Pursuing the resolution of the previously mentioned scientific problems, three main areas of the literature were tailored for the purpose of this study. The first subchapter (2.1) presents the context of urban landscapes, from an early perspective on its development to a deeper understanding of the intricate elements it is composed of, focusing on urban greenspace description and typologies. In addition, the biophilia hypothesis is presented and analysed being further applied to the methodology of this research. The second subchapter (2.2) comprises the effects of greenspaces on urban health and social well-being, presenting the benefits for both physical and mental health. The third and last subchapter (2.3) focuses on the role of planting design to the aforementioned, as well as glancing on the aspects of biodiversity, sustainability and aesthetics as factors to be considered. Overall, these are proposed as essential in order to improve urban health and social well-being.

## 2.1 The context of urban landscapes

To understand the meaning of urban landscapes it is first necessary to answer the question: *what is landscape?* The word can simply mean a picture of nature which can be seen from a distance (Mansouri, 2005). As observed and concluded by Wylie (2011), there are three ways of understanding landscapes in a general perception. The first is the sense of the 'world around us', built or natural, especially the outdoor world. The second way is seeing landscape as a visual depiction of a view or scene such as landscape photography, painting, art, picture and so on. The third and final definition according to him would be landscape related to design, landscape practice, architecture and gardening. According to the studies of geography landscapes can be describe as "the combination of environmental and human phenomena that coexist together in a particular place on Earth's surface" (Tschakert et al., n.d.).

Considering that the meaning of landscape is a combination of these definitions and many others presented by respected scholars (Cosgrove, 1985, 2004; Gombrich, 1971; Hirsch & O'Hanlon, 1995; Kirchhoff & Trepl, 2015; Leuprecht, 1996; K. Olwig & Olwig, 2002; K. R. Olwig, 1996, 2004), an undeniable conclusion presents itself where landscape is closely related to humans and their perception of space. Thus, there is no landscape without humans since, according to Wylie (2011, p.302) "Landscape is both the phenomenon itself and our perception of it". In 1968 the Hungarian landscape architect Mihály Mőcsényi officially defined landscape as a anthropo-sociocentric concept, both a "cultural product" and "humanized nature". These observations also undertake the principles of The European Landscape Convention - ELC, where "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (COE[1], cited in Pedrazzini, 2017).

[1] COE - Council of Europe (2000)

In this perspective, urban landscape can be described as a sub-division or type of landscape. Moreover, in present days the perception of landscape is changing due to the ever-growing city structures and advancements in technology, resulting in an imbalanced human-environment coexistence where the "natural" landscapes are becoming scarcer, together with the constant modification in urban scenarios, defining the city as a landscape (Turner, 1996). In addition, as described by Szilagyi (2015), urban landscape is not a new concept in urban planning.

### *2.1.1 Laconic overview on urban development*

As mentioned in the previous chapter, human beings lived a nomadic life as hunter-gatherers in its primitive times, which meant living in close connection to nature (Kellert & Wilson, 1993). With the evolution from the first settlements, cities have evolved over thousands of years being shaped by social, economic, political, and environmental factors (Hall, 2001; Mumford, 1961). People began developing networks of urban areas, thus creating the first civilizations between 4.000 and 3.000 B.C.E. in Mesopotamia, what is now known as Iraq. Some declined and were extinguished, while others thrived. Anthropologists suggests that both natural disasters and the misuse of the environment could have contributed to their decline (Diamond, 2005; Redman, 1999; Steffen et al., 2007).

When cities started to become congested and with poor or inexistent sanitation solutions, the Romans were the first civilization to acknowledge the benefits of having rural features within a city such as lakes, spaces for leisure and recreation, and urban villas in greenspaces known as '*horti'*. This desirability for nature was considered a symbol of civilization and a promoter of health and well-being (Livius, 2017; Millar, 1998; Vitruvius Pollio, 1999). In addition, to describe this trend they created the concept of *'rus in urbe'* or 'the country in the city', a term still being used in Britain (Rudd-Jones, 2015). In contrast, the 19$^{th}$ century brought unprecedent changes with the industrial revolution, transforming the urban landscape and the urban experience as factories, railways, and other new technologies reshaped the physical and social fabric of cities (Dyos, 2000), rapidly intensifying urbanization and greatly enhancing urban pressure. As a result, urban centres were over populated, poorly organized and lacking basic infrastructure (Berg & Hudson, 1992; Nardinelli, 2019).

The need for better sanitation and open spaces led non-conformists in Great Britain, both politicians and philanthropists to initiate movements to improve the life of city dwellers through better sanitation and creation of open spaces (Rudd-Jones, 2016). Stemming from this collective action, in the 1830s the Public Parks Movement starts to arise in Great Britain with the 'Report of the Select Commission on Public Walks' being published in 1833, advocating for the provision of public parks in urban centres as a crucial factor in improving urban health (Rudd-Jones, 2015). When the 19$^{th}$ century drew to a close, the Progressive Movement is registered in the United States from the 1890s to the 1920s, as the cities' demands for public sanitation accelerates, emerging as a response to the problems raised by the rapid industrialization and urbanization (Cain & Rotella, 2022; Library of Congress, n.d.). This was the dawn of the first concepts of city planning with the emergence of new concepts and approaches to urban planning, including the idea of comprehensive planning, the use of zoning to regulate land use, and the creation of public parks and open spaces (Mohl, 1997). Later this transition reflected society as a whole, as presented in Rudd-Jones' (2015) analysis where he observed the urban environment changes being referenced even in literature, to which he points out that "whereas the romantics tended to use nature as a means of looking into their own soul in solitude – a sort of 'reflective intro-spection', these urban explorers were the reverse – they used their journeys to look out at the masses – a sort of 'extra-spection".

Thereafter, greater attention was directed towards such needs. According to Le Corbusier (2010), urban planning should be based on scientific principles and be carried out by experts. He further argues that the creation of greenspaces, such as parks and gardens, is essential for the well-being of urban residents, to which the quality of a city's public spaces is crucial to its livability and success (Lynch, 1964). Nevertheless, in the 21st century cities are still becoming more congested in an ever-increasing pace (Glaeser, 2014). On the other hand, natural solutions have been widely investigated in recent scientific studies in order to plan more nature-like urban landscapes, in addition to urban regeneration becoming a matter of political priority in some countries (Vento, 2017). Even though this cannot be considered a unanimous belief, it is viable to say that society is bringing forth multidisciplinary strategies to move towards greener and more liveable cities.

### *2.1.2 Elements of an urban landscape*

Many are the elements composing the urban landscape, and it can be stated that the urban structure comprises buildings and the overall infrastructure. Urban functions include waste collection and delivery of resources, and regarding dynamics it includes variations in building stock and development of new transportation corridors (Pickett & Cadenasso, 2008). Nevertheless, not only human related elements should be considered but other living elements and ecological processes as well, owing to their important role on the function, structure and dynamics of urban ecosystems. For instance, Ridd (1995) states that the elements composing the urban structure is the combination of surfaces, buildings, and vegetation. Hence, as proposed by Cadenasso et al. (2007), these three components reflect human agency.

From another perspective, the elements comprising the urban landscape can be classified into two categories: soft and hard elements. Soft elements encompass the organic components of the landscape, such as trees and other vegetation type that requires time to mature and is dependent on climatic factors. In contrast, hard elements are the man-made streetscape composed of non-organic things which is effectual once constructed and it is independent of climatic factors. Tiling and street furniture can be examples of hard elements on the urban landscape (Hussaini bin Wahab, 2018; Motealleh et al., 2017). Furthermore, there is an essential element that can be comprised within both categories: water. As a soft element, water can add movement and visual interest with the use of fountains, water walls, and other water features to create dynamic and engaging open spaces, while bioswales and rain gardens can be used to manage stormwater and provide ecological benefits (Ahern, 2007; Haris et al., 2016), creating more naturalistic and visually appealing urban environments. In contrast, as a hard element water can be used as a physical boundary or barrier, like a river or canal that separates different neighbourhoods or districts. In this sense, water is a fixed, permanent feature that is used to structure the urban landscape and can be difficult to modify (Gandy, 2014).

However, not only the tangible aspects should be considered as elements of urban landscapes. It is of utmost importance to include its inhabitants as well, seeing that the relationship between the environment and humans is dynamic and reciprocal, and the landscape has a pivotal role in increasing life quality (Motealleh et al., 2017). Within this context, the relation and ratio between all of these elements are key factors for a healthier and more resilient urban environment. Moreover, for the purpose of this research the study of surface and vegetation elements will be prioritized, with a greater focus on urban greenspaces.

### *2.1.3 Urban greenspace*

A greenspace can be simply described as a surface covered with some sort of vegetation (Warren, 1973), therefore being considered biologically active surfaces. However, in a systematic review and meta-analysis of 125 journal articles related to this topic, Taylor & Hochuli (2017) concluded that less than half of the articles provided a definition of what greenspace was in relation to their study, although many implied a definition. Within the ones which provided one, six different characterizations were found. Nevertheless, instead of suggesting one single and universal definition for greenspace, Taylor & Hochuli propose that "researchers construct a definition of greenspace for the context of their research that utilises both qualitative and quantitative aspects" (2017, p. 25). Hence the goal of this subchapter is to provide the applicable definition relevant to the objectives of this study.

Various research has been done about vegetated greenspaces and its benefits, but alternatively some used the term applied to non-vegetated land, such as "green space bipropellant" which refers to an environmentally-friendly design of space propulsion (Kang et al., 2016). For this reason, instead of using the term as a noun phrase where 'green' gives a quality to 'space', this research concentrates on the one-word compound as it has a distinct meaning and it is easier to distinguish from a noun phrase (Verhoeven & van Huyssteen, 2013). This is clearly exemplified by Taylor & Hochuli (2017) when they write that a greenspace is more than just a place with greenery, it is rather a combination of multiple factors that create a beneficial and enjoyable environment. Nonetheless, the two-word term 'green spaces' will still be present throughout this research in cited literature.

Regarding categorization greenspaces can vary in size, type, vegetation coverage, number and type of species, environmental quality, and location in the urban fabric. For a more systematic approach, greenspaces can be divided into two categories: public and private. Public greenspaces include parks, cemeteries, sporting fields, natural reserves, streams and riverbanks riparian zones, trails, greenways, street trees, conservation areas, green walls, trails, community gardens and alley ways (Roy et al., 2012). On the other hand, private greenspaces can include communal grounds of apartment buildings and corporate campuses, or private backyards (Wolch et al., 2014). In further studies, Rudd-Jones (2016) proposes six main categories of urban greenspaces: ‘Tended’ greenspaces for pleasure; ‘Tended greenspaces for use; ‘Un-tended’ greenspaces; Water features; ‘Natural’ greenspaces; ‘Controlled’ greenspaces.

Urban greenspaces have oftentimes appeared resulting from discontinuities in cities, opposed to its organic development. In contrast, nowadays a great amount of such spaces is designed for a specific function and they provide a sense of creating ‘a living city’, being a central part of everyday life (Rudd-Jones, 2016). Within a broader context, three categories of greenspaces can be defined: for production, for protection and for regeneration, including climate adaptation, enhancing life conditions and recreation options. Greenspaces for production are agricultural lands, forestry, vineyards, fields, grasslands, meadows, to cite a few. Regarding greenspaces for protection, there are nature reserves and environmental protection sectors. As for greenspaces for regeneration, parks, gardens, alleyways and planted promenades can be some examples (Nagy & Almási, 2018). A further possible classification for greenspace analysis is concerning structure, in which there are compact elements, being two dimensional spaces measured in meters square, and linear elements. The latter are two-dimensional spaces as well but measured in meters length, such as promenades, alleyways, greenways, among others (Pereira Rosa, 2019). This study focuses on public greenspaces, consisting of both linear and compact elements, with greater emphasis on the latter.

### *2.1.4 The biophilia hypothesis and biophilic design principles*

The term biophilia was coined by Erich Fromm in 1973, a German-born American psychoanalyst who described it as “the passionate love of life and of all that is alive” in his study about the anatomy of human destructiveness (Rogers, 2019). In 1979, the American biologist Edward O. Wilson applied the term in his research for the first time in an article by that title published in the New York Times Book Review. Afterwards, Wilson became a reference researcher in this field with his book *Biophilia* published in 1984, where he proposes the idea that biophilia is “the innate tendency to focus on life and lifelike processes” (Wilson, 1984, p.1). In 1993 he further explores the theme together with other authors with a multidisciplinary approach in the book titled *The Biophilia Hypothesis*, explaining that biophilia “is the innately emotional affiliation of human beings to other living organisms. Innate means hereditary and hence part of ultimate human nature” (Kellert & Wilson, 1993, n.p.). Wilson makes a bold claim as his definition of biophilia consists of two main hypotheses: firstly, that humans have this inherent connection with nature, secondly that this might be in our genes due to evolution.

Despite the theoretical and empirical evidence that has been presented in support of this hypothesis thus far, it certainly involves many daunting assertions, and the research is at a relatively early stage of development. Owing to this, Kellert & Wilson (1993) emphasize that it is presented as a hypothesis in order to avoid claims that their exploration is an attempt to romanticize the idealization of nature. Furthermore their research varied in topics so as to analyse a multitude of factors, including the “role of nature in human cognitive and mental development, the biological basis for diverse values of nature, the evolutionary significance of the human aesthetic response to varying landscapes and species, the sociobiological importance of human altruism and helping behaviour, and the role of nature in human emotional bonding and physical healing, to mention but a sample" (Kellert & Wilson, 1993, n.p.). Hence, the results and benefits presented in multiple areas, encompassing the human craving for aesthetic, intellectual, cognitive, and even spiritual meaning and satisfaction. For the purpose of this research the use and discussion of biophilia concentrates on natural physical environments.

According to Jignesh (2018) we co-evolved from nature, therefore having nature in our lives is not optional but mandatory. In this perspective, Beatley (2011) claims that biophilic cities could be a key strategy in green urbanism, as it is the connection with and design in nature within cities. He additionally defines biophilic cities as "a city that puts nature first in its design, planning, and management; it recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural systems" (Beatley, 2011, p.45). Beatley further elucidates that besides the similarities with green urbanism, biophilic cities are more than simply a biodiverse urban space, but rather a place that learns from nature and mimics natural systems, in addition to incorporating natural forms into architecture, designing and planning with nature. Seeking to further elaborate the topic on how to apply the biophilia hypothesis in landscape, architecture and urban planning, biophilic design principles have been elaborated and proposed by researchers in the past decades, especially by its pioneer Stephen R. Kellert. Notwithstanding, it is important to note that this field of research is still evolving, and different researchers and experts may emphasize different principles.

In his book '*Biophilic Design: The theory, science, and practice of bringing buildings to life'*, (Kellert et al., 2008) emphasize the integration of nature into the built environment to enhance human well-being. Based on multidisciplinary research regarding the positive effects of biophilia, they propose the following elements of biophilic design: Environmental features; Natural shapes and forms; Natural patterns and processes; Light and space; Natural ventilation and airflow; Biomorphic forms and patterns; Connection to natural systems; Complexity and order; Prospect and refuge; Evolving and changeable environments. Furthermore, they present strategies on how to implement biophilic design, such as by incorporating and maximizing natural light, providing views of nature, integrating natural materials to create a sensory connection with nature and evoke a sense of warmth and authenticity, incorporating vegetation both indoors and outdoors, introducing water features, creating nature-inspired patterns and textures, designing sensory experiences, supporting biodiversity, and creating opportunities for learning and exploration. These design strategies aim to foster a stronger connection between humans and the natural environment, promoting well-being, productivity, and a sense of harmony within architectural projects (Kellert & Calabrese, 2015). In addition to Kellert's and other works related to biophilic design and spatial patterns, Browning et al. (2014) proposes 14 patterns of biophilic design, which will be further elaborated in the next chapter (3.2).

Biophilia-informed design might be mistaken for ecological planting design, hence the importance of highlighting their differences and relevance to urban planning. Both approaches aim to create more sustainable urban environments, but they have different goals and focus on different aspects of nature. Differing from the biophilic design aspects presented thus far, ecological planting design is focused on the ecological functions of plants and seeks to create landscapes that support biodiversity conservation, provide ecosystem services and integration, sustainable resource use, regenerative approaches, lifecycle thinking, and resilience to climate change. This approach emphasizes the use of native plant species and ecological principles to create landscapes that are self sustaining and require minimal maintenance (McCormack, 1991). While ecological planting design and biophilia-informed design have different goals, they can be complementary strategies to create more sustainable and livable urban environments. By incorporating ecological principles into biophilia-informed design, it is possible to plan landscapes that support biodiversity and provide ecosystem services while also promoting urban health and social well-being (Ahern, 2022; M. Hunter, 2011).

However, contrary to all the arguments presented in this chapter, this connection with nature cannot be assumed unanimous among all human beings. The aversion to nature is known as biophobia and, according to Orr (1993), this is a phenomenon increasingly common among people raised with technology excess such as television, video games, Walkman radios, or people living amidst dense urban or suburban environments where nature is used solely as decoration. According to him, “biophobia, in short, is the culturally acquired urge to affiliate with technology, human artifacts, and solely with human interests regarding the natural world [...] as well as those who regard nature ‘objectively’ as nothing more than resources to be used any way the favoured among the present generation see fit” (published in Kellert & Wilson, 1993, n.p.). Orr concludes by saying that biophobia is a hazard since it is the foundation for a politics of exploitation and domination.

## 2.2 Efficacy of urban greenspaces

### *2.2.1 To urban health*

Publications about greenspace efficacy have increased since the turn of the century, with a growing interest in the impacts of ecosystem functions and biodiversity and the benefits they can provide (Taylor & Hochuli, 2017). This could be partly due to a human divergence from the natural world that happened with the technological advances and rapid urbanization in the 19$^{th}$ and 20$^{th}$ centuries, which radically changed human interactions with nature (Rogers, 2019). Researchers of biophilia, to exemplify, claim a sense of urgency on such research based on their conviction that the modern onslaught upon the natural world is partly driven by the alienation from nature, in a certain degree. They further allege that the current environmental crisis is considered the symptom of a fundamental rupture of human spiritual and emotional relationship with the natural world (Kellert & Wilson, 1993).

As a result of urbanization, an increasing percentage of the population lives in cities, supressing the existence or access to nature, resulting in an increased exposure to certain environmental hazards like noise and air pollution (Gurjar et al., 2008), increasing impacts of climate change (Dasgupta et al., 2013) and urban pressure, to mention a few. By addressing these challenges cities can provide healthier and sustainable living environments, thus urban greenspaces or other nature-based solutions can help increase urban health and enhance resilience, in addition to making cities more liveable and enjoyable (Hartig et al., 2014; WHO, 2017). Research about the benefits supplied by greenspaces is not new, hence they were recognised in British towns as early as the $17^{th}$ century (Rudd-Jones, 2015). Evidently, in modern days there is no question if they are beneficial but rather how they are contributing to a healthier urban environment.

Urban air pollution consists of gases and tiny particles called ‘particulate matter.’ According to scholars, shrubs and trees have the capacity to remove both particles and gases from the air, therefore having urban vegetation can result in an overall improvement of air quality by reducing pollution (Nowak et al., 2000, 2006; Pugh et al., 2012; Scott, 2015). Temperatures in urban centres are typically higher than in the surrounding rural areas, fact that coined the term urban heat island effect (UHI). This occurs because cities are being built with materials that absorb more sun energy than natural surfaces, and as a result heat waves are becoming increasingly constant and with higher temperatures (Heaviside et al., 2017; Oke, 1982; Scott, 2015). Urban greenspaces can ameliorate the effects of UHI (Santamouris, 2014; Tzoulas et al., 2007) by cooling the air through the process of evapotranspiration and providing shade, being on average $1^{o}$ C cooler than built-up areas (Bowler et al., 2010). Moreover, Yu & Hien (2006) present that the cooling effect can extend to the surrounding urban areas, therefore being able to reduce energy use associated with air conditioning during summer in nearby buildings (McHale et al., 2007). Additionally, plants in greater quantities can also help mitigate elevated temperatures by reducing the amount of carbon dioxide ($CO_2$) in the atmosphere with the process of carbon sequestration.

Modern technology has been creating countless types of pavement materials, nevertheless the majority being used in urban areas for pavement and roads are impermeable, meaning that rain cannot be absorbed and remains on the surface (Pauleit & Duhme, 2000), which leads to flooding in periods of heavy rainfall. Furthermore, according to Ellis (1991) high levels of surface water can transport pollutants from surfaces and into water courses, being destructive to water quality in rivers, streams and lakes (Characklis & Wiesner, 1997). In contrast, vegetated surfaces can store and intercept water (Asadian & Weiler, 2009; Sanders, 1986), reducing the volume of rainwater run-off (Scott, 2015).

Another highly important area which benefits from urban greenspaces regards wildlife and habitat. According to McKinney (2006), cities are considered to host a less diverse spectrum of birds, animals and plants than nearby rural zones. However, other authors observed that urban areas can provide more favourable habitats for some species instead of the heavily farmed zones (Baldock et al., 2015; R. A. Fuller et al., 2009), therefore suggesting that cities can still provide a substantial contribution to national conservation efforts (Scott, 2015). Research shows that urban greenspaces can serve as wildlife corridors in connecting the green infrastructure. Additionally, not only big parks and woodland can support a wide range of species (Cornelis & Hermy, 2004), but small areas can further support a scope of plants, birds and insects, such as green roofs (Baumann, 2006; Brenneisen, 2006) roundabouts (Helden & Leather, 2004) and roadside verges (Saarinen et al., 2005). Research within this realm is ever evolving and continuous, still the benefits greenspaces can provide to the environment and urban health are undeniable.

### *2.2.2 To social well-being*

The impacts of greenspaces, both positive and negative, to the urban environment directly affects city dwellers and social well-being. Therefore, by focusing on strategies that enhance the positive effects and lessen negatives ones, can lead to increasing urban health and social well-being. The ideology that contact with nature is beneficial for humans is an old and widespread notion. To date, countless studies present evidence that nature has positive impacts in human well-being (Frumkin, 2013; Taylor & Hochuli, 2015). According to (Wolch et al., 2014, p.324) "urban green spaces provides a wide range of ecosystem services that could help combat many urban ills and improve life for the city dwellers – specially their health", to which Chiesura (2004) further adds by claiming that such connection "enrich human life with meanings and emotions". Moreover, the belief that exposure to nature can improve physical and psychological well-being (Parsons & Ulrich, 1992; Ulrich, 1984) is the reason for planning parks, preserving wilderness for public use and providing other natural solution in urban centres (Parsons, 1991; Ulrich et al., 1991). Ulrich further claims that these ideas might even contribute to the early forms of the biophilia hypothesis (published in Kellert & Wilson, 1993).

#### *2.2.2.1 Impacts on physical health*

Regarding the effects on physical well-being, parks are often chosen sites for physical activities which are associated with enhanced health, reduced morbidity (Maas et al., 2009), risk of multiple chronic diseases and all-cause mortality (Anon., 1996; Barton & Pretty, 2010; Bush et al., 2007; Casey et al., 2008; Gascon et al., 2015; Grahn & Stigsdotter, 2010; Hartig, 2008; Kuo, 2001; Woodcock et al., 2009). Moreover, many scholars discussed the link between park proximity and physical activities (see Brownson et al., 2001; Cohen et al., 2006, 2007; Diez Roux et al., 2007; Evenson et al., 2013; Gordon-Larsen et al., 2006; McCormack et al., 2010; Sallis et al., 2012), and Coutts et al. (2010) found that the lack of access to parks has been linked with mortality.

In fact, in a study conducted across Europe, Ekelund et al., (2015) discovered that approximately one in every fifteen deaths is related to lack of physical activity. (DoH, 2011)(Scarborough et al., 2011; Scott, 2015)On the other hand, mortality can also be reduced amongst the elderly as they can greatly benefit from urban greenspaces, since these promote greater levels of social activity and stronger neighbourhood bonds (Sullivan et al., 2004). Additionally, access to greenspaces can improved physical health and assist on healthy aging in the elderly (de Keijzer et al., 2020), helping them maintain a high quality of life (Kweon et al., 1998a; Sugiyama et al., 2009; Sugiyama & Thompson, 2007). Urban greenspaces can also affect positively the immune system and metabolism, reduce cardiovascular disease, and improve pregnancy outcomes (Alcock et al., 2014; Donovan et al., 2013; Kondo et al., 2018; Nieuwenhuijsen et al., 2017; Rojas-Rueda et al., 2019).

Overall, greenspaces can promote physical health by providing a pleasant environment, therefore encouraging exercise (Coombes et al., 2010). Linear greenspaces such as woodland trails can encourage walking and cycling (Scott, 2015), while larger parks with sports facilities can encourage more formal types of physical activity (Brown et al., 2014). However, studies have showed that size and attractiveness of the greenspace are essential to attracting people (Giles-Corti et al., 2005). Research conducted in Australia revealed that the propensity of parks encouraging exercise was higher if they were perceived as aesthetically pleasing, with minor traffic, sidewalks, retail shops, among others (Giles-Corti et al., 2003; Giles-Corti & Donovan, 2002). Veitch et al. (2012) also discovered that park use increased significantly after improvements were done, by collecting and analysing data before and after the improvement work. Nevertheless, this is still growing scientific field and further research needs to be done in order to better understand the benefits of greenspaces to humans' physical health (Kellert & Wilson, 1993).

#### *2.2.2.2 Impacts on mental health*

Physical and mental health are closely related and can be dependant of one another. Exercising or doing activities in greenspaces, or 'green exercise' as proposed Wolch et al. (2014), has a beneficial impact on mental health as well. Even though environmental psychology is a small and peripheral subfield within psychology (Kellert & Wilson, 1993), there are many studies showing the beneficial aspects correlated to greenspaces. Research shows that mental well-being can be improved by only visiting greenspaces (White et al., 2013) or simply looking at them (Ulrich, 1984). For instance, spending time in such spaces can make the brain produce levels and patterns of chemicals that are associated with low stress (Ward Thompson et al., 2012), have positive impacts on blood pressure (Hartig et al., 2003), and potentially assist/reduce the need for treatment of anxiety, mental health conditions and depressive disorders (Nutsford et al., 2013).

The stress-reducing effects of outdoor recreation has been presented in multiple studies, and results from those conducted on urban parks and urban natural scenarios have shown that restoration from stress is a well perceived benefit (Kaplan, 1983; Schroeder, 1989; Ulrich & Addoms, 1981). In addition, a Danish study found that people living 1km from greenspaces have a 1.42 times higher likelihood of experiencing stress than individuals living <300m from greenspaces (Stigsdotter et al., 2010), suggesting that access is a relevant factor. Dallimer et al. (2014) reported that the most frequent visitors presented greatest benefits to their mental well-being. Furthermore, for decades studies have shown that stress can cause reduced performance on cognitive tasks (Glass & Singer, 1972; Hockey, 1983). Similarly, positive connections have been presented between performance in attention-demanding tasks and time spent, both before or during, in greenspaces (Hartig et al., 2003; Hartig & Mang, 1991; Roe & Aspinall, 2011; Tennessen & Cimprich, 1995). According to the influential nineteenth-century landscape architect and planner Frederick Law Olmsted (1865), solely viewing nature could assist on stress recovery and lead to recovery from mental fatigue, thus restoring mental performance. Moreover, recent research using neuro-imaging to monitor the brain has found that walking in nature reduces rumination (Bratman et al., 2015) and increases meditative feelings (Aspinall et al., 2015).

Nevertheless, only being green is not enough. Studies show that the quality of the greenspace has a crucial role in regards of the health benefits and their underlying mechanisms (Knobel et al., 2021). Elements such as available functions, quantity of greenspaces, infrastructure, design, planting design and biodiversity can be detrimental in order for the greenspace to provide optimal benefits. According to Fuller et al. (2007), the psychological benefits gained for visiting urban greenspaces increases according to their biodiversity, suggesting that greenspaces alone are not sufficient; the quality of the 'green' is important. A contemporary research method using social media was done by comparing 50 million tweets a day before, during, and after visits to 150 parks, playgrounds and plazas, where results showed a spike in happiness while in greenspaces, with afterglow of four hours. According to the results, parks increase happiness to a level similar to the effect of Christmas, which typically is the happiest day of the year (Schwartz et al., 2019). In addition to increasing happiness level, experiences in greenspaces can assist as a crisis coping mechanism (Beyer et al., 2014; McMahan & Estes, 2015), which has been proven extremely important since the COVID-19 pandemic made irrevocable changes in the world in 2019.

Awareness on the role of urban nature in mitigating negative impacts on health and well-being related to COVID-19 has heightened since the start of the pandemic, hence global studies suggest that owing to this, an increased demand for urban greenspaces was notable. After travel restrictions were applied, there was a growing interest for outdoor recreation (Kleinschroth & Kowarik, 2020). A study performed in Brisbane – Australia, aimed to understand how people utilized and valued these spaces as a response to the stress and restrictions caused by the pandemic. The results showed that urban greenspaces played a crucial role in supporting well-being and coping with stress during this period. The research participants reported increased appreciation for such open spaces, observed an increased visitor numbers and changes in visitor behaviour, and acknowledged the importance of quality urban greenspaces for physical/mental health, and connecting with nature (Berdejo-Espinola et al., 2021). Even though accessibility might not be optimal, people's interest for urban greenspaces did not diminish (Zhu & Xu, 2021). In fact, Ugolini et al. (2020) shows that people were willing to commute longer distances in order to utilize such spaces, and Yap et al. (2022, p.505) further concluded that "the pandemic has heightened the demand for cultural ecosystem services provided by urban green spaces".

## 2.3 The role of planting design on urban greenspaces

As presented by the literature reviewed so far, greenspaces play a key role in providing benefits to urban health and citizens. Additionally, it was also proposed that being green is not a solution in itself, but the quality and characteristics of the place is of high importance. This PhD research further proposes that especial focus should be directed towards planting design and applied taxa, as this is detrimental for urban environments to fully benefit from greenspaces.

### *2.3.1 Plant evaluation and adaptation in the 21st century*

Plants are living organisms that humans have domesticated over centuries, being genetically altered and used as they see fit. However, nature only needs water to thrive and "a crack in the pavement is all a plant needs to put down roots", as observed by nature writer Richard Mabey (2010), which means that as nature, plants' behaviours can be unpredictable. Even though cultivar species are resistant to certain planned conditions and are created to withstand and thrive in the urban environment, some external factors such as bacterial and fungus infestations can be a hazard. In this perspective, planting design in urban centres should be constantly studied and cared for in order to prosper in its current era, as living organisms are always changing. Additionally, with the extreme climatic conditions being experienced today it is essential to have the appropriate species that can help mitigate urban ills and climate change negative effects (Kabisch et al., 2015; McPhearson et al., 2015; Shanahan, Lin, et al., 2015). Moreover, in high-crime cities the importance of planting design is considerable since dense vegetation can cause insecurity. Hence, the relationship between crime, fear of crime, and the design of urban greenspaces, highlighting the importance of planting design in the creation of safer and more secure environments (Kweon et al., 1998b; Maruthaveeran & Van den Bosh, 2015; Troy & Grove, 2008), is of extreme urgency in the 21st century.

Trees have always played a significant role in everyday life, being registered in ancient texts, drawings and folk tales. Within climatic and circumstantial possibilities, almost the majority of world communities plant and preserve trees in their towns and cities' centre (Rudd-Jones, 2016). They also have a significant impact on urban health, as many studies indicate that trees impacts people's concepts of environmental quality (Kellert & Wilson, 1993), they help reduce pollutants, temperature, amount of ultraviolet radiation, greenhouse gas concentration and emission (Nowak & Heisler, 2010), and large, healthy canopy trees can be tools to mitigate the negative effects of urban climate (Szabó et al., 2022). Increasing urban tree canopy can overall reduce air temperatures by 1 to 3$^{o}$ C (O'Neill et al., 2009), and studies have indicated that this reduction can be between 6 to 10$^{o}$ C if the canopy cover increases by 25%, and a simulation registered 6$^{o}$ C lower temperatures with a 30% vegetation cover (Goode, 2006). Studies conducted in Japan comparing temperatures in city parks and its surrounding areas presented differences of 2.5 to 4$^{o}$ C (Asaeda & Ca, 1998). Further studies showed that the qualities of the leaves' surface can also enhance gas capture, thus trees with complex, hairy or ridged leaves such as pines, tend to capture more particles than broader, smoother leaves (Beckett et al., 2000; Freer-Smith et al., 2005; Räsänen et al., 2013). When it comes to individual trees, according to Armson et al. (2013) their effects can be maximised by planting them in tree pits containing permeable soils, or structural soils that will facilitate root growth beneath paved areas (Bartens et al., 2008), avoiding infrastructure damage caused by overgrown roots.

When assessing and planning for planting design it is also extremely important to consider potential threats. For instance, in some narrow streets large trees can obstruct wind flow and limit trees ability to remove pollutants (Buccolieri et al., 2009; Vos et al., 2013). In such scenarios choosing hedges may present a better solution (Wania et al., 2012), and green walls may be more beneficial in polluted street canyons (Pugh et al., 2012). Similarly, the shape and size of the vegetation can create an intimidating and dangerous atmosphere, as mentioned previously. Research shows that in urban areas with high crime rates, fear/risk associations amplify negative responses to greenspaces having dense foreground vegetation blocking surveillance (Hull & Harvey, 1989; Schroeder & Anderson, 1984).

Landscape architects should emphasize and prioritise the use of native and/or endemic species as much as possible, be aware of invasive specimens and select plants that will not be hazardous, such as with allergens, fallen fruits, weak branches, damaging roots, to mention a few. Policy makers should also provide regulatory pathways to reduce possible negative effects of increased greenspaces, such as crime, danger to objects and living beings, gentrification, among others (Rojas-Rueda et al., 2019). Furthermore, ongoing research focuses on water use in arid climates and increased pests and allergens (Lõhmus & Balbus, 2015; D. E. Pataki et al., 2011).

### *2.3.2 Biodiversity and aesthetics as key factors*

The rapid urbanization process has isolated people from experiencing nature (Miller, 2005; Wilson, 1984). Therefore, for grand part of the population public urban greenspaces can be the only direct contact with the natural environment (Fuller et al., 2007). As a result, some people yearn for a stronger and deeper connection to nature while others lose the desire to interact with it, and this phenomenon is greatly discussed withing the biophilia hypothesis. The loss of desire to connect to nature is a threat since it results in a decreased admiration for the biodiversity that support human survival (Rogers, 2019). As described by Wilson (1993, n.p.), “there is no question in my mind that the most harmful part of ongoing environmental despoliation is the loss of biodiversity”. Thus, reconnecting humans with nature is an important theme in conservation.

While the effects of greenspaces are well understood, not much research has been done on the importance of variation in the quality of such spaces, for providing optimal benefits to social well-being (R. A. Fuller et al., 2007). However, research on this topic has been driven by an emerging interest in how ecosystem function and biodiversity impact urban health (Taylor & Hochuli, 2017). According to Fuller et al. (2007) results, greenspace users can perceive species richness, to a certain level, depending on the taxonomic group. These indicate that in order to enhance human well-being, and therefore urban health, the successful planning and management of urban greenspaces should emphasize planting design and biological complexity. Moreover, studies have already presented that ‘forest-like’ greenspaces with native species, many trees and ground cover specimens can maximise carbon sequestration, in comparison to less diverse places designed with fewer trees and mown grass (Strohbach et al., 2012).

Sustainability is a wide topic that can be applicable and discussed across many study fields. Biodiversity within plant populations is intricately linked to sustainability, seeing that diverse plant communities with a variety of taxa have greater resistance to the proliferation of pests and pathogens (Tilman & Downing, 1994). The connection between biodiversity in plant populations and sustainability is a well-established concept in ecology and conservation biology, and a few aspects that highlight this connection are: increased ecosystem resilience; provision of varied ecosystem services; genetic diversity; productivity and stability; conservation and restoration of ecosystems (Cardinale et al., 2012). Therefore, increased biodiversity in urban greenspaces helps create more sustainable spaces.

Another important aspect of greenspaces to be considered in order to achieve the desired benefits is aesthetics. Fuller et al. (2007) presented results which indicated that simply providing greenspaces overlooks the fact that they can vary greatly regarding their contribution to social well-being and biodiversity provision. The quality of greenspaces needs to be considered to ensure it serves the purposes of providing ecosystem services, enhance biodiversity (Arnold & Gibbons, 1996), create opportunities for contact with nature (Miller, 2005), motivate people to use and interact with the space, and enhance psychological well-being. For instance, according to the biophilia hypothesis, if humans have an innate bias for some landscape types and elements, it is viable to assume that adding these features to greenspace environments can enhance their appeal (Kellert & Wilson, 1993).

As revealed by multiple studies, trees figure largely influence people perception of environmental quality. According to Orians (1980), trees with shapes and characteristics that provides high quality habitats is preferable to ones with shapes characterizing poor habitats. His analysis indicated that trunk height, canopy layering, canopy width / tree height ratio significantly influenced attractiveness scores. Trees presenting signs of depletion or unhealthiness had a negative effect on the attractiveness score (Kellert & Wilson, 1993; Orians & Heerwagen, 1992). Moreover, factors such as maintenance, amenities, safety, and proximity are important for encouraging greenspace use (McCormack et al., 2010).

## 3. MATERIALS AND METHODS

In this study the author follows a pragmatic approach with a cyclic study method of analysing, observing, and assessing best practices and deficiencies of case studies, thus deducting reasonable conclusions. Furthermore, this chapter utilises the presented literature review as a basis for urban greenspace assessment strategy, and reinforcing the hypothesis that greenery alone is not enough. By providing contextualization and definitions of greenspaces, green system and biophilic design, this study analysed and deducted concepts and main factors to be considered as key elements for this research. In addition, the methodology also consists of best practices' case study analysis as well, by choosing urban greenspaces in Budapest – HU and Campo Grande – BR, assessing its historical development and current site situation, with a deeper planting design evaluation of each site. With the assessment and deductions from the selected Budapest urban greenspaces, improvement strategies can be proposed for the urban greenspaces in Campo Grande, suggesting urban green infrastructure as a method to increase urban resilience.

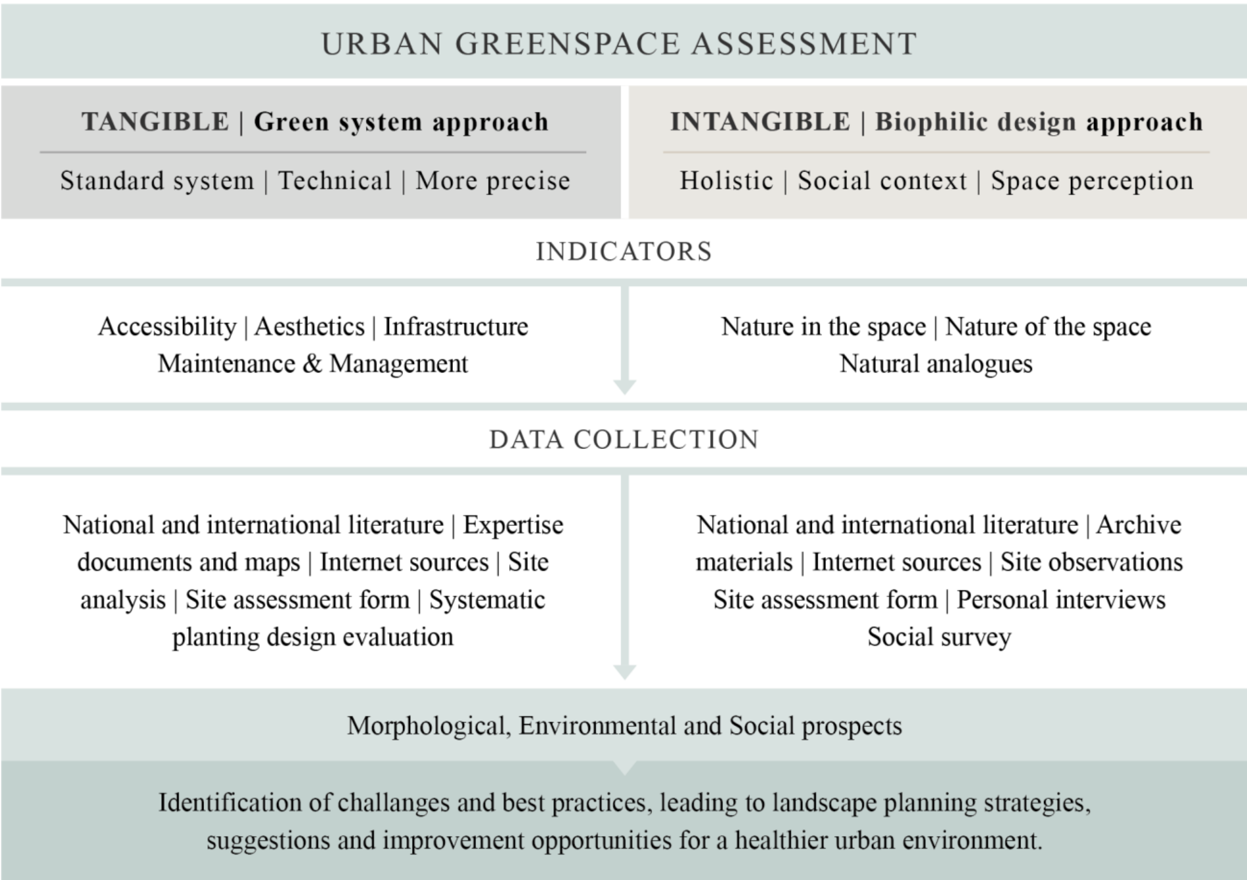


**Figure 1.** Graph showing this study's methodology (Source: Author)

The graph above [Figure 1] presents a summary of the urban greenspace evaluation method proposed. Through an exploratory and analytical research, this study attempts to establish a well-developed and concise data collection in a way to better understand the planting design of the selected urban greenspaces, in order to enable them to provide optimal benefits for urban health and social well-being. Moreover, unveiling possible issues and conflicts as well as the areas with the highest potential for improvement. Owing to this, the author proposes two main assessment categorisations: tangible and intangible aspects. Tangible aspects comprise historical development, landscape and planting design, hard and soft landscapes and technical elements. On the other hand, intangible aspects encompass cultural values, social well-being, social relation to greenspaces, and space use and perception. Furthermore, the method proposed to evaluate the tangible aspects is based on the green system approach, whereas the intangible is based on the biophilic design approach. Both were developed by the author based on curated elements from the reviewed literature, and which are considered most relevant to the purposes of this study.

### 3.1 Green system approach – Tangible aspects

The green system approach elaborated to asses tangible aspects is a standard system consisting of technical, quantitative, qualitative and precise data, to some degree. In Roué Le Gall's (2015) research findings on greenspaces, urban design and mobility in relation to health, she suggests that the present challenge is moving from knowledge to action, to which she proposes the development of a causal model to assess greenspaces and its effects on urban health and social well-being [Figure 2].

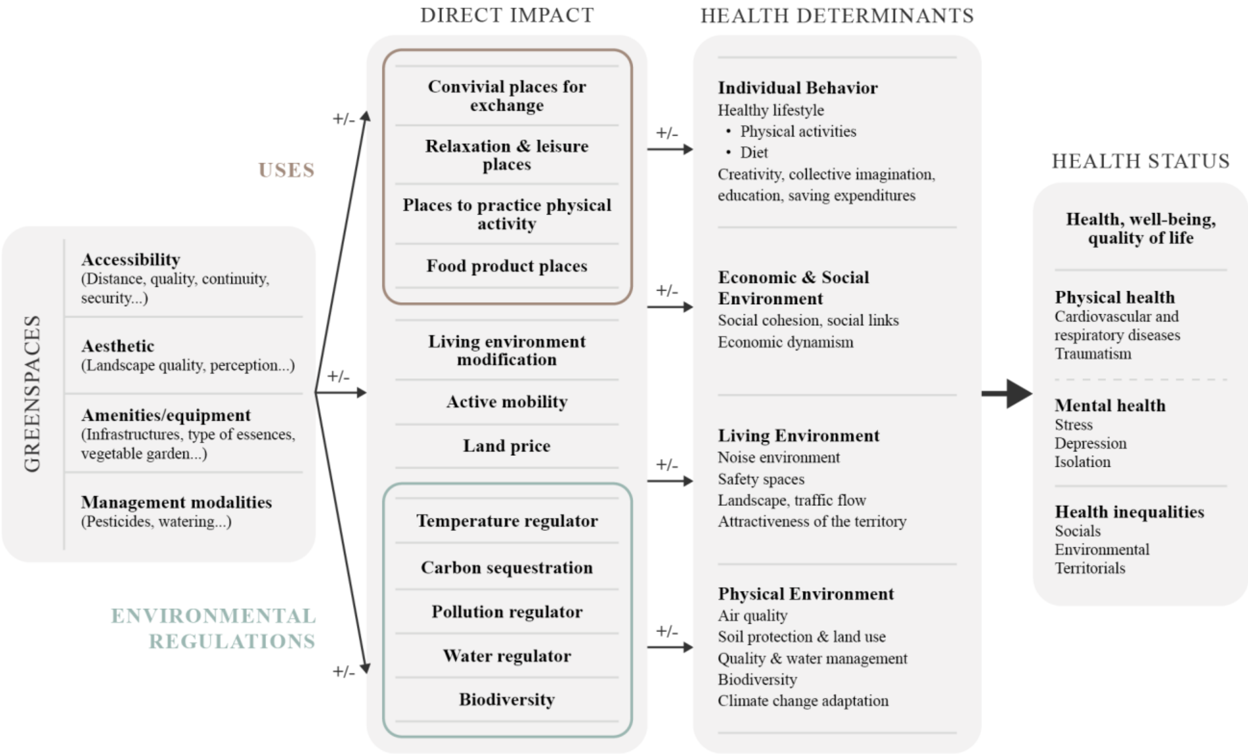


**Figure 2.** Roué Le Gall's proposal for causal model between greenspaces & health (Source: Roué Le Gall, 2015. Adapted by the author)

This section of the methodology consists of the simplified adaption of her method, which consists of four main greenspace aspects to be addressed: accessibility, aesthetics, infrastructure and maintenance & management. Furthermore, these four aspects are also suggested as essential elements in greenspace evaluation by multiple authors, as presented in the previous chapter. In addition to the well-established research on the more technical aspects, in recent studies the quality of greenspaces has been suggested as crucial for their health benefits and underlying mechanisms

(Knobel et al., 2021; Wheeler et al., 2015). Moreover, McCormack et al. (2010) further claims that quality can predict the use of greenspaces.

In this respect, data is collected from expertise documents and maps, national and international literature, archive materials, internet sources and further quantitative and qualitative data collected by site observation and creation/analysis of heatmaps. For this instance, an assessment form [Appendix A] was developed to be completed in each selected urban greenspace individually, using standardized visit times (Monday to Friday within working hours; Saturdays and/or Sundays in the afternoon), which took place in December 2020, January 2021, March 2022 for the Brazilian sites, and October 2020, June 2021 and September 2022 for the Hungarian sites, using repeated evaluation aiming for better result estimation. The assessment form consists on the following analysis criteria: Overall aesthetics (square, park); Character (nature/garden like with no functions, contemplation, recreation); Use and users; Infrastructure (sidewalk, paved pathways, light poles, benches, other); Accessibility (by car, bus, bike lane); Maintenance level (low – bimonthly, medium – monthly, ideal – twice a month, high – weekly); Water management (Irrigation, sewage/drainage, rain water catchment, water features); Applied planting design aspects (plantation level, canopy coverage, endemism, among others). The latter is systematically analysed by a thorough assessment of each individual plant on the site.

Moreover, in addition to the methods mentioned in the previous paragraph regarding site analysis, a questionnaire was created to better assess park users in the UGSs of Campo Grande [Appendix B]. The structured questions were formulated on a multiple-choice format based on ‘yes’ or ‘no’ options, Likert scale methods and open answers as well. The evaluation was done in loco by talking to the users in each site during the site visits, which took place from Monday to Friday within working hours, and Saturdays in the mornings and afternoon in May 2023. A further assessment criterion added to this regards the unique value of plants. While collecting data in Campo Grande for my master’s research, I noticed that people were collecting and eating fruits from two huge *Inga edulis* (Ice-cream-bean) trees. Over the years of my PhD research, I noticed this pattern repeat itself in other sites and with street trees as well. To confirm and test my hypothesis that this is a common and appreciated activity by the local residents, I added a few questions related to this.

Regarding the planting design, the materials and methods used a systematic analysis consisting of identifying the canopy coverage, cataloguing the taxa, and estimating biodiversity level. The taxa evaluation consists of photographic register, identification of species based on professional knowledge, recognized literature (Almeida et al., 1998; da Silva, 2006; Gonçalves Rodrigues et al., 2002; Lorenzi, 2008; Mabberley, 2017; Medeiros, 2011; Pedrinho et al., 2020; Pott & Pott, 1994; *Protected and Special Animals and Plants of Budapest*, n.d.; Szilágyi et al., 2021; Tjhio Cesar Pestana et al., 2019; Veloso, 1992; Zelenák et al., 2016), official governmental documents such as plans and directives (Arruda et al., n.d.; LEI COMPLEMENTAR n. 184, DE 23 DE SETEMBRO DE 2011, 2011; DECRETO n. 11.971, DE 19 DE SETEMBRO DE 2012, 2012; Planurb, 2012; SEMADUR, n.d., 2010; SEMAGRO, 2020), the help of database applications such as ‘PlantNet’, ‘Seek’, and other trustworthy online sources like botanical gardens database, government pages, university catalogues, etc (Barroso et al., n.d.; da Silva Pereira, n.d.; Gardenia, n.d.; IBF, n.d.; Mocsáry, n.d.; B. Pataki, n.d.; *Pl@ntNet*, n.d.; *Seek*, n.d.; *ZÖLDKALAUZ*, n.d.; Portal São Francisco, n.d.; Singapore Government Agency Website, n.d.; UFEI, n.d.). With the information gathered using the aforementioned methods, the vegetation registration and identification was carried out by filling out a spreadsheet [Appendices F and G], which includes the scientific names, family, genus, common names (in English, and Portuguese in some instances on the Brazilian UGSs), native range, endemism situation (native, non-native, endemic, established[2] or invasive), values (medicinal, edible fruit - for human consumption, etc), parts of the plant that can be used based on these values, potential threats and amount of individuals (adults and small, both on the site and in the surrounding sidewalks). The findings from this analysis are presented in the UGSs subchapters, within the 'summarised findings of taxa identification' tables.

The canopy coverage was assessed using a tree canopy assessment tool called i-Tree, a peer-reviewed software suite from the USDA Forest Service. As explained by the creators, "This tool is designed to allow users to estimate tree and other cover classes easily and accurately (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon."(Ellingsworth et al., 2022). By creating a geographic boundary of the studied sites, the software allocates 100 random points that were manually defined as either tree or non-tree surfaces, resulting in the approximate canopy coverage. Even though carbon sequestration is more relevant for large-scale vegetation, the i-Tree tool also provides an estimate quantity for each analysed site. With a city level perspective, the carbon sequestration of the UGSs individually might not be of huge influence on the urban environment, but considering green infrastructure and network, the carbon sequestration of each UGS do have an indirect impact on urban health. Therefore, it will be presented in the case study findings. According to i-Tree's calculations, the amount sequestered is based on 0.000 g of Carbon, or 0.000 g of $CO_2$, per $ft^2$/yr and rounded. Amount stored is based on 716.48 grams of Carbon, or 2627.06 grams of $CO_2$, per $ft^2$ and rounded ($ft^2$ = square feet) (Ellingsworth et al., 2022).

Within the vegetation assessment, the evaluation of biodiversity is done based on the data collected on each site with the calculation of vegetation level (ground cover, perennial beds, shrubs and trees), percentage of endemic species, and quantity of individuals, following the 30/20/10 rule which indicates that an area can be considered biodiverse if no more than 30% of the species belong to the same family, no more than 20% belong to the same genus and no more than 10% belong to the same species. Furthermore, embracing a multidisciplinary approach, the evaluation of the greenspaces in Campo Grande was assisted by two professionals: one local landscape architect (de Souza, L. K, personal communication, 2022) and one botanic focused biologist (Mamoru, R, personal communication, 2022).

[2] Established refers to a plant species that has been introduced to a region or ecosystem where it did not naturally occur but has successfully adapted and acclimatised to the new environment without becoming invasive.

After obtaining the data and analysing the results, this study proposes two vegetation lists for the UGSs in Campo Grande. The first comprises suggestions of plant species to be avoided, and can be found in Appendix D. This list was elaborated based on professional knowledge, according to local literature and official government documents (de Arruda et al., n.d.; LEI COMPLEMENTAR n. 184, DE 23 DE SETEMBRO DE 2011, 2011; DECRETO n. 11.971, DE 19 DE SETEMBRO DE 2012, 2012; Costa & Durigan, 2010; Lorenzi, 2008; Lorenzi et al., 2003; Lorenzi & Matos, 2002; Pedrinho et al., 2020; Planurb, 2012; SEMADUR, n.d., 2010; Tjhio Cesar Pestana et al., 2019). Moreover, the list contains the scientific names, common names (in the local language, Portuguese) and the threat the species poses. All the taxa listed should be avoided in Campo Grande for either having characteristics that are not suitable for the urban environment or are prohibited by legislation in the municipality (SEMAGRO, 2020).

The second list consists of suggested plant species for Campo Grande, and can be found in Appendix E. This list was elaborated prioritizing native species that present adaptability to adverse conditions in the urban environment, while also considering those non-native but adapted to the local climate and conditions, that proved favourable for implantation in the city. Further criteria for selection: species less propense to cause damages (e.g., having aggressive roots, being toxic, etc), aesthetics, height (from 4 – 12 meters), among other aspects. In addition to the methods and sources cited so far, further literature was considered with greater focus on native species of Brazil, and endemic species of the Cerrado (Almeida et al., 1998; da Silva, 2006; Eiten, 1972; Gonçalves Rodrigues et al., 2002; Medeiros, 2011; Neto et al., 1994; Pedrinho et al., 2020; Planurb, 2012; Pott et al., 2011; SEMADUR, n.d.; Tjhio Cesar Pestana et al., 2019; Veloso, 1992). Furthermore, similarly to Appendix D, this list comprises the scientific names and common names (in the local language, Portuguese).

### 3.2 Biophilic design approach – Intangible aspects

The intangible aspects to be analysed with a biophilic design approach embodies a more holistic attitude, consisting of the social context, space quality, use and perception. In the literature review chapter, the biophilia hypothesis was presented, and the method consists of translating it into design, supported by the biophilic design principles previously presented. This adaption from a hypothesis to design of the built environment was first introduced as a topic of a 2004 conference and subsequent book on biophilic design in which more than 70 different mechanisms for creating a biophilic experience were proposed by Stephen Kellert. Furthermore, contributing authors William Browning and Jenifer Seal-Cramer proposed three biophilic classifications of user experience: Nature in the space, Nature of the space and Natural analogues (Kellert et al., 2008). Based on these, the concepts of the biophilia hypothesis and other works related to spatial patterns, Browning et al. (2014) proposes 14 patterns of biophilic design based on the biophilic principles and benefits, as shown in Table 1. According to them, these patterns are flexible and replicable strategies that can be used to enhance user experience, with the possibility to be implemented under a range of circumstances.

**Table 1.** Biophilic design patterns & biological responses. Source: Browning et al., 2014. Adapted by the author

| | 14 Patterns | * | Stress Reduction | Cognitive Performance | Emotion, Mood & Preference |
|---|---|---|---|---|---|
| NATURE IN THE SPACE | **Visual Connection with Nature (**Viewing elements of nature, living systems and natural processes) | * * * | Lowered blood pressure and heart rate (Brown et al., 2013; van den Berg et al., 2007; Tsunetsugu & Miyazaki, 2005) | Improved mental engagement /attentiveness (Biederman & Vessel, 2006 ) | Positively impacted attitude and overall happiness (Barton & Pretty, 2010) |
| NATURE IN THE SPACE | **Non-Visual Connection with Nature** (Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes) | * * | Reduced systolic blood pressure and stress hormones (Park et al., 2009; Hartig, et al., 2003; Orsega-Smith et al., 2004; Ulrich et al., 1991) | Positively impacted cognitive performance (Mehta et al., 2012; Ljungberg et al., 2004) | Perceived improvements in mental health and tranquillity (Li et al., 2012; Jahncke et al., 2011; Tsunetsugu et al., 2010; Kim et al., 2007; Stigsdotter & Grahn, 2003) |
| NATURE IN THE SPACE | **Non-Rhythmic Sensory Stimuli** (Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely) | * * | Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991) | Observed and quantified behavioural measures of attention and exploration (Windhager et al., 2011) | |
| NATURE IN THE SPACE | **Thermal & Airflow Variability** (Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments) | * * | Positively impacted comfort, well-being and productivity (Heerwagen, 2006; ham & Willem, 2005; Wigö, 2005) | Positively impacted concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989) | Improved perception of temporal and spatial pleasure (alliesthesia) (Parkinson et al., 2012; Zhang et al., 2010; Arens et al., 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979) |
| NATURE IN THE SPACE | **Presence of Water** (A condition that enhances the experience of a place through the seeing, hearing or touching of water) | * * | Reduced stress, increased feelings of tranquillity, lower heart rate and blood pressure (Alvarsson et al., 2010; Pheasant et al., 2010; Biederman & Vessel, 2006) | Improved concentration and memory restoration (Alvarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Alvarsson et al., 2010; Hunter et al., 2010) | Observed preferences and positive emotional responses (Windhager, 2011; Barton & Pretty, 2010; White et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983) |
| NATURE IN THE SPACE | **Dynamic & Diffuse Light** (Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature) | * * | Positively impacted circadian system functioning (Figueiro et al., 2011; Beckett & Roden, 2009) Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007) | | |
| NATURE IN THE SPACE | **Connection with Natural Systems** (Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem) | | | | Enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008) |

| | | | | | |
|---|---|---|---|---|---|
| NATURE OF THE SPACE | **Prospect** (An unimpeded view over a distance for surveillance and planning) | *** | Reduced stress (Grahn & Stigsdotter, 2010) | Reduced boredom, irritation, fatigue (Clearwater & Coss, 1991) | |
| | **Refuge** (A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead) | *** | | Improved concentration, attention and perception of safety (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993) | |
| | **Mystery** (The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment) | ** | | | Induced strong pleasure response (Biederman, 2011; Salimpoor et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001) |
| | **Risk/Peril** (An identifiable threat coupled with a reliable safeguard) | * | | | Resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008) |
| NATURAL ANALOGUES | **Biomorphic Forms & Patterns** (Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature) | * | | | Observed view preference (Vessel, 2012; Joye, 2007) |
| | **Material Connection with Nature** (Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place) | | | Decreased diastolic blood pressure (Tsunetsugu et al., 2007) Improved creative performance (Lichtenfeld et al., 2012) | Improved comfort (Tsunetsugu et al., 2007) |
| | **Complexity & Order** (Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature) | ** | Positively impacted perceptual and physiological stress responses (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988) | | Observed view preference (Salingaros, 2012; Hägerhäll et al., 2014; 2008; Taylor, 2006) |

As explained by Browning et al. (2014):

> The table illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigorous empirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern. (p. 12)

In addition to the aforementioned, biophilic design approach can integrate with other building strategies and have the potential to improve systems efficiency and user experience. Notwithstanding, biophilia is one of the puzzle pieces to creating more sustainable, vibrant and restorative environments, therefore addressing it with a multidisciplinary approach early in is essential to ensure cost-effective opportunities (Browning et al., 2014). In this perspective and considering each place uniqueness, aspects such as climate, ecology, character, scale, feasibility, culture, and demographics present both opportunities and challenges for creativity.

Using biophilia as an environmental quality, based on the biophilia hypothesis, an adaptation of the biophilic design patterns and strategies from ecological planting design, data collection focuses on national and international literature, archive materials, internet sources, site analysing, empirical analysis, in person interviews and social surveys, providing qualitative and quantitative data. For this instance, the second part of the previously mentioned assessment form [Appendix A] was developed based on the biophilic design approach, and consists of the following analysis criteria: Is there a design? (yes, no, partially); Overall space quality (terrible (hazardous), bad, average, good, excellent); Ownership/stewardship (yes, no, cannot say); Noise level (low, medium, high; based on site observations and traffic analysis); Biodiversity observations (birds, insects, others); Which of the 14 biophilic design patterns are present, and to which extent (assessed by empirical observation based on the presented literature, and using a 3-point grade ordinal – *Likert* – scale: inexistent, somewhat present, considerably present). In addition to being used as an analysis criterion in the site evaluation form, the patterns will be further employed in the strategy proposal by, for an example, proposing the creation and/or enhancement of the patterns (e.g. designing a more complex and biodiverse greenspace relates to pattern number 2 'Non-Visual Connection with Nature').

Further aspects to be evaluated regarding social well-being and space use were formulated as a social survey [Appendix C], performed online by a total of 290 participants worldwide, provided both in English and Portuguese to optimise accessibility. The structured questions were formulated on a multiple-choice format, with some of the questions enabling open answers as well, via the option '*other.'* As a psychometric measurement tool, Likert scale methods were applied in the social questionnaire as well, in order to assess people's attitudes, opinions, perceptions, or experiences. As a result, the provision of standardized and quantifiable ordinal data can be analysed to gain insights into the subject matter and subjective experiences (Göb et al., 2007).

### 3.3 Case study analysis – Best practices strategy

Based on the assessment criteria mentioned above (subchapters 3.1 and 3.2), this research is based on case analysis with a best practices strategy. For this, urban greenspaces selected belong to different continents, South America and Europe, and are situated in the cities of Campo Grande – Brazil, and Budapest – Hungary [Figure 3]. Each city has unique characteristics, hence the reason this method is based on analytical research and not comparative. Nevertheless, the differences in geographic aspects and landscape design practices between both cities provide many opportunities, hence the importance of assessing case studies from both cities. For instance, to explore how each has been managing urban greenspaces and planting design, which (if any) similarities in applied taxa can be found between the two cities, as well as the opportunity to uncover potential factors for landscape design strengths, that could be replicated in other cities, and weaknesses to be worked through.


**Figure 3.** Two selected cities for the case study (Source: Patrik Oening and Web[1]. Edited by the Author)

The first case study referred to is the Brazilian city of Campo Grande, where nine compact greenspaces, located in multiple neighbourhoods, were selected. The selection criteria was based on them being compact elements, having neighbourhood character and all belonging to the same neighbourhood/district, landscape design possibilities due to lack of such, and potential links for green infrastructure and green network improvement, due to close connection to linear parks and protected areas. It is important to mention that at this research's initial stages the focus was on the study of linear elements, whereas with the progress and refinement of the work the focus is re-directed and established on compact greenspaces.

The second case study referred to is the Hungarian city of Budapest, where three compact greenspaces were selected. The selection criteria consist of them belonging all to the same district (IX), which has great relevance to the city regarding green infrastructure, with the addition of them being sites with high value landscape design, a wide variety of qualities/relevance/links and recent renovation improvements, seeing that the Budapest case study serves primarily as a best practice evaluation. As a result, based on the findings, the green system approach and biophilic design patterns, enhancement strategies can be proposed to the urban greenspaces of Campo Grande, as well as deficiencies to be considered.

Overall, the case study analysis starts with an analytical assessment of the geographical aspects of each city, such as location, climate, topography, hydrography, and vegetation, with a further assessment of the urban context (city development overview, land use, current legislative framework, green infrastructure, among others). Afterwards, an in-depth planting design evaluation was performed in person and for each greenspace by using the materials and methods previously explained.

# 4. CASE STUDIES: A SYSTEMATIC EVALUATION OF URBAN GREENSPACES

There may be several major differences that cannot be standardized while analysing urban greenspaces in Brazil and Hungary, including: Climate and weather conditions, as Brazil and Hungary have different climate and weather conditions that can affect the types of vegetation and wildlife found in urban greenspaces; Culture and traditions practices may influence the design, management, and use of urban greenspace; Socioeconomic factors such as income levels, population density, and access to resources may vary between Brazil and Hungary, which can impact the availability and quality of urban greenspaces; Political and institutional factors such as governance structures, policies, and regulations may differ between Brazil and Hungary, affecting the management and planning of urban greenspaces; The ecological context of Brazil and Hungary is different, including the types of ecosystems, biodiversity, and natural resources available, which can impact the design and management of urban greenspaces. However, they can be associated through some factors, such as social and socio-political facts, challenges and changes related to environmental constant mutations, similarities in temperature during summer, tolerance to certain species, among others. While some of these differences can be accounted for through standardization and adaptation of methodologies, others may require a contextualized approach.

Regarding urban greenspaces, Budapest is smaller in territory (compared to Campo Grande) and with a densely built urban area. Relating to this and to the work of urbanists, landscape architects and advocates, greenspaces are treated with more urgency and attention. In contrast, Campo Grande is a more horizontal city with a considerable portion of urban voids or empty open spaces. Owing to this, greenspaces are not regarded with the same level of importance or attention, with most of the time consisting of open lots with some level of vegetation. Therefore, the strategies and approaches being utilised and applied in Budapest can be proposed in Campo Grande, by refining and selecting the relevant applicable aspects.

## 4.1 Budapest – Hungary

*"A táj antroposzociocentrikus fogalom… A táj a kultivált (művelt), humanizált (emberiesített) természet."* - Mihály Mőcsényi

Mihály Mőcsényi was a Hungarian horticultural engineer, landscape architect, university professor and founder of landscape planning education in Hungary. Among his many qualities and contributions to national history, he became an internationally recognized scientist in landscape architecture with his versatile preparation and advocacy of the harmony of disciplines (interdisciplinarity). This beautiful quote can be translated as: *"Landscape is an anthropo-sociocentric concept... Landscape is cultivated, humanized nature."*

### 4.1.1 Geographical aspects

Budapest is the capital city of Hungary [Figure 4], counting with an estimated population of 1,784,199 people (*Budapest Population*, 2023), approximately 17% of the country's population. Situated along the Danube and in the heart of the Carpathian basin, the city consists of 525.2 km² corresponds to the urban area.

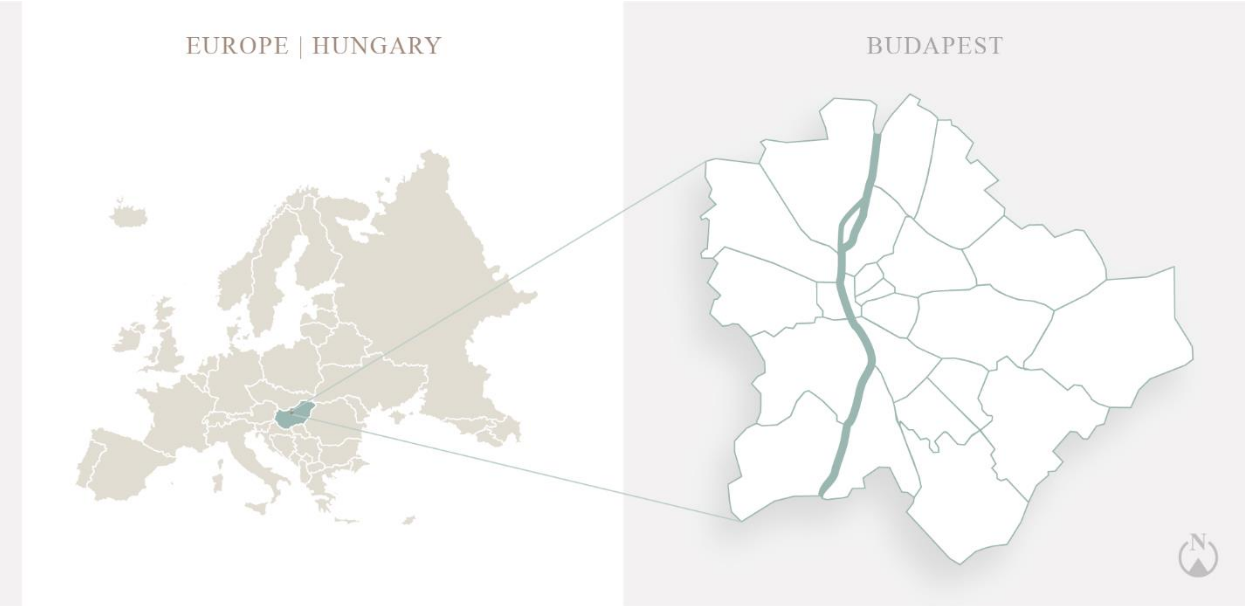


**Figure 4.** Map of Europe situating Hungary and Budapest (Source: Author)

#### <u>4.1.1.1 Climate</u>

Situated halfway between the Equator and the North Pole, Budapest is a city where the four seasons are apparent, with a moderately dry continental climate. The summers are warm, and the winters are very cold and snowy, in addition to being partly cloudy year-round. The temperature typically varies from -3°C to 27°C during the year and is rarely below -11°C or above 33°C (Mezősi, 2017). However, owing to the climate crises these are changing. Nowadays winters are not so cold, with the average annual temperature around 10°C, which used to be 7–6°C. This change can also be felt during summer as well, with temperatures being registered above 37°C in the past couple of years.

The warm season, comprising spring and summer, lasts for 3.6 months, from May 24 to September 12, with the average daily temperature above 22°C. The hottest month of the year is July, with the high being 27°C and the low 16°C. The cold season, comprising autumn and winter, lasts for 3.5 months, from November 21 to March 3, with the maximum average daily temperature below 8°C. The coldest month of the year is January, with the low being -3°C and the high being 3°C. Regarding precipitation, rain falls all year round in Budapest, with the wettest month being June with an average rainfall of 50 millimetres. The month with least rain is January, with an average rainfall of 18 millimetres. However, according to recent studies the precipitation patterns is predicted to change in the coming years (Bede-Fazekas & Somodi, 2020). Another important factor to consider is snowfall season, which lasts for 3.7 months, from November 17 to March 7, with a sliding 31-day snowfall of at least 25 millimetres. The month with most snow possibility is January, with an average snowfall of 57 millimetres (Weather Spark, 2022).

*4.1.1.2 Topography and soil*

Most of the current topography of Hungary is a result of neo-tectonic activities and peri-glacial processes during the quaternary period. The low elevation areas are mostly covered by alluvial and aeolian materials, and the higher areas derives from older volcanic and sedimentary rocks (Michéli et al., 2007). Budapest presents a very particular topographic scenario, with the two parts of the city divided by the Danube River having different profiles. Buda is located on the higher river terraces and hills of the western side, while Pest spreads out on a flat and featureless sand plain on the river's opposite bank, and considerable larger area. Pest's terrain rises with a slight eastward gradient, so the easternmost parts of the city lie at the same altitude as Buda's smallest hills, notably Gellért Hill and Castle Hill. The minimum elevation is 95m, the maximum 517m and the average 154m (*Budapest Topographic Map, Elevation, Terrain*, n.d.). Lying on the drainage basin of the Danube, the most present soils are gray-brown podzolic (leached) and brown forest soils predominate in the forest zones, while rich black earth, or chernozem, soil has developed under the forest steppe. Sand dunes and dispersed alkali soils are also characteristic (Macartney et al., 2022).

*4.1.1.3 Vegetation*

Hungary used to be a densely forested area with varied vegetation, especially in the Transdanubian low mountain range and the Alpine foreland. The forests consisted of mainly oak species (pedunculate oak, sessile, pubescent oak and Turkey oak), with hop beeches, and hornbeams as well. Bakony Forest is the largest, with Börzsöny, Bükk, and Mátra also being covered with forests. Although the total of forests has decreased to 15% of the area of the country over the years, these areas still have a varied vegetation. In contrast, the low plains have been almost completely deforested (Balint et al., n.d.).

Due to the urbanization processes, Budapest's original vegetation remains only partially in the mountainous part, the vast majority of the city's plants have been planted in the past decades. These can be found as rows of trees planted next to the roads and the city's parks and squares. However, it is worth mentioning that the common horsetail (*Ephedra distachya*) found on Gellért and Sas hills, is a highly protected and medicinal plant. Additionally, another highly protected plant is the yellow sycamore (*Silene flavescens*), found in Hungary only on Gellért hill (Brooks, 2006; *Protected and Special Animals and Plants of Budapest*, n.d.). Regarding the trees, there are several notable species, with the oldest tree in Budapest probably being the Crimean linden (*Tilia x euchlora*) in a garden in Pesthidegkút and estimated to be five hundred years old. Further species that are considered historical trees are the white acacia (*Robinia pseudoacacia*), Lebanese cedar (*Cedrus libani*) (*Richpoi Hírek: 223 Éves Budapest Legöregebb Akácfája + Képek*, n.d.). Overall, Budapest is rich in green areas. Of the 525 $km^2$ occupied by the city, 83 $km^2$ is from green area, parks and forest.

*4.1.2 Urban analysis*

Consisting of the unification of Buda, Óbuda and Pest in 1873, Budapest is an ever evolving and growing metropolis. For instance, in 1848 only 140,686 people lived in the city, but at the time of the 1869 census, the population was already 280,349, presenting it doubled in just over twenty years. For this reason, in 1869 the engineer Ferenc Reitter summarized in a document from a technical point of view, what actions he considered necessary for the development of the city concerning urban planning. This document formed the basis of the tasks of the Budapest Public Works Council (Public Works Council in short). In March 1871 announced an international tender for the preparation of urban regulatory plans for the unified capital, where the applicants were expected to solve five important tasks: 1. grouping the city districts; 2. the designation of main roads and squares; 3. the proposed placement of the public buildings specified in the program; 4. proposal for the solution of public utilities; 5. proposal for park planning.

According to the winner, Lajos Lechner, the capital could become unified if its two parts are in harmony with each other. Therefore, he would have placed more emphasis on the development of Buda. However, the ideas proposed by the three winners were not fully used but served as inspiration for the strategies proposed by the Technical Department of the Capital, which did the projects in Pest in 1872, the Buda side in 1876, and for Óbuda in 1878. In spite of this, the realization still took many decades: the new boulevard leading to the Városliget – today's Andrássy Avenue – was fully built by 1885, and the Outer Ring Road was not handed over until the millennium of 1896, but even then some lots were empty. Although the applicants also made proposals for public buildings, a separate competition was finally announced for most of them, for the Parliament in 1881, and for the Szabadság Square palaces only at the turn of the century (Bodó, 2022). Budapest is a capital that is always improving and rethinking spaces, focusing on creating a more sustainable, pedestrian friendly, greener and liveable city.

*4.1.3 Urban greenspaces evaluation*

The total green areas in Budapest nowadays is under the critical 50% green area ratio (Hutter, 2015). From the greenspace developments that emerged during the 20$^{th}$ century, only a has been realized (M. Szilágyi et al., 2012), and according to a report from Budapest in 2013, the central zone of the city has a low level of greenspace intensity, and there is a need for substantial improvements in the green area intensity within the transition zone for the 21$^{st}$ century (Adorjan et al., 2019). Nevertheless, Budapest has been making efforts to enhance its green infrastructure to improve environmental sustainability, livability, and quality of life for its residents. The city counts with various parks, projects and efforts to develop and revitalize its riverbanks and waterfront areas, as well as initiates on urban forestry, including tree planting and maintenance program, and growing interest in developing rooftop gardens and green roofs and walls (Ben Salem, 2021). A good example of such initiatives is the Ferencváros block rehabilitation program.

In the past 3 decades the Ferencváros block rehabilitation program has been changing the urban profile of the district, focusing on better housing and enhancement of urban greenspaces.

According to the media, more than 1,200 apartments were completely renovated, together with 76,000 square meters of new or renovated greenspace, winning the FIABCI Prix d'Excellence grand prize in 2016 (Borbás, 2021). This initiative has been significantly improving liveability in the area, hence the project brought measurable market benefits, such as appreciation of occupied property, in addition to helping create a neighbourhood community (Urban Regeneration in the District of Ferencvaros - Budapest, n.d.). Moreover, it was a successful tool in mitigating the negative effects of urban heat island, showing that summer air temperatures significantly decreased. It was quite a unique initiative in Budapest at the time, and it is presenting the benefits and necessity of properly planned and designed urban greenspaces till this day, thus the reason it was chosen for this research as the location of the UGSs to be studied.

As explained in the previous chapter (3.1), the main selection criteria for urban greenspaces are focused on compact elements, alongside the other criteria explained. Furthermore, the analysis of revitalised greenspaces in Budapest would serve as references and best practices for application in the urban greenspaces of Campo Grande. In this regard, three compact urban greenspaces were chosen which presented the desired ‘neighbourhood’ character, being either a square or a park like place. Located in the 9th district, Ferencváros, the selected sites have been renovated with a great attention to landscape design serving as contemporary examples. The sites are referred to as UGS_1, UGS_2 and UGS_3 [Figure 5].


**Figure 5.** Map of Budapest situating selected UGS (Source: Author)

*4.1.3.1 UGS 1*

Popularly known as Kerekerdő park, UGS_1 is situated between the streets Márton utca, Vendel utca, Lenhossék utca and Tűzoltó utca, encompassing an area of 9.000 m$^2$. The current location of the site used to be a heavily built area with housing blocks, common in Budapest as it can be seen on the map from 1944 [Figure 6]. However, the map from 2000 already show a less dense site. As part of the aforementioned municipality rehabilitation program, in 2003 the remaining building blocks were demolished in order to create a new public park, that it was concluded in 2005 and later named Kerekerdő Park in 2008.

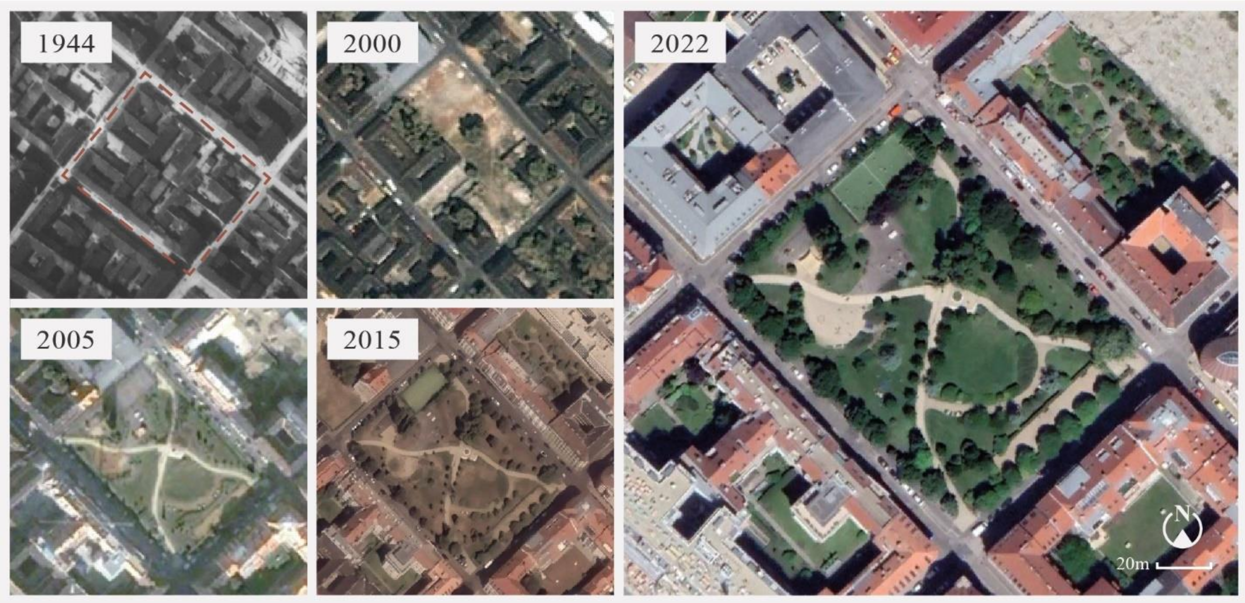


**Figure 6.** Historical overview maps of UGS_1 BP (Source: Web[2]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_1 presents the overall aesthetic of a small park with a contemplation and recreational character, with multiple functions. The space use can be considered as crossing through, contemplating nature, dog walking (even though it is not officially permitted), sports and leisure, where the users can be identified as mostly local residents from the district/neighbourhood. Moreover, its immediate surroundings have an approximate 60% residential use, with around 40% being commercial on the ground floor of the residential buildings [Figure 7]. The traffic can be categorized as busy, with parking spots surrounding the site. Additionally, there are no bus stops adjacent to the square, however there are many bus stops and tram stops nearby, in addition to cycling routes (with a MOL Bubi [3]bicycle station), making the square easily accessible. Concerning the infrastructure, the site has a paved sidewalk, internal paved and unpaved pathways, light poles, garbage bins, benches, two playgrounds, chess tables, sculptures, pergolas, water fountains and a soccer field. For water management, irrigation and sewage/drainage could be identified.

[3] MOL BuBi is a bicycle sharing network in Budapest, part of the public transport service by BKK (Budapesti Közlekedési Központ/Centre for Budapest Transport)


**Figure 7.** Map and photos of UGS_1 BP (Source: Author)

Regarding the planting design findings, there are four plantation levels: grass, perennial bed, shrubs and trees. The tree canopy coverage could be estimated to approximately 37% with a 4.83% error margin, whereas 63% belongs to non-tree land cover [Figure 8], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 26,765,799.97g carbon sequestration and 98,141,267.06g of $CO_2$ equivalent. The findings related to taxa identification can be seen on Table 2.

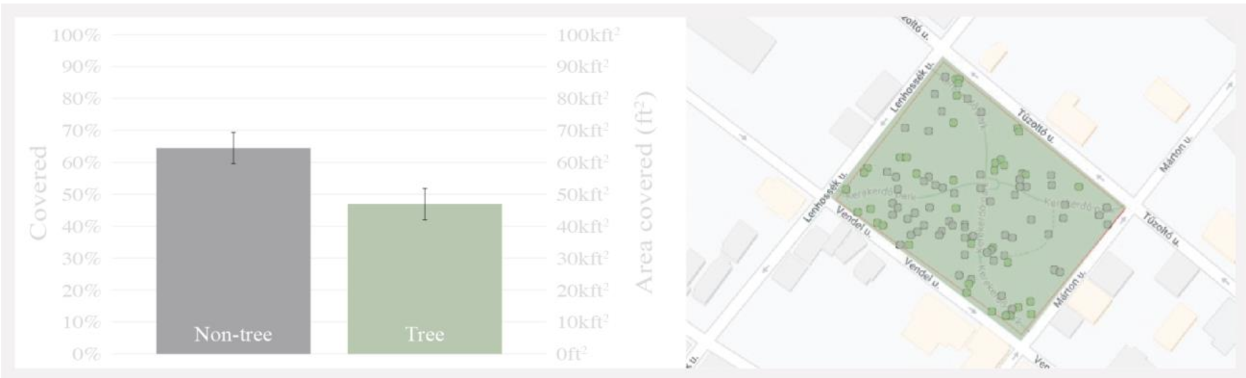


**Figure 8.** Tree canopy coverage of UGS_1 (Source: iTree. Edited by the author)

**Table 2.** Summarised findings of taxa identification for UGS_1 BP

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 26 | 1 | 147 on site (all adult); 0 on the opposite sidewalks | 37% native; 37% non-native; 11% established; 11% unknown (considered as such for being cultivars); 4% unidentified |


**Figure 9.** Taxa variety in UGS_1 BP (Source: Author)

| Biodiversity: family | Biodiversity: genus | Biodiversity: species | Unique values | Maintenance |
|---|---|---|---|---|
| 15 families; highest concentration of 30% from *Oleaceae* | 24 genus; largest amount of 30% from *Fraxinus* | Highest portion corresponds to 30% from *Fraxinus excelsior* | Medicinal: 66%<br>Edible fruits: 18%<br>Other edible part: 4%<br>Cosmetics: 4%<br>Ecological restoration: 4%<br>Unidentified: 4% | Ideal |

**Further observations:** the way the landscape plays with the levelling of the site creates an interesting and exciting atmosphere, providing 'open spaces,' but enclosed and more private ones as well. The current situation of the site can be visualised in Figure 10 below.

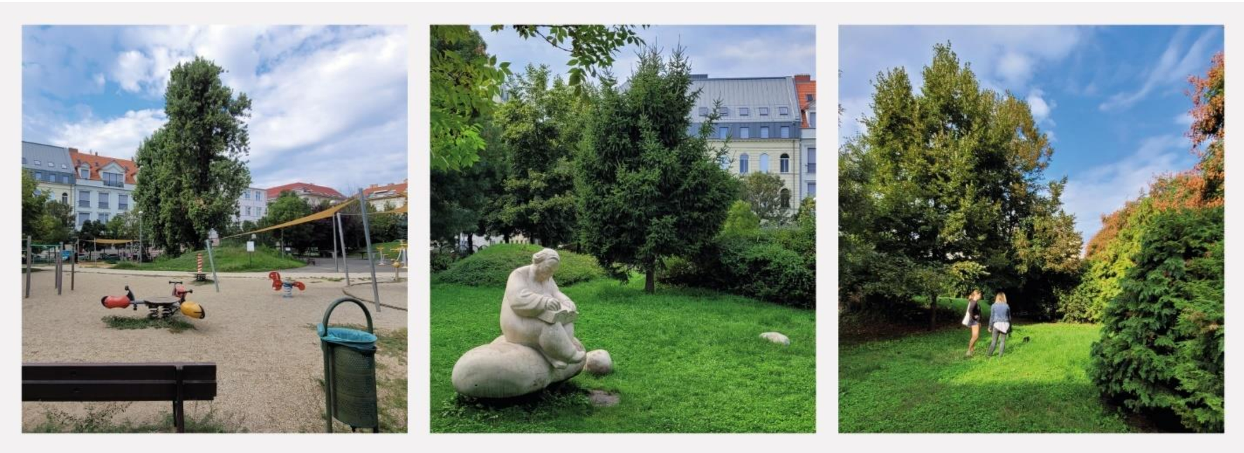

**Figure 10.** Photos from UGS_1 BP (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_1 has a very creative landscape design, indicating an excellent quality. Furthermore, certain degree of biodiversity could be observed apart from the plants, with the presence of birds and insects. The park also presented a low noise level, and the vegetation and levelling contribute greatly to this factor. Moreover, the empirical observations pointed to a certain level of stewardship by the local residents, who use make use of the space to entertain themselves or just relax, as if they were in their own backyard. Regarding the 14 biophilic patters presented in the methodology (chapter 3.2), the findings of each one can be seen on Figure 11 below.

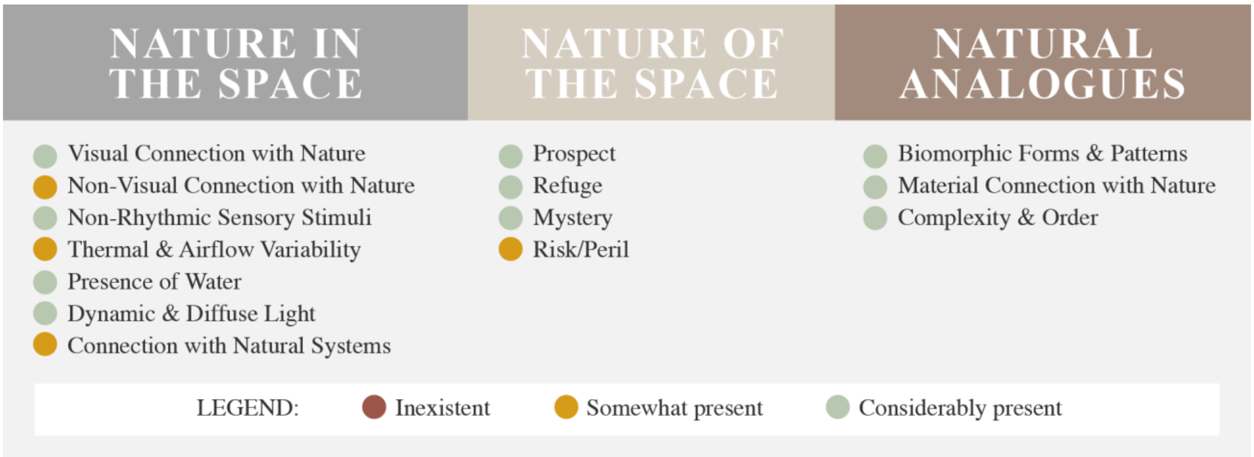


**Figure 11.** Biophilic patterns analysis of UGS_1 BP (Source: Author)

*Observations and learnings*

Despite the fact that this site did not present a high canopy coverage, the landscape design provided multiple vegetation levels, played with the terrain and created interesting and diverse atmospheres throughout the site. Furthermore, the presence of multiple functions provides the community a space that can be enjoyed by everyone. Even though the site presents very diverse vegetation type and arrangement indicating biodiversity, related to the 30/20/10 (%) rule explained in the methodology, it performed as 30/30/30 (%), indicating that a greater diversity in genus and species would be appreciated since these categories surpassed the maximum suggested (20% and 10% respectively). Moreover, this site presents all 14 biophilic patterns, which is an indication that the user can receive the optimal benefits provided by the greenspace. Nevertheless, the greenspace also presented a few factors that would need some attention, such as the need for maintenance to be constant, otherwise the more 'secluded' spaces created by the use of vegetation can pose a dangerous atmosphere without daylight.

#### *4.1.3.2 UGS 2*

Popularly known as Ferenc tér - Közösségi Park, UGS_2 is situated between the streets Berzenczey utca, Bokréta utca, Tompa utca and Balázs Béla utca, encompassing an area of approximately 7.200 m$^2$. The current location of the site used to be filled with one-story housing blocks, but after a flood that took place sometime around 1838, the houses were destroyed or fatally damaged, leading to their demolition. Owing to that, Ferenc tér, or Ferencz tér as it was called at the time, was created by expropriating the houses. In its original design, Nagyfő utca crossed the square in the middle and stretched until the second half of the 19$^{th}$ century, as it can be seen on the map from 1872 [Figure 12]. Alongside the rehabilitation of the district, Ferenc tér went through a renovation in 1989, with minor changes occurring in 1993-95 as well, such as the addition of the so-called whales, the unique fountains. The design of the fountains became a hazard as people were climbing them, therefore another renovation was motioned and finalized in 2016. However, this time the professionals involved used a participatory design approach with the local residents, which resulted in a great design leading to an optimal use of the space, and adoration by the users until present days (Vass, 2018).

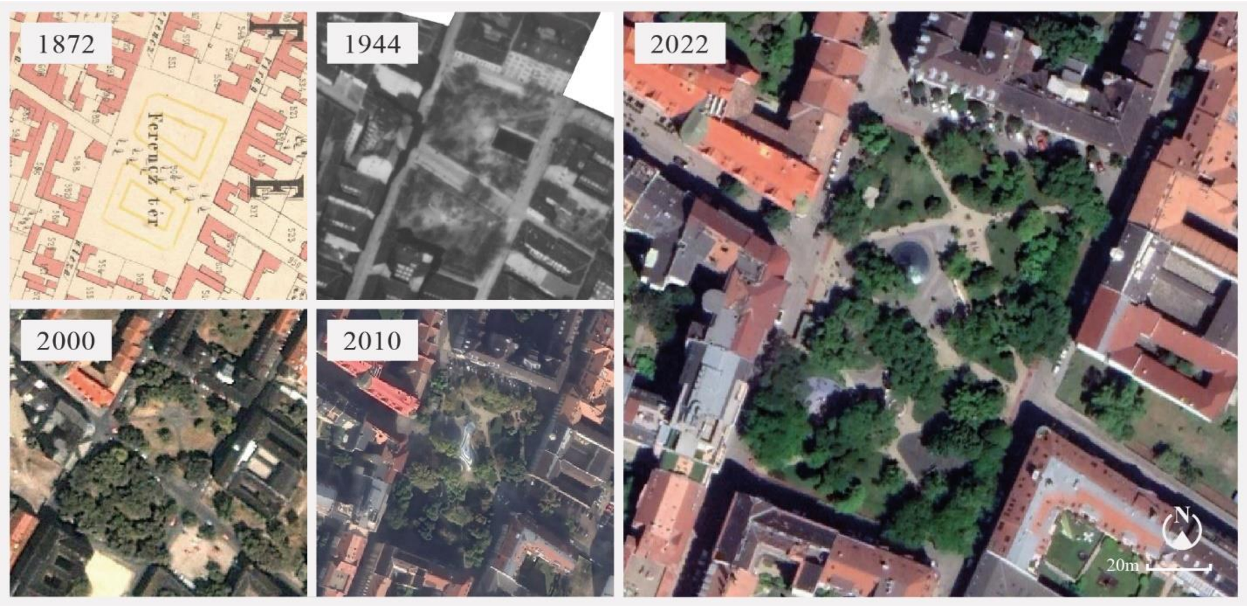


**Figure 12.** Historical overview maps of UGS_2 BP (Source: Web[2], Web[3]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_2 presents the overall aesthetic of a square with a contemplation and recreational character, with multiple functions. The space use can be considered as crossing through, walking/jogging, contemplating nature, dog walking, sports and leisure, where the users can be identified as mostly local residents from the district/neighbourhood. Moreover, its immediate surroundings have an approximate 60% residential use, with around 40% being commercial on the ground floor of the residential buildings [Figure 13]. The traffic can be categorized as low. Additionally, there are no bus stops adjacent to the square, however there are many bus stops and tram stops nearby, in addition to cycling routes (with a MOL Bubi bicycle station), making the square easily accessible. Concerning the infrastructure, the site has a paved sidewalk, internal paved pathways, light poles, garbage bins, benches, playgrounds, water fountains, running track, music pavilion and toilets. For water management, irrigation and sewage/drainage could be identified.


**Figure 13**. Map and photos of UGS_2 BP (Source: Author)

Regarding the planting design findings, there are five main plantation levels: grass, groundcovers, perennial bed, shrubs and trees. The tree canopy coverage could be estimated to approximately 69% with a 4.62% error margin, whereas 31% belongs to non-tree land cover [Figure 14], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 41,815,080.82g Carbon sequestration and 153,321,963.03g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 3.


**Figure 14.** Tree canopy coverage in UGS_2 BP (Source: iTree. Edited by the author)

**Table 3.** Summarised findings of taxa identification for UGS_2 BP

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 10 | 2 | 80 on site (all adult); 11 on the opposite sidewalks | 25% native; 33% non-native; 25% established; 17% unidentified |


**Figure 15.** Taxa variety in UGS_2 BP (Source: Author)

| Biodiversity: family | Biodiversity: genus | Biodiversity: species | Unique values | Maintenance |
|---|---|---|---|---|
| 8 families; highest concentration of 20% from *Cannabaceae* | 9 genus; largest amount of 20% from *Celtis* | Highest portion corresponds to 20% from *Celtis occidentalis* | Medicinal: 58%<br>Edible fruits: 17%<br>Other edible part: 8%<br>Unidentified: 17% | Ideal |

**Further observations:** The participatory design approach proved to be advantageous, leading to a good design and high space use and 'likeness'. The current situation of the site can be visualised in Figure 16 below.

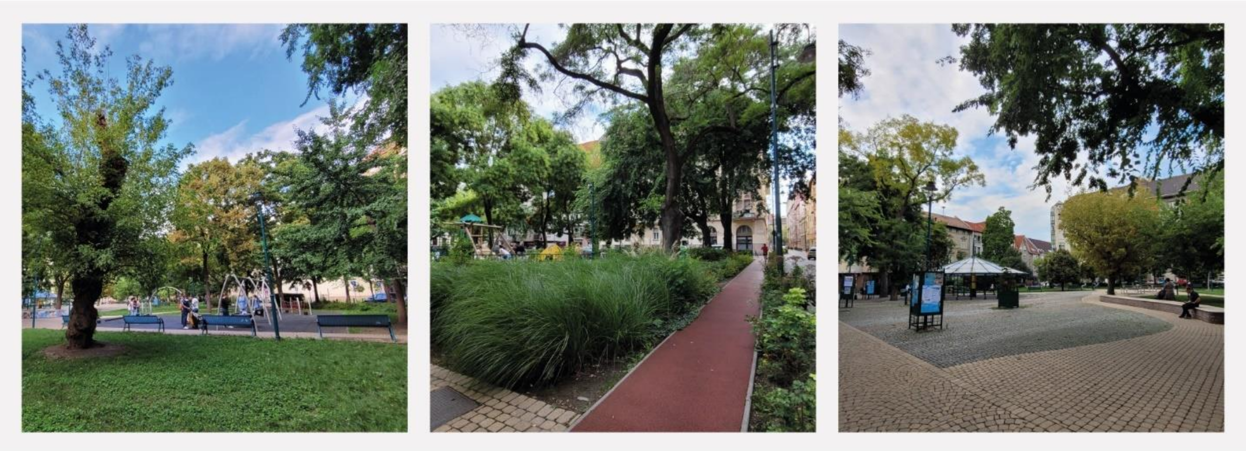

**Figure 16.** Photos from UGS_2 BP (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_2 has a very creative landscape design, indicating a good quality. Furthermore, certain degree of biodiversity could be observed apart from the plants, with the presence of birds and insects. The park also presented a medium noise level, due to the intense use it can be somewhat noisy, especially near the playgrounds. Moreover, the empirical observations pointed to a certain level of stewardship by the local residents, which could be linked to them being part of the design and planning process. Regarding the 14 biophilic patters presented in the methodology (chapter 3.2), the presence and average of each one can be seen on Figure 17 below.

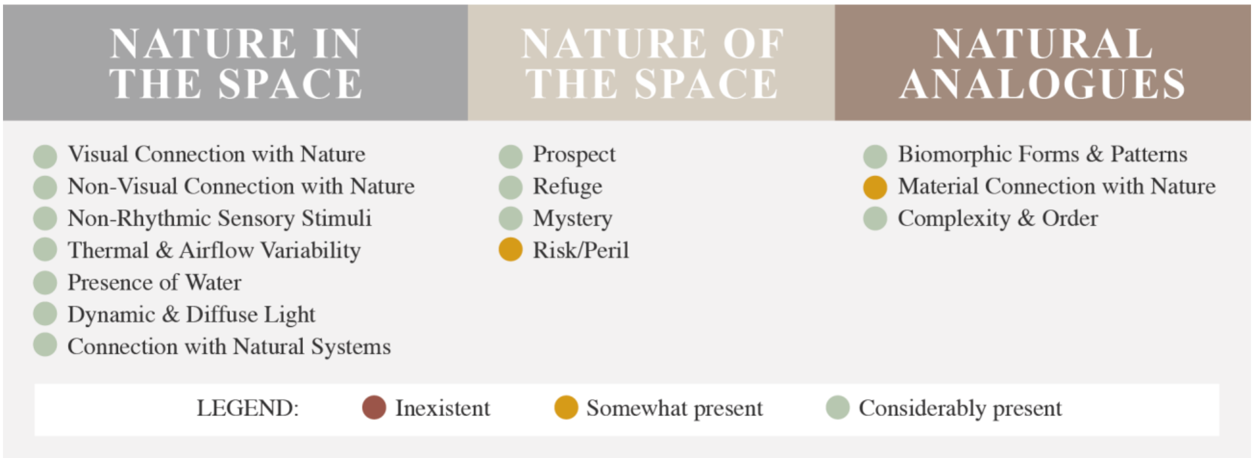


**Figure 17.** Biophilic patterns analysis of UGS_2 BP (Source: Author)

*Observations and learnings*

This greenspace presented a particularity that can be considered very important in landscape planning, as proposed in this research, which is participatory design. During the last renovations, the professionals involved the community for a better understanding of their needs and wishes, and this proved effective with the use of the space being constant. According to Bukovszki (2016), Ferenc tér is also harmonious and heavily used because it has exactly what was needed, owing to the community participation in the design process.

The landscape architecture design provides multiple vegetation levels, and the presence of multiple functions provides the community a space that can be enjoyed by everyone, in addition to the cultural events that take place in the pavilion all year round. Even though the site presents very diverse vegetation type and arrangement indicating biodiversity, related to the 30/20/10 (%) rule it performed as 20/20/20 (%), thus a greater diversity in genus and species would be appreciated. Moreover, this site presents all 14 biophilic patterns, which is an indication that the user can receive the optimal benefits provided by the greenspace.

*<u>4.1.3.3 UGS 3</u>*

Popularly known as Bakáts tér, UGS_3 is situated between the streets Ráday utca, Knézits utca, Tompa utca and Bakáts utca, encompassing an area of approximately 8.600 $m^2$. This site is one of a few public spaces where the institutions that determine the life of the community can be found, where in the past people could find the church, school, hospital, and official office right at the square. In 1822 a small chapel was built on the site, initially as a temporary construction [Figure 18]. However, after the great flood of 1838 the square acquired its present form, as all the buildings in the area were either destroyed or severlly damaged. In 1867 the school was already operating, and in 1870 the hospital followed. The existing church was completed in 1879, and it is based on the designs of Miklós Ybl in neo-Romanesque style (Gönczi, 2020). The current design was completed in December 2021. Regarding the name of the square, until 1872, it was called Templom tér and then Nándor tér, after which it was named Bakáts tér after Cardinal Tamás Bakócz.

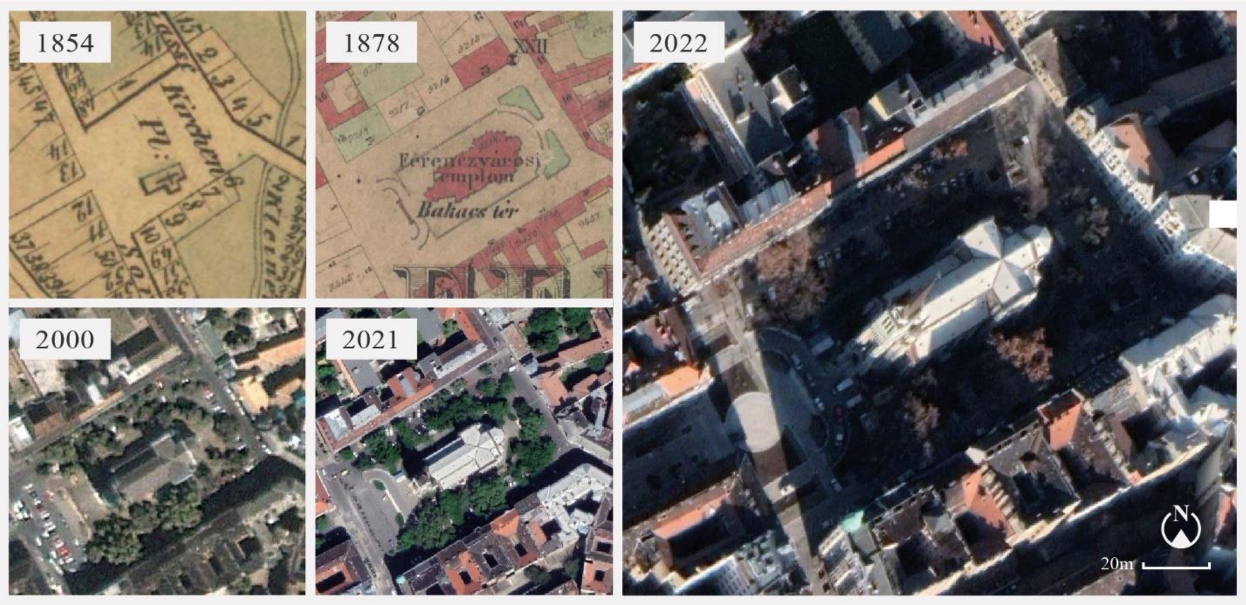


**Figure 18.** Historical overview maps of UGS_3 BP (Source: Web[2], Web[3]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_3 presents the overall aesthetic of a square with a contemplation and resting character, with minor recreational aspects. The space use can be considered as crossing through, resting, contemplating, dog walking, where the users can be identified as local residents from the district/neighbourhood, passers-by, users and visitors of the school and the municipality office, worshipers and visitors of the church, and tourists. Moreover, its immediate surroundings have an approximate 30% residential use, 40% being commercial and 30% cultural, with the municipality building, school and former hospital [Figure 19]. The traffic can be categorized as low. Additionally, there are no bus stops adjacent to the square, however there are many bus stops and tram stops nearby, in addition to cycling routes (with a MOL Bubi bicycle station), making the square easily accessible. Concerning the infrastructure, the site has a paved sidewalk, internal paved pathways, light poles, garbage bins, benches, water fountains and chess tables. For water management, irrigation and sewage/drainage could be identified.


**Figure 19.** Map and photos of UGS_3 BP (Source: Author, and photo from Web[7])

Regarding the planting design findings, there are five main plantation levels: grass, groundcovers, perennial bed, shrubs and trees. The tree canopy coverage could be estimated to approximately 43% with a 4.95% error margin, whereas 57% belongs to non-tree land cover [Figure 20], consisting of both active and inactive surfaces. It is worth mentioning that with the new landscape design, the canopy coverage will increase due to the addition of new trees. According to the i-Tree software calculations, the current vegetation present an estimated benefit of 25,035,346.22g Carbon sequestration and 91,796,269.00g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 4.


**Figure 20.** Tree canopy coverage in UGS_3 BP (Source: i-Tree. Edited by the author)

**Table 4.** Summarised findings of taxa identification for UGS_3 BP

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 14 | 1 | 63 on site (all adult); 26 on the opposite sidewalks | 53% native; 20% non-native; 20% established; 7% unidentified |

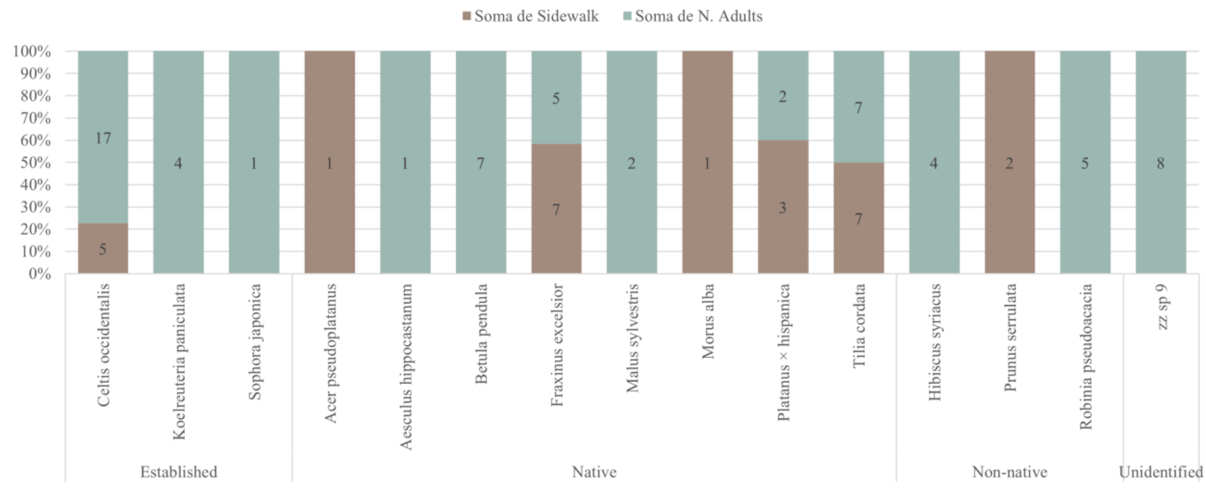


**Figure 21.** Taxa variety in UGS_3 BP (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 9 families; highest concentration of 25% from *Cannabaceae* | 14 genus; largest amount of 25% from *Celtis* | Highest portion corresponds to 25% from *Celtis occidentalis* | Medicinal: 53%<br>Edible fruits: 27%<br>Other edible part: 6%<br>Ornamental: 7%<br>Unidentified: 7% | Ideal |

**Further observations:** The current situation of the site can be visualised in Figure 22 below.

**Figure 22.** Photos from UGS_3 BP (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_3 has a newly finished landscape design with innovative solutions, such as suspended enclosures and the Stockholm-method[4], which greatly contribute to sustainability and indicating an excellent quality. Furthermore, certain degree of biodiversity could be observed apart from the plants, with the presence of birds and insects. The square also presented a medium noise level, which can vary during the day due to the movement from the school children. Moreover, the empirical observations pointed to a certain level of stewardship by the local residents, with local crochet art on the trees. Regarding the 14 biophilic patters presented in the methodology (chapter 3.2), the presence and average of each one can be seen on Figure 23 below.

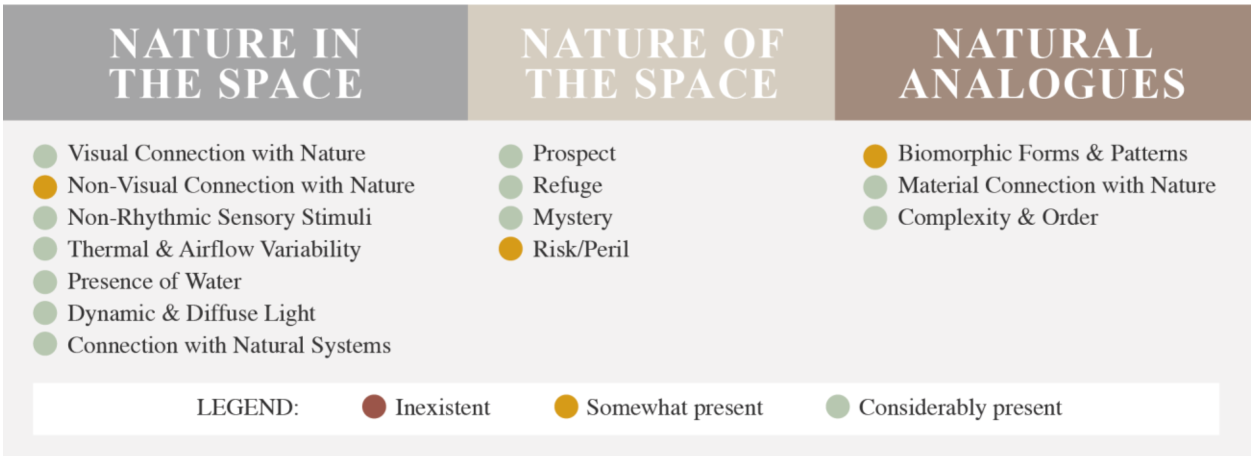


**Figure 23.** Biophilic patterns analysis of UGS_3 BP (Source: Author)

*Observations and learnings*

Among the researcher sites, UGS_3 is the one which has most recently being renovated and redesigned, where the priority was to increase the greenery and create a barrier-free space with the input of the community. Also counting with a participatory design approach, although with the use of questionnaires, this urban greenspace provides a place for resting, contemplation, entertainment, local cultural events and nature appreciation. The landscape project is an example to be followed in other urban greenspace rehabilitation. Furthermore, the professionals applied the Stockholm-style tree planting, which ensures that the roots of the trees will receive more space, air, water and nutrients, helping them live longer and grow larger, without their roots trying to grow upwards, destroying the pavement (Ferencváros, n.d.; Ferencvárosi Municipality, 2021).

The landscape design provides multiple vegetation levels, and the presence of different functions provides the community a space that can be enjoyed by everyone, in addition to the cultural events that take place in front of the church. Even though the site presents very diverse vegetation type

[4] The Stockholm method is an approach that has been in development since the mid-2000s in Stockholm, which has consistently achieved positive results for tree establishment using clean, angular stone mixed with nutrient-enriched biochar and compost. To date, trees planted in these pits with structural soils have grown up to be very healthy with exceptional growth rates (Embrén & Alvem, 2017).

and arrangement indicating biodiversity, related to the 30/20/10 (%) rule it performed as 25/25/25 (%), thus a greater diversity in genus and species would be appreciated, although these numbers can change seasonally due to the changing perennial beds that are replanted in different seasons. Moreover, this site presents all 14 biophilic patterns, which is an indication that the user can receive the optimal benefits provided by the greenspace.

## 4.2 Campo Grande – Brazil

*"Para compor um tratado de passarinhos*
*É preciso por primeiro que haja um rio com árvores e palmeiras nas margens.*
*E dentro dos quintais das casas que haja pelo menos goiabeiras…"* - Manoel de Barros

Manoel de Barros was a famous Brazilian poet born in Cuiabá, but who lived in Campo Grande from a young age till his death in 2014, and dedicated his verses to nature and regional elements, therefore being considered an advocate for the environment and local culture. The excerpt from one of his poems cited above can be translated as: "*To compose a treatise of birds, first of all, there must be a river with trees and palm trees on the banks. And inside the backyards of the houses that there are at least guava trees…*". In a sensitive and simple manner, this poem explains that we must face nature as a whole, a set of elements that are interconnected. Barros further stresses the need to be close to nature and learn from it, in order to be able to truly know it. In a way, this translates to biophilia.

### *4.2.1 Geographical aspects*

Campo Grande is the capital city of Mato Grosso do Sul, one of the 26 states in Brazil [Figure 24], counting with an estimated population of 2.880.560 people in the whole state (IBGE, n.d.). Located in the Midwestern part of the country, the city consists of 8.082,978 km² in territory, from which 252,63 km² corresponds to the urban area. Campo Grande has 786.797 inhabitants according to the last census from 2010, and an estimate of 916.001 in 2021 (IBGE, n.d.), though with the potential to house 4 million people (Arruda, 2016).

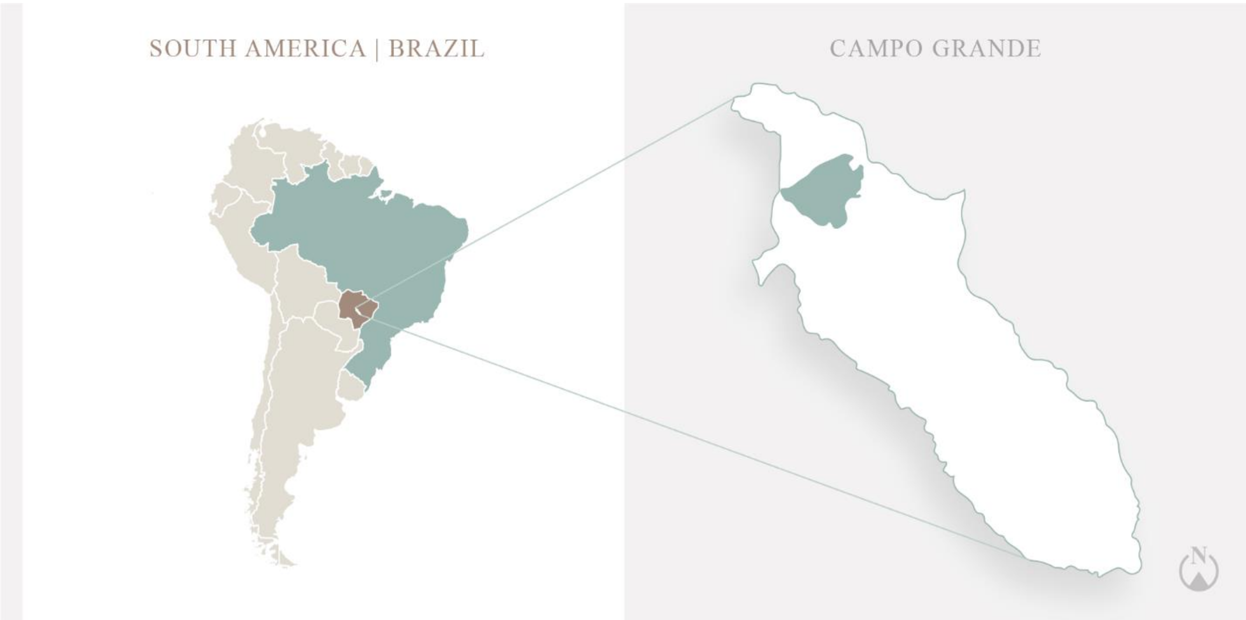


**Figure 24.** Map of South America situating Campo Grande in Brazil, where the bigger white part represents the whole municipality, and the highlighted in green is the urban area (Source: Author)

#### *4.2.1.1 Climate*

Situated between the Tropics of Capricorn and Equator, Campo Grande has variable temperatures throughout the year, with a predominance of tropical savanna climate with dry seasons, where only two seasons can be clearly identified: summer and winter (Pereira Rosa, 2019). Summers are long, lasting for 7.6 months, from August 26 to April 13, hot, stuffy and humid with a high level of rainfall, with the maximum daily temperature above 31°C. However, higher temperatures were registered, for instance, 38°C were marked in the city's thermometers in January 2019, being considered the hottest day of the year. As aforementioned, summer hosts the highest rainfall season, with probability above 41% that a given day has precipitation. The maximum probability of a day with precipitation is 70% on January 14 (Weather Spark, 2022). Winter is considered the cool, fresh and dry season, lasting 2.3 months with the maximum average daily temperature below 28°C. However, in recent years lower temperatures have been registered, reaching 2°C at night. With less precipitation than summer, the dry season lasts 6.2 months, from April 6 to October 11. The minimum probability of a day with precipitation is 11% on July 19.

Even though the rain season usually occurs during the summer, these patterns are changing, and heavy rain periods are occurring outside the expected seasons, owing to the ever-increasing environmental problems and global warming. Campo Grande has extreme seasonal variation in the monthly precipitation of rainfall, and it rains all year round in the city. The average precipitation amounts to 1470 millimetres (57.9 inches) per year, and maximum rainfall occurs during the 31 days around January 7, with a total average accumulation of 182 millimetres. The minimum rainfall occurs around July 21, with total average accumulation of 26 millimetres for the whole month (Weather Spark, 2022). However, due to climate change impacts the dry season is getting longer and the rainfalls stronger. As a result, Campo Grande has been experiencing droughts for more than a month straight and having extreme rainfalls that floods multiple parts of the city in less than half an hour. In addition, according to climatic research the tendency is to have higher temperatures and less precipitation. These are generating not only economic loss but health hazards as well (Peracio, 2016).

#### *4.2.1.2 Topography and soil*

The topography of Campo Grande and within a 3 km perimeter contains only small variations of altitude, with maximum change of 106 meters and average altitude above sea level equal to 575 meters. In geological terms, Campo Grande is comprised by Serra Geral and Botucatu formations of the São Bento and Caiuá Group Bauru. Regarding the soil, there are four types covering the municipality: dark red latosol, purple latosol, quartz sands and a small extension of littoral soils. The predominant type is the dark red latosol, which normally consists of medium texture and with salic character, extending from the upper part of the municipality to the border of its territory with the towns of Ribas do Rio Pardo and Rio Brilhante, in the confluence of the rivers Anhanduizinho and Anhanduí. At the same time, it is accompanied by a wide range of Quartz Sands, which descends in the same direction (Dieckow et al., 2009; Planurb, 2022).

#### *4.2.1.3 Vegetation*

Campo Grande belongs to the neotropical zone in the domains of the Cerrado phytogeographic region, constituting a set of vegetation forms that are presented according to a biomass gradient, directly related to soil fertility. The main physiognomies of this vegetation forms are the Campo Limpo, Campo Sujo, Cerrado, Cerradão, in addition to the presence of the Alluvial Forest (riparian forest) and areas of ecological tension, represented by the contact between the Cerrado (Seasonal Semideciduous Forest) and areas of anthropic formations used for agriculture (Eiten, 1972; Neto et al., 1994; Pott et al., 2011).

The Cerrado covers most of Mato Grosso do Sul, including the selected sites for this research. In the Pantanal alluvial plain there is the so-called Pantanal Complex, a vegetation cover in which the Cerrado and meadows are combined, with the predominance of meadow vegetation, constituting 5% of the state's vegetation and still occupying a small area in Campo Grande. The remaining vegetation cover identified for the year 2007 amounted to 168,133 hectares of the 810,000 ha of the municipal territory, corresponding to 20.7% of its area. The introduced pastures predominate the landscape nowadays and occupy large extensions of the municipal land, though this physiognomy has been gradually changing due to the introduction of soybean and corn cultivation in the West, and Eucalyptus in the Eastern portion (Planurb, 2022).

### *4.2.2 Urban analysis*

On June 21$^{st}$ of 1872 a caravan coming from the state of Minas Gerais arrived, and José Antônio Pereira established the first settlement. The village's initial boundaries were defined in 1875 and named "Arraial de Santo Antônio do Campo Grande" in honour of St. Anthony and the 'large field' they were located at (literal translation for 'Campo Grande'). The settlement was rapidly growing and attracting people from other regions due to the climate, natural richness of the area and the promise of free land for farming activities. At the beginning of 1889, in response to the inhabitant's demands, arrived the master José Rodrigues Benfica, who opened the first school of Campo Grande (Guimarães, 2001).

In 1910 the county was created and the modernizing ideas of the first administrators influenced several areas, from livestock to urban planning, where the urban zone was traced with broad, tree-lined avenues and streets. The urban fabric was developed between the streams Prosa and Segredo, with the purpose of occupying the tabular forms of the lands with an orthogonal plan, in checkerboard arrangement, with wide east-west streets. According to data from the ARCA Magazine, the Campo Grande Historical Archive, the new model had strong influences of positivist ideas, predominant among Brazilian intellectuals, which prevailed for 'a modern urban organization, from defined functions. Urban cities should articulate with each other in an agile way, through straight streets towards an urban centre of command (Junior, 2009). The main streets were considered those established from south to north, having as central axis Marechal Hermes, currently known as Afonso Pena Avenue [Figure 25].


**Figure 25.** Campo Grande's first map, highlighting Afonso Pena avenue in the early plans, and overlaid in the current city fabric with the help of satellite imagery (Source: Web[4]. Edited by the author)

As a result of the initial urban planning, nowadays, according to a research about arborization of public roads done by the Brazilian Institute of Geography and Statistics, Campo Grande is considered one of the most forested cities in the country, with 96.3% of the houses being shaded with trees (IBGE, 2010), and an estimate of 1 tree for 5 inhabitants ratio (Planurb, 2022). Moreover, the city has a well-structured urban fabric, with wide and well vegetated streets and avenues. These, together with the efforts from the environmental government sector, Campo Grande has been acknowledged as one of the Tree Cities of the World, by the Food and Agriculture Organization of the United Nations and the Arbor Day Foundation, for three consecutive years thus far, a big accomplishment seeing that from Brazil only 7 other cities are part of this network (Arbor Day Foundation, n.d.; Pereira Rosa & Szabó, 2019).

### *4.2.3 Urban greenspaces evaluation*

As explained in the previous chapter (3.1), the main selection criteria for urban greenspaces are focused on linear and compact elements. Therefore, as a continuation of the author master's research and on this study's initial stages, the first site selected was a strategic section of the Anhanduí river and its environ, a key linear greenspace in the city. However, due to a shore reconstruction project that removed more than 90% of the original vegetation and changed the site as a whole, no further research could be done for this PhD. Therefore, new greenspaces were selected for the study continuation, focusing on a systematic planting design evaluation and comprising the compact element category. In this regard, nine urban greenspaces were chosen which presented a 'neighbourhood' character, being either a square or a park like place. Moreover, their current situation and strategic location in the city shows great potential for green infrastructure and network creation/enhancement, thus reinforcing the selection criteria. These are referred to as UGS_1, UGS_2, UGS_3, UGS_4, UGS_5, UGS_6, UGS_7, UGS_8, UGS_9 [Figure 26].


**Figure 26.** Situation map of selected UGS in Campo Grande (Source: Author)

*<u>4.2.3.1 UGS 1 to 9 overview</u>*

The additional nine selected sites are located within the same neighbourhood, known as Autonomista. Seeing that they all share equal land use and other specifications, a brief overview of the historical development of the area, together with further relevant information will be collectively presented in this sub-chapter.

According to the oldest satellite images of the urban area registered in 1966, the whole neighbourhood was still undeveloped, and only half of it was appearing in the images. In the 70s decade however, parts of the area have been split into lots and main streets have been developed, together with a few housing projects on the North border. During the 80s the neighbourhood had a significant popularization, being almost half allotted and built up, and the sites current demarcation is already present. In 1999's map is possible to see the incredible change of the fast urbanization and densification, together with indications of landscape design on UGS_6 and UGS_8. Forward to 2002 it is visible a slight increase in trees planted on the selected greenspaces, as well as a landscape design on UGS_4. From the available imagery, in 2017 all UGSs were already present, with their current design and enhanced canopy coverage (SISGRAN, n.d.).

In present days, as stated in the latest urban master plan of Campo Grande, the greenspaces are located on the neighbourhood Autonomista, within the urban region of Prosa; zone Z3; macro zone MZ 2; environmental zone ZA 3; close to two special zones of environmental interest, ZEIA 1 and ZEIA 2 and one environmental centre 'Leonor Reginato Santini' (SISGRAN, n.d.). The area is approximately 213,96 hectares and has a mixed profile, containing both commercial and residential character, howbeit the latter is predominant with the habitation type being 93.15% houses. According to the last census of 2010, the total population of the neighbourhood consists of 7,580 citizens, contains 2,409 permanent domiciles with 3.15 people per house, resulting in a 35.43 demographic density rate (inhabitant/hectare). Furthermore, the average age of the local population is 37.54 years old (IBGE, 2010).

#### *4.2.3.2 UGS 1*

Located in the allotment 'Jardim Vitrine' and popularly known as Vila Rica square, UGS_1 is situated between the streets Santa Bárbara, Itaimbé and Itaguaí, encompassing an area of 2,883.30 $m^2$. The first demarcation of the site can be seen in the 80's decade, where some of the original trees could still be seen. In contrast, in 1999 almost all the vegetation was removed making the site solely an urban void, through which spontaneous paths were starting to be created by passers-by. In 2008 the level of green slightly increased with the plantation of a few trees and grass coverage, although no design is existent. Aerial images from 2013 already present the current design of the site, although it was not possible to identify precisely the year it was realised [Figure 27].

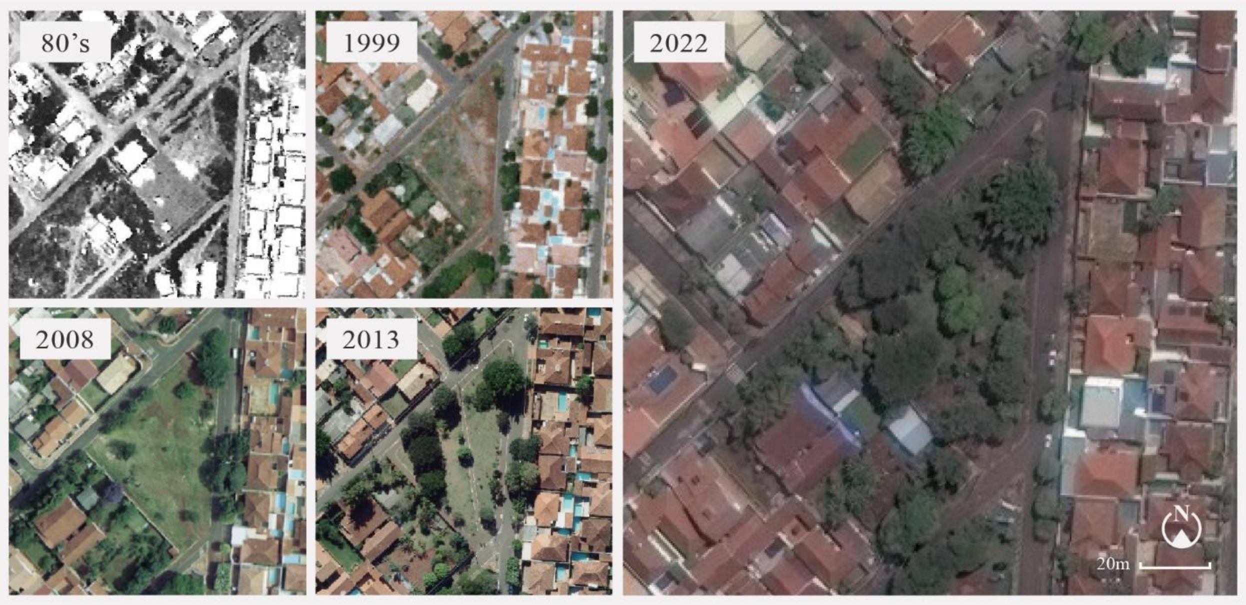


**Figure 27.** Historical overview maps of UGS_1 CG (Source: Web[2], Web[5]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_1 presents the overall aesthetic of a small square with a minor recreational character. The space use can be considered mainly as crossing through and walking/jogging, where the users can be identified as mostly local residents, with the addition of passers-by to/from work. The square has a triangular shape with the 'back' being aligned with the wall of a private residence. Moreover, its immediate surroundings have a 100% residential use, although two important facilities can be found in the corners: SESAU CAPS II, a basic health unit, on the South, and BTCC Telecommunications enterprise on the North [Figure 28]. The traffic can be categorized as busy, with one of the limit streets being a collector road. Additionally, there are no bus stops adjacent to the square, no cycling lanes, or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has a cement sidewalk, internal paved pathways, light poles, garbage bins (handmade and installed by the population), and no water management aspects could be identified.


**Figure 28.** Map and photos of UGS_1 CG (Source: Author)

Regarding the planting design findings, there are 2 plantation levels: grass and trees. The tree canopy coverage could be estimated to approximately 71% with a 4.54% error margin, whereas 29% belongs to non-tree land cover [Figure 29], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 18,120,898.09g Carbon sequestration and 66,443,292.45g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 5.

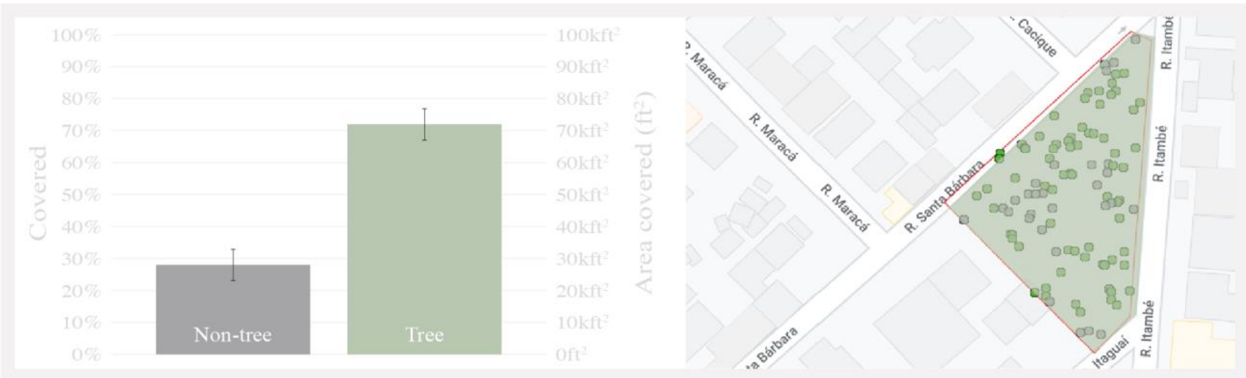


**Figure 29.** Tree canopy coverage of UGS_1 CG (Source: i-Tree. Edited by the author)

**Table 5.** Summarised findings of taxa identification for UGS_1 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 28 | 3 | 58 on site (3 young; 55 adult); 3 on the opposite sidewalks | 55% native; 6% endemic; 13% non-native; 13% established; 3% unknown (considered as such for being cultivars); 10% unidentified |


**Figure 30.** Taxa variety in UGS_1 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 15 families; highest concentration of 23% from *Bignoniaceae* | 27 genus; largest amount of 11% from *Handroanthus* | Highest portion corresponds to 11% from *Handroanthus ochraceus* | Medicinal: 42%<br>Edible fruits: 29%<br>Ornamental: 3%<br>Cosmetics: 3%<br>Aromatic: 3%<br>Condiment: 10%<br>Unidentified: 10% | Low |

**Further observations:** old *Ficus* trees' roots caused considerable damage to the sidewalks; fallen or cut branches left scattered; the shaded areas lack ground cover species, leaving the soil exposed; vandalised infrastructure; lack of furniture, such as garbage bins and benches; lack of functions; litter. The current situation of the site can be visualised in Figure 31 below.

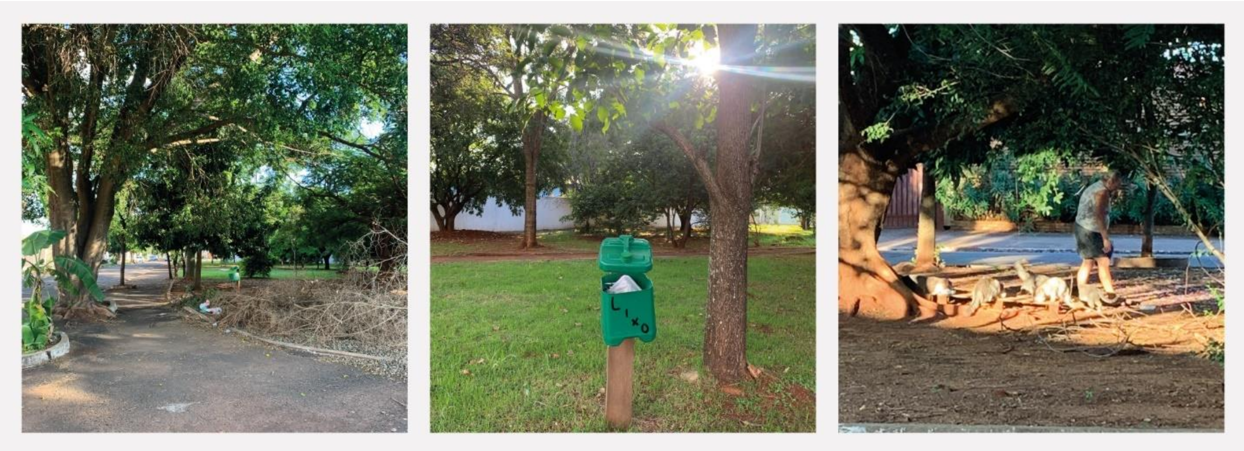


**Figure 31.** Photos from UGS_1 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_1 has some level of landscape design, although it indicated an overall bad quality. Nevertheless, certain degree of biodiversity could be observed apart from the plants, with the presence of birds and insects. Since it is a ‘corner’ and small space with a triangular shape, it contains high noise level. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who created cat and bird feeding areas, in addition to installing handmade garbage bins. Additionally, due to the high vegetation density, less then optimal maintenance level and lighting infrastructure, a feeling of unsafeness could be experienced at night if crossing inside the square. Regarding the 14 biophilic patters presented in the methodology (chapter 3.2), the presence and average of each one can be seen on Figure 32 below.

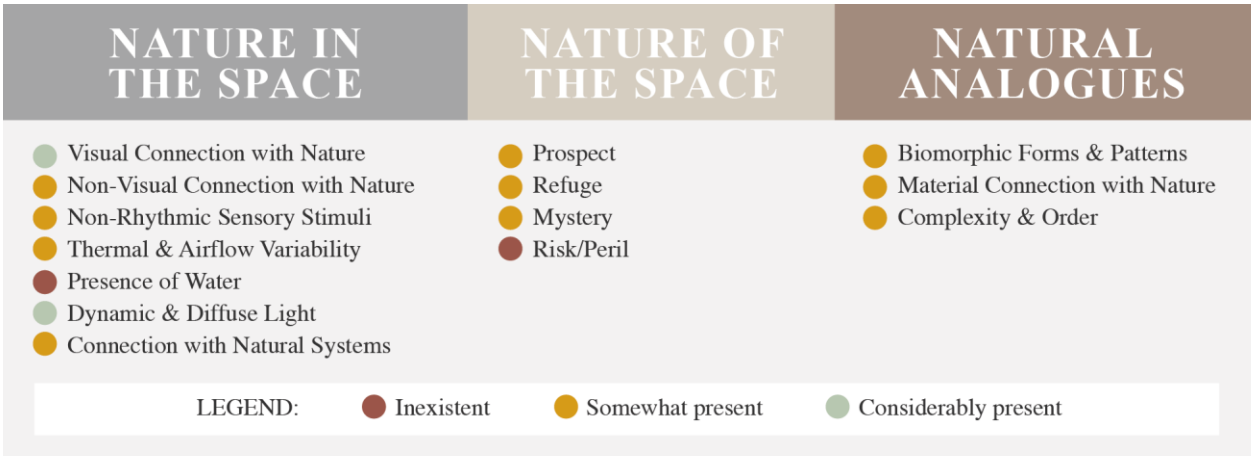


**Figure 32.** Biophilic patterns analysis of UGS_1 CG (Source: Author)

*Observations and suggestions*

Despite the fact that the analysis indicates an increase of vegetation in the past 40 years, the results presented a somewhat neglected space lacking a proper landscape design. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 23/11/11 (%), the numbers are close to the limit regarding family, under as of genus and over 1% for species. Furthermore, the plantation level is not ideal as it consists mainly of trees and grass. Further observations:

- **Strengths:** high canopy coverage; biodiverse to some extent; stewardship and interest from local residents; strategic location.
- **Weaknesses:** maintenance; lack of furniture and functions; infrastructure.
- **Opportunities:** biodiversity enhancement; increase/improve space use.
- **Threats:** unsafeness due to lack of maintenance and infrastructure; aggressive *Ficus* roots damaging sidewalks.

**Table 6.** Suggestions for the study area UGS_1 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing ground covers, especially for shady areas, and shrubs<br>- Introducing more species, especially native and endemic with edible unique values | - Maintain an 'openness' and clear views, in order not to create unsafe atmospheres<br>- The possibilities of increasing the maintenance level | - More space use<br>- Higher benefits related to mental health<br>- Improved urban health |

*4.2.3.3 UGS 2*

Located in the allotment 'Vila Orsi' and popularly known as João Siufi square, UGS_2 is situated between the streets Jales, Praia do Leblon, Amazonas and rua do Caribe, encompassing an area of 3,881.82 $m^2$. The first demarcation of the site can be seen in the 80's decade, where only the road on the right being visible. In contrast, in 1999 the demarcation is clear, a few small trees can be spotted and spontaneous paths were starting to be created by passers-by. In 2008 the current design of the site, which aerial images from 2006 suggest the construction was under way, and the level of green slightly increased with the plantation of a few trees and growth of others. In 2013 presents a considerable canopy coverage increase, although 2022 shows bigger growth [Figure 33].


**Figure 33.** Historical overview maps of UGS_2 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_2 presents the overall aesthetic of a small park with a nature/garden like, contemplation and minor recreational character. The space use can be considered as crossing through, walking/jogging and pet walking, where the users were identified as local residents and people from other neighbourhoods, due to the presence of the food truck. Moreover, its immediate surroundings have an 90% residential use, with the remaining 20%

representing a food truck in the square's corner and a butcher shop in front of it [Figure 34]. The traffic can be categorized as busy, with one of the limit streets being an arterial road (Amazonas). Additionally, there are no bus stops adjacent to the square, no cycling lanes, or other means of public transportation, hence the accessibility is only by car or on foot, since biking on the roads without dedicated lanes is considered dangerous in the city. Concerning the infrastructure, the site has a cement sidewalk, internal paved pathways, light poles, no water management aspects could be identified although sewage/drainage is present.


**Figure 34.** Map and photos of UGS_2 CG (Source: Author)

Regarding the planting design findings, there are two main plantation levels: grass and trees, with a subtle hint of ground covers and perennial plants scattered indicating a clear sign of local residents' influence. The tree canopy coverage could be estimated to approximately 77% with a 4.21% error margin, whereas 23% belongs to non-tree land cover [Figure 35], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 24,090,019.74g Carbon sequestration and 88,330,072.03g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 7.

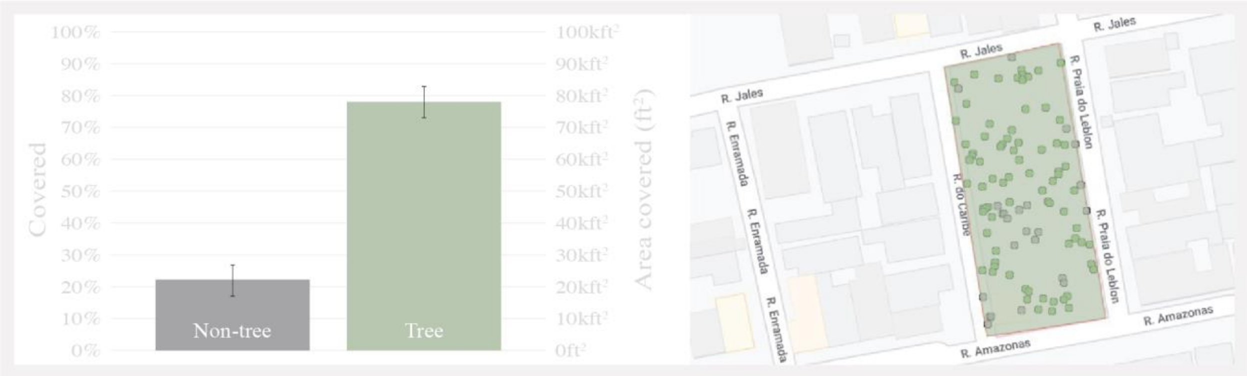


**Figure 35.** Tree canopy coverage in UGS_2 CG (Source: i-Tree. Edited by the author)

**Table 7.** Summarised findings of taxa identification for UGS_2 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 32 | 2 | 84 on site (7 young; 77 adult); 17 on the opposite sidewalks | 35% native; 9% endemic; 23% non-native; 21% established; 3% invasive; 3% unknown; 6% unidentified |

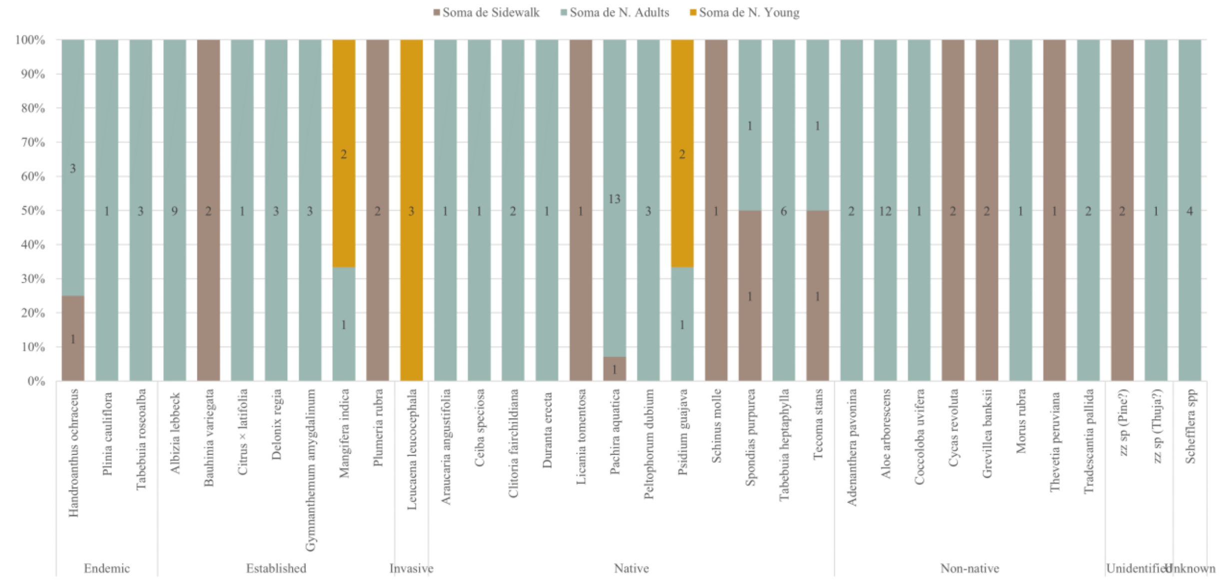


**Figure 36.** Taxa variety in UGS_2 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 18 families; highest concentration of 24% from *Fabaceae* | 31 genus; largest amount of 14% from *Pachira* | Highest portion corresponds to 14% from *Pachira aquatica* | Medicinal: 44%<br>Edible fruits: 26%<br>Other edible part: 3%<br>Ornamental: 6%<br>Cosmetics: 3%<br>Aromatic: 3%<br>Condiment: 3%<br>Ecological restoration: 3%<br>Unknown: 3%<br>Unidentified: 6% | Medium |

**Further observations:** fallen or cut barks left scattered, and apparently being used as benches; the shaded areas lack ground cover species, leaving the soil exposed; lack of furniture, such as garbage bins and benches; lack of functions; 4 dead trees; young seedlings were carefully protected, however the materials and structure used indicates being the work of local residents. The current situation of the site can be visualised in Figure 37 below.

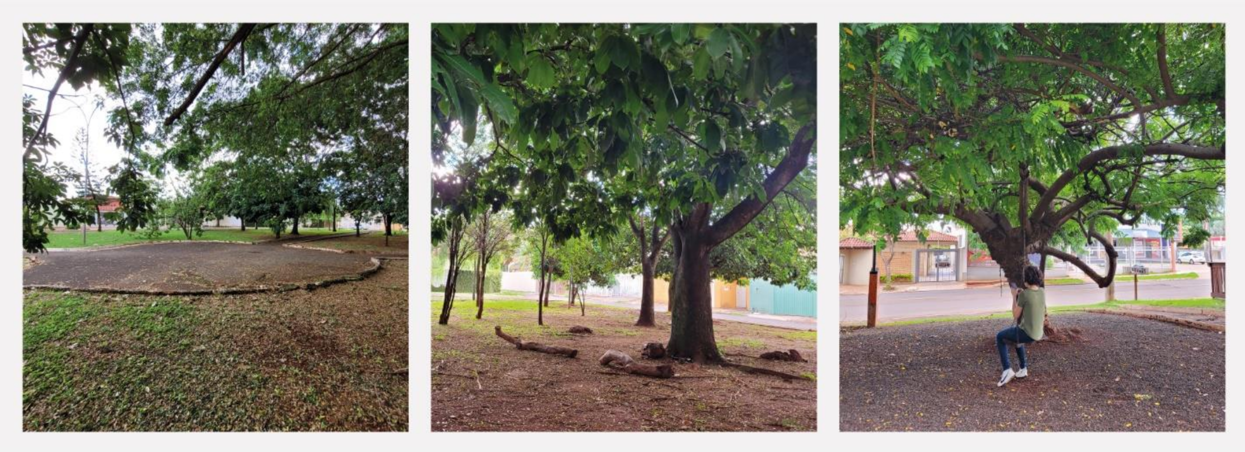

**Figure 37.** Photos from UGS_2 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_2 has some level of landscape design, thus it indicated an overall bad average quality. Nevertheless, certain degree of biodiversity could be observed apart from the plants, with the presence of bird flocks. The square also presented a low noise level during the day, with a tranquil atmosphere, changing to a medium noise range at night due to the food truck. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who were using fallen tree branches as sitting areas, planting and protecting some young trees. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 38 below.

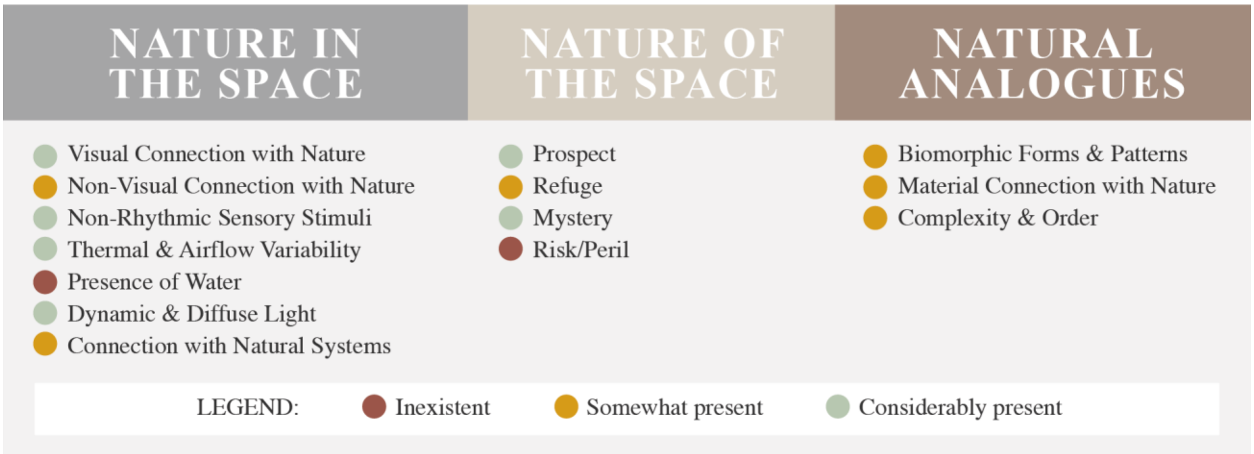


**Figure 38.** Biophilic patterns analysis of UGS_2 CG (Source: Author)

*Observations and suggestions*

Despite the fact that the analysis indicates an increase of vegetation in the past 40 years, the results presented a space lacking a proper landscape design. For instance, there are four paths leading to a circular paved area at the middle of the site, where there is nothing apart from open paved space. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 24/14/14 (%), the numbers are close to the limit regarding family, albeit under as of genus and over the species variety. Furthermore, the plantation level is not ideal as it mainly consists of trees, grass and 2 scattered clumps of one perennial and groundcover species. Further observations:

- **Strengths:** high canopy coverage; biodiverse to some extent; stewardship and interest from local residents; strategic location due to food truck.
- **Weaknesses:** maintenance; lack of furniture and functions.
- **Opportunities:** biodiversity enhancement; increase/improve space use; create a water feature.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat.

**Table 8.** Suggestions for the study area UGS_2 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing more ground covers, especially for shady areas, and shrubs<br>- Introducing more and variable species, especially native and endemic<br>- Create a contemplation space in the middle circle area, with a water feature and benches<br>- Propose a dog park | - Maintain an 'openness' and clear views, in order not to create unsafe atmospheres<br>- The possibilities of increasing the maintenance level<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Increased socio-economic values |

#### *4.2.3.4 UGS 3*

Located in the allotment 'Jardim Autonomista II' and popularly known as João Siufi square, UGS_3 is situated between the streets Jales, Praia de Itapuã, Amazonas and Praia de Ipanema, encompassing an area of 1,308.72 m$^2$. The first demarcations of the site can be seen in the 80's decade, appearing to be just an empty lot between houses. In contrast, in 1999 the demarcation is clear, although there is no vegetation and clear function. In 2008 the site is still an urban void, although some vegetation is already visible. In 2013 there is still no functional design or considerable increase in vegetation, apart from the natural growth of already existing plants. The exact date of the current landscape design is not known since the information could not be gathered from the city council, however based on satellite image it is possible to say it happened between 2013 and 2019 [Figure 39].


**Figure 39.** Historical overview maps of UGS_3 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_3 presents the overall aesthetic of a small square or pocket park, with a strong recreational character. The space use can be considered as walking/jogging, pet walking, playground for kids, open air gym and running track. The users were identified as local residents and people from close by neighbourhoods, due to the presence of the fitness functions. Moreover, its immediate surroundings have an 99% residential use, with the remaining 1% representing a convenience store in the square's corner [Figure 40]. The traffic can be categorized as semi-busy, with one of the limit streets being an arterial road (Amazonas). Additionally, there are no bus stops adjacent to the square, no cycling lanes or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has only a paved sidewalk on the Amazonas street front, internal paved running track, light poles, small playground for kids and open air gym. No water management aspects could be identified, although sewage/drainage is present.


**Figure 40.** Map and photos of UGS_3 CG (Source: Author)

Regarding the planting design findings, there are 3 plantation levels: grass, shrubs and trees. The tree canopy coverage could be estimated to approximately 56% with a 4.96% error margin, whereas 44% belongs to non-tree land cover [Figure 41], consisting on both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 10,746,910.44g Carbon sequestration and 39,405,338.19g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 9.


**Figure 41.** Tree canopy coverage in UGS_3 CG (Source: i-Tree. Edited by the author)

**Table 9.** Summarised findings of taxa identification for UGS_3 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 24 | - | 56 on site (10 young; 46 adult); 17 on the opposite sidewalks | 29% native; 9% endemic; 29% non-native; 25% established; 8% unknown |

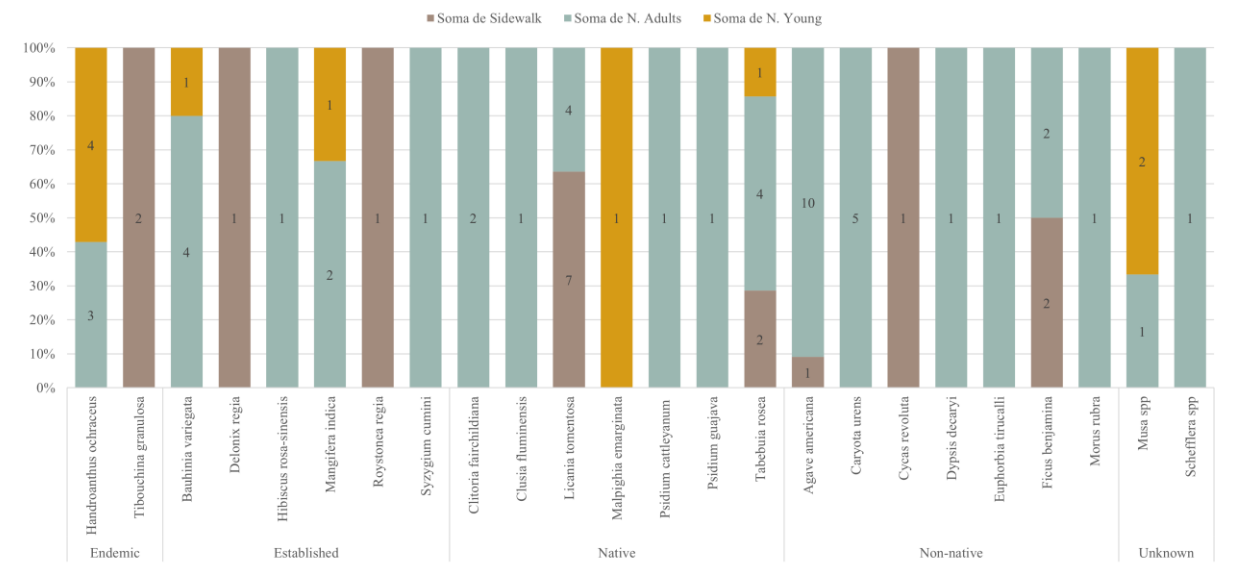


**Figure 42.** Taxa variety in UGS_3 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 24 families; highest concentration of 19% from *Bignoniaceae* | 23 genus; largest amount of 15% from *Licania,* tied with a 15% of *Agave* | Highest portion corresponds to 15% from both *Agave americana* and *Licania tomentosa* | Medicinal: 46%<br>Edible fruits: 33%<br>Other edible part: 4%<br>Ornamental: 13%<br>Unknown: 4% | Medium |
| **Further observations:** potted plants outgrowing and braking containers, and protected seedling, an apparent contribution of local residents; lack of furniture, such as garbage bins and benches; The *Ficus* trees aggressive roots were starting to cause damage to the road; 3 dead trees. The current situation of the site can be visualised in Figure 43 below. | | | | |

**Figure 43.** Photos from UGS_3 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_3 has a landscape design and indicates a good overall quality. Apart from the plants, there were no other biodiversity observations. The square also presented a medium to high noise level, probably due to the small size and being surrounded by roads. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who were planting and protecting some young trees, in addition to placing potted plants in some areas. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 44 below.

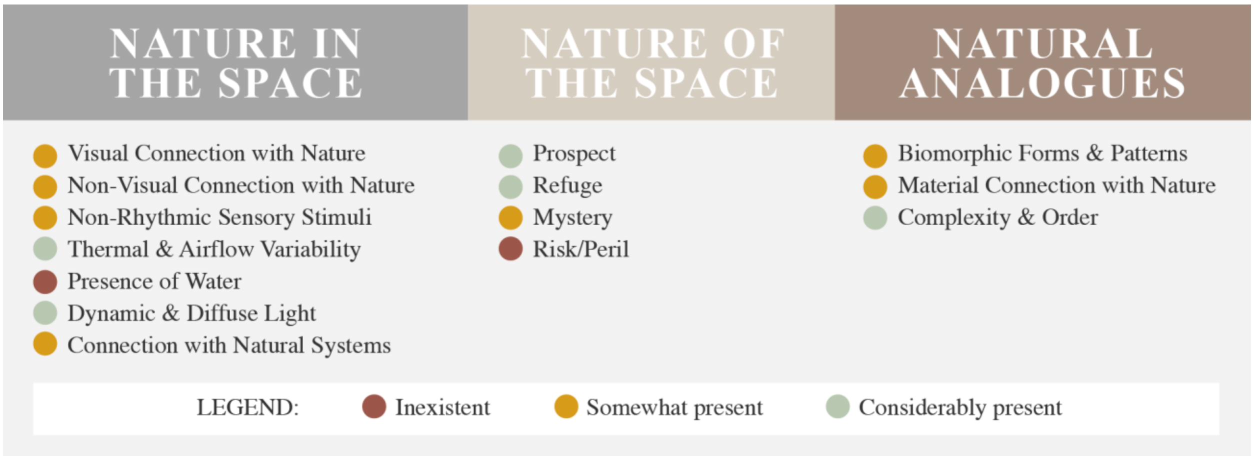


**Figure 44.** Biophilic patterns analysis of UGS_3 CG (Source: Author)

*Observations and suggestions*

The analysis indicates an increase of vegetation in the past 40 years, with a landscape design project being realised between 2013 and 2019. The design presents a clever solution for the narrow greenspace with the clear function of exercising and playing with the vegetation density in a way not to densify the space and views. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 19/15/15 (%), the numbers regarding family are good, albeit under as of genus and over for species variety. Further observations:

- **Strengths:** clear and objective design and functions; biodiverse to some extent; stewardship and interest from local residents.
- **Weaknesses:** narrow shape; could present a greater variety in plantation level.
- **Opportunities:** biodiversity enhancement; create a drinking water feature as the space is designed for exercising.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat; outgrown vegetation can block the views, paths and create a feeling of unsafeness.

**Table 10.** Suggestions for the study area UGS_3 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing more shrubs and perennials<br>- Introducing new species, especially native and endemic<br>- Create a drinking water fountain<br>- Propose a resting area | - Maintain the openness and clear views<br>- Play with vegetation level without blocking views<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental and physical health<br>- Improved urban health |

*4.2.3.5 UGS 4*

Located in the allotment 'Jardim Autonomista II' and popularly known as Portugal square, in honour of the Luso Brazilian Association located in front of it. UGS_4 is situated between the streets Jales and Amazonas, encompassing an area of 1,270.44 $m^2$. The first demarcations of the site can be seen in the 80's decade, however being just an empty lot between a housing estate and the initial indications of a road. In contrast, in 1999 the demarcation is clear and spontaneous walking paths are visible. In 2008 the site already presents the current design, which was done between 2000 and 2002. In 2013 does not show great changes apart from normal vegetation growth [Figure 45].


**Figure 45.** Historical overview maps of UGS_4 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_4 presents the overall aesthetic of a square, with a contemplation and slight recreational character. The space use can be considered as pet walking, playground for kids and contemplation area. The users were identified as local residents, people visiting the Luso Brazilian Association, and homeless couple were slipping under the pergola in a permanent/regular basis. Moreover, its immediate surroundings have a 60% residential use and 40% commercial [Figure 46]. The traffic can be categorized as calm due to the location and street arrangement. Additionally, there are no bus stops adjacent to the square, no cycling lanes or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has a paved sidewalk, internal paved paths, light poles, playground for kids, and a pergola with a sitting area. No water management aspects could be identified, although sewage/drainage is present.


**Figure 46.** Map and photos of UGS_4 CG (Source: Author)

Regarding the planting design findings, there are 3 plantation levels: grass, shrubs and trees. The tree canopy coverage could be estimated to approximately 31% with a 4.62% error margin, whereas 69% belongs to non-tree land cover [Figure 47], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 8,459,896.29g Carbon sequestration and 31,019,619.55g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 11.

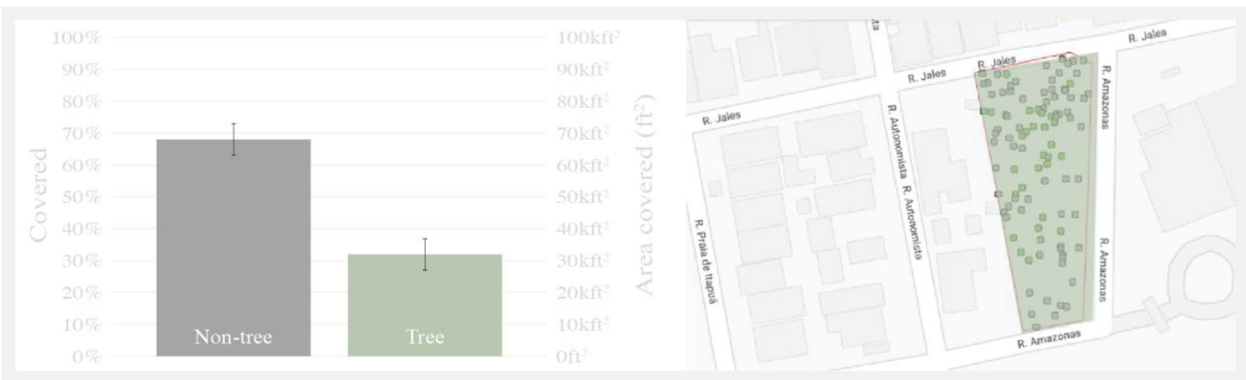


**Figure 47.** Tree canopy coverage in UGS_4 CG (Source: i-Tree. Edited by the author)

**Table 11.** Summarised findings of taxa identification for UGS_4 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 23 | 1 | 78 on site (10 young; 68 adult); 5 on the opposite sidewalks | 54% native; 8% endemic; 13% non-native; 13% established; 8% invasive; 4% unidentified |

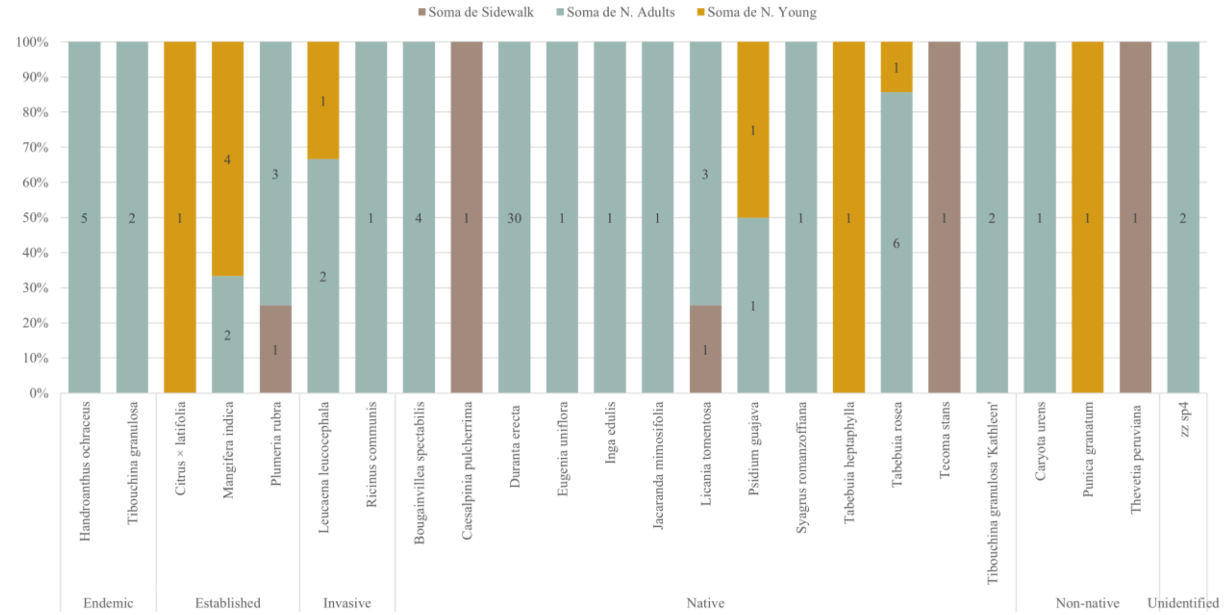


**Figure 48.** Taxa variety in UGS_4 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 13 families; highest concentration of 36% from *Verbenaceae* | 21 genus; largest amount of 36% from *Duranta* | Highest portion corresponds to 36% from *Duranta erecta* | Medicinal: 50%<br>Edible fruits: 34%<br>Other edible part: 4%<br>Ornamental: 4%<br>Aromatic: 4%;<br>Unidentified: 4% | Low |

**Further observations:** homeless people living in the square; various involuntary growth; weed growth on the sidewalk; invasive species growing and blocking sidewalk; the playground is damaged impeding use; grass to knee height; litter. The current situation of the site can be visualised in Figure 49 below.

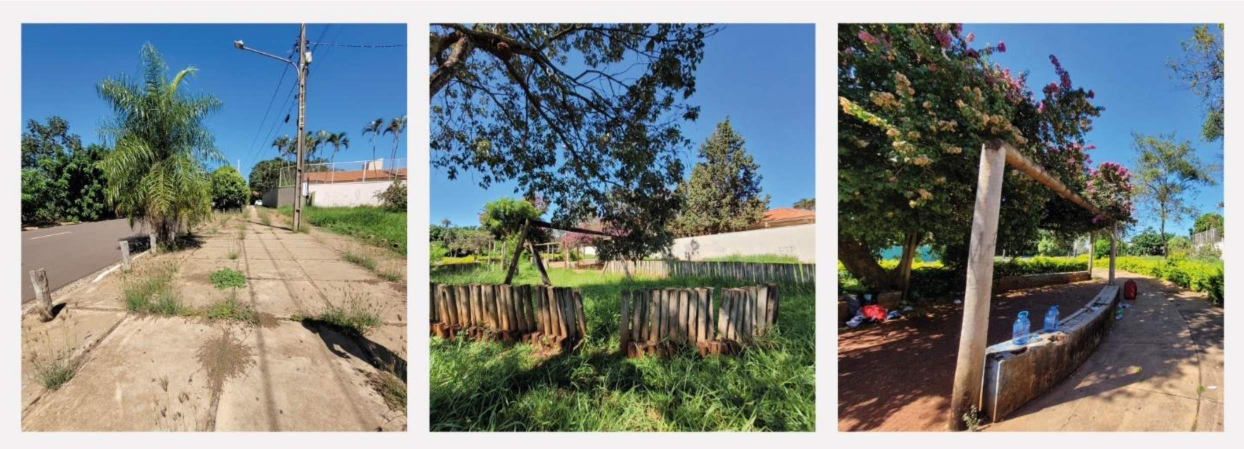

**Figure 49.** Photos from UGS_4 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_4 has a landscape design and indicates a bad overall quality. Apart from the plants, there were no other biodiversity observations. The square also presented a low noise level, probably due to the location and having the 'back' part paired with housing walls. Moreover, the empirical observations pointed to some sense of stewardship, although for this site is due to illegal occupation from homeless people. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 50 below.

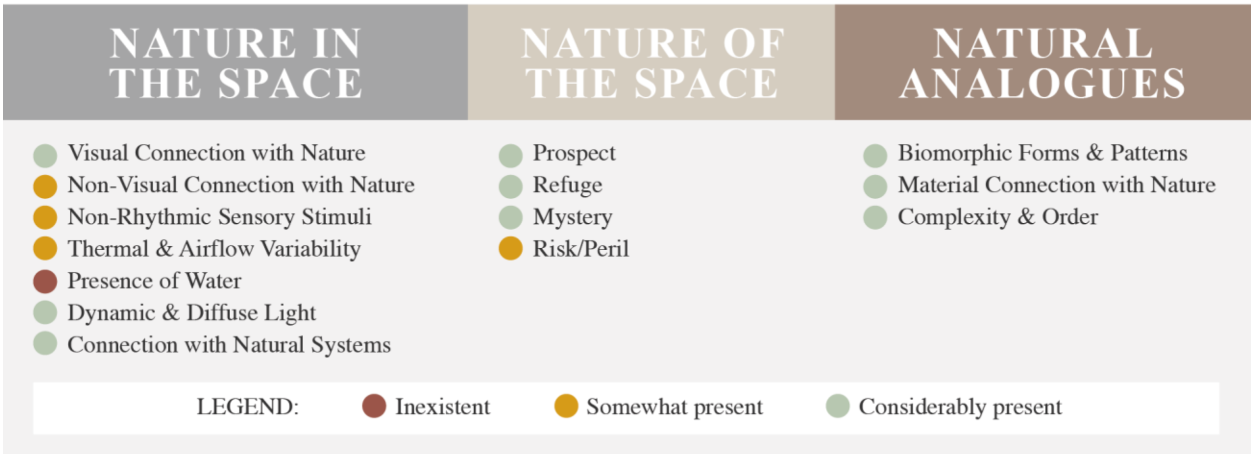


**Figure 50.** Biophilic patterns analysis of UGS_4 CG (Source: Author)

*Observations and suggestions*

Even though the analysis indicates an interesting landscape design, using organic shapes and natural materials to create and interesting and dynamic site, the planting design failed. Furthermore, the site can not be considered biodiverse, since related to the 30/20/10 (%) rule it performed as 36/36/36 (%), being over the maximum accepted ratio for family, genus and species variety. Further observations:

- **Strengths:** clear and objective design and functions; most of the 14 biophilic design patterns are present.
- **Weaknesses:** neglected site; not biodiverse; damaged and unused playground.
- **Opportunities:** improve biodiversity.
- **Threats:** homeless people taking advantage of the 'secluded' space created by the use of vegetation, also creating a feeling of unsafeness.

**Table 12.** Suggestions for the study area UGS_4 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increase biodiversity by introducing new species from different families and genus<br>- Create a drinking water fountain | - Play with vegetation level without blocking views<br>- Rethink the design of the secluded space<br>- Local government action to increase maintenance frequency | - Improve space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Habitat enhancement |

*4.2.3.6 UGS 5*

Located in the allotment 'Jardim Autonomista', UGS_5 is situated between the streets Praia da Costa, Hermelita de Oliveira Gomes, Praia da Amaralina and Búzios, encompassing an area of 7,008.38 m$^2$. The first demarcations of the site can be seen in the 80's decade, however being just an empty lot between roads. In contrast, in 1999 the demarcation is clear with some vegetation, and the surroundings is already populated with housing. In 2008 and 2013 no great changes are visible apart from normal vegetation growth, which is comprehensible as the site has no clear landscape design [Figure 51].


**Figure 51.** Historical overview maps of UGS_5 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_5 presents the overall aesthetic of a park, with a nature/garden like character with no functions. The space use can be considered as pet walking, and perhaps a space for contemplation. The users were identified as local residents. Moreover, its immediate surroundings have a 100% residential use [Figure 52]. The traffic can be categorized as calm due to the location two streets being dead-end ones. Additionally, there are no bus stops adjacent to the square, no cycling lanes or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has only a paved sidewalk surrounding it and light poles. No water management aspects could be identified.

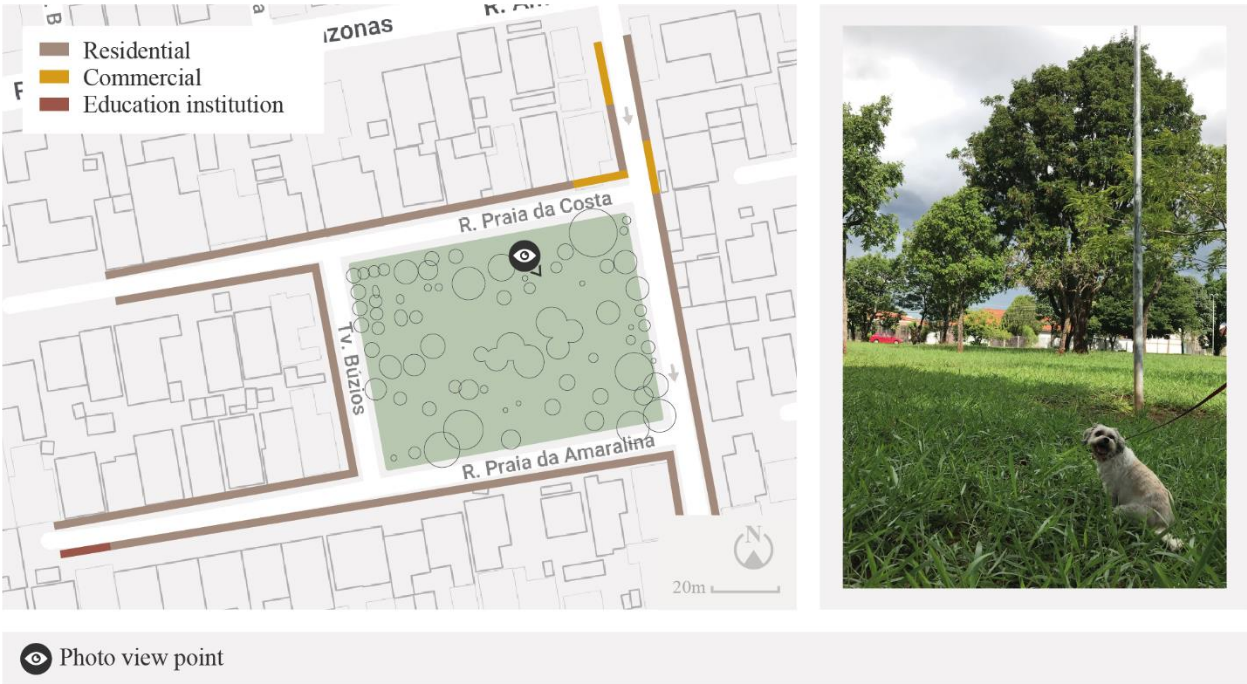


**Figure 52.** Map and photos of UGS_5 CG (Source: Author)

Regarding the planting design findings, there are 2 plantation levels: grass and trees. The tree canopy coverage could be estimated to approximately 61% with a 4.88% error margin, whereas 39% belongs to non-tree land cover [Figure 53], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 40,802,006.08g Carbon sequestration and 149,607,355.91g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 13.


**Figure 53.** Tree canopy coverage in UGS_5 CG (Source: i-Tree. Edited by the author)

**Table 13.** Summarised findings of taxa identification for UGS_5 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 46 | 2 | 89 on site (9 young; 80 adult); 35 on the opposite sidewalks | 42% native; 12% endemic; 23% non-native; 13% established; 2% invasive; 4% unknown; 4% unidentified |

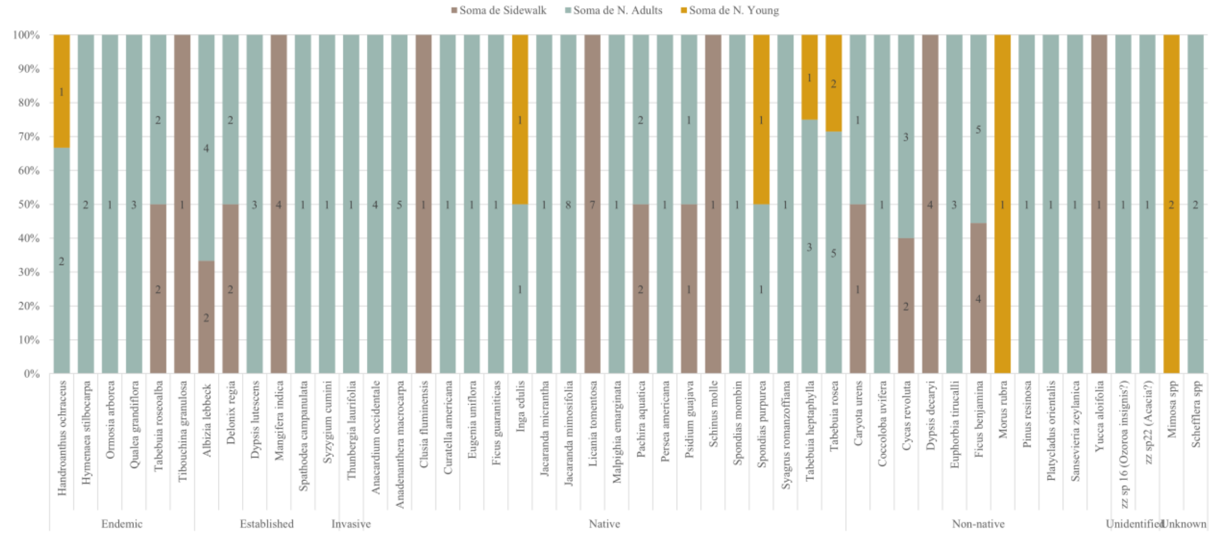


**Figure 54.** Taxa variety in UGS_5 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 22 families; highest concentration of 23% from *Bignoniaceae* | 40 genus; largest amount of 12% from *Tabebuia* | Highest portion corresponds to 7% from *Ficus benjamina* | Medicinal: 46%<br>Edible fruits: 31%<br>Ornamental: 11%<br>Condiment: 2%<br>Ecological restoration: 2%<br>Unknown: 4%<br>Unidentified: 4% | Ideal |

**Further observations:** termite and ant nests; lack of furniture, such as garbage bins and benches; lack of functions; 4 dead trees; young seedlings were carefully protected, however the materials and structure used indicates being the work of local residents; bird feeders. The current situation of the site can be visualised in Figure 55 below.

**Figure 55.** Photos from UGS_5 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_5 has no landscape design whatsoever and indicates an overall average quality. Apart from the plants, other biodiversity observations include insects and birds. The park also presented a low noise level, probably due to the completely residential surroundings. Moreover, the empirical observations pointed to some sense of stewardship, with local residents planting new trees and taking care of existing ones, in addition to hanging bird feeders in some tree trunks. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 56 below.

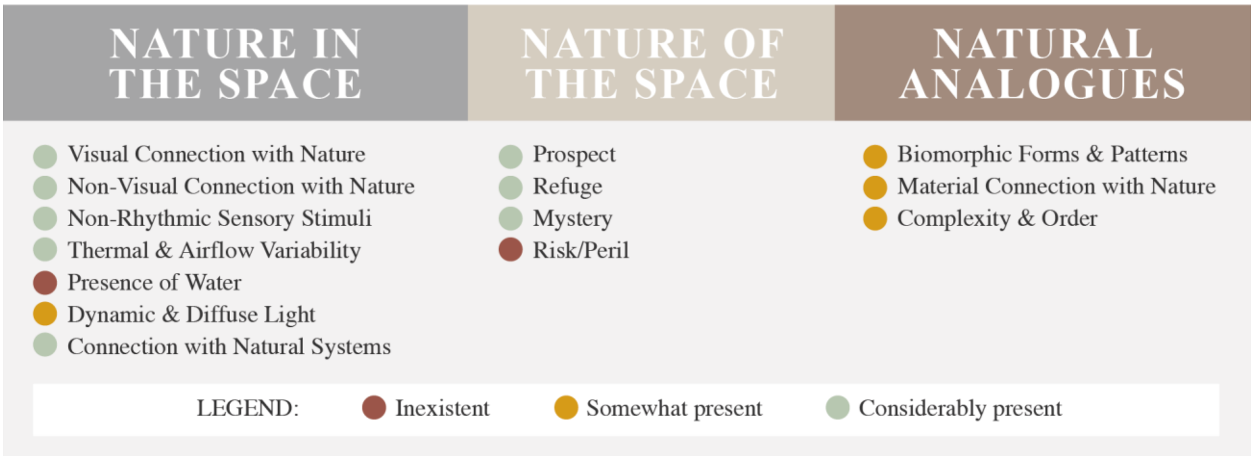


**Figure 56.** Biophilic patterns analysis of UGS_5 CG (Source: Author)

*Observations and suggestions*

Even though the analysis show that there is no landscape design, the park and contemplation atmosphere is appreciated, heightening the ‘natural’ or nature-like feeling. Furthermore, the site can be considered biodiverse, since related to the 30/20/10 (%) rule it performed as 23/12/7 (%). Further observations:

- **Strengths:** nature-like atmosphere; most of the 14 biophilic design patterns are present; potential site for contemplation, relaxation and connection to nature.

- **Weaknesses:** no clear design and functions; lack of infrastructure.
- **Opportunities:** enhance biodiversity; improve infrastructure.
- **Threats:** local residents planting species without guidance.

**Table 14.** Suggestions for the study area UGS_5 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increase biodiversity by introducing new species, especially native/endemic with edible values<br>- Improve plantation level by adding shrubs and perennials<br>- Create a water feature and take advantage of the sounds<br>- Improve the infrastructure with benches and a few paths | - Play with vegetation level without blocking views<br>- Keep the tranquil and nature-like atmosphere, like a safe heaven | - Improve/create space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Habitat enhancement |

*4.2.3.7 UGS 6*

Located in the allotment 'Jardim Autonomista' and popularly known as Humberto Canale Junior square, UGS_6 is situated between the streets Praia da Areia Branca, Dr. Paulo Machado, Praia do Canto and Tv. Arraial do Cabo, encompassing an area of 8,625.03 m$^2$. The first demarcation of the site can be seen in the 80's decade with and spontaneous paths crossing through. In contrast, in 1999 there is already a design presenting strong geometric shapes. In 2008 the maps show a big change where the current design of the site can be seen, and it is believed it was done in 2006 according to satellite imagery, respecting the existing vegetation and using more organic shapes. From 2013 to 2022 it is possible to see the canopy coverage increase significantly [Figure 57].


**Figure 57.** Historical overview maps of UGS_6 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_6 presents the overall aesthetic of a park/square with a nature/garden like, contemplation and minor recreational character. The space use can be considered as crossing through, walking/jogging, pet walking and exercising, where the users were identified as local residents and people from close neighbourhoods. Moreover, its immediate surroundings have a 100% residential use [Figure 58]. The traffic can be categorized as low, due to the location and two of the surrounding streets being dead-end ones. Additionally, there are no bus stops adjacent to the square, no cycling lanes or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has a paved sidewalk, internal paved pathways, light poles, benches, garbage bins and open-air gym. No water management aspects could be identified although sewage/drainage is present.


**Figure 58.** Map and photos of UGS_6 CG (Source: Author)

Regarding the planting design findings, there are 2 main plantation levels: grass and trees. The tree canopy coverage could be estimated to approximately 52% with a 5% error margin, whereas 48% belongs to non-tree land cover [Figure 59], consisting on both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 34,621,341.70g Carbon sequestration and 126,944,920.06g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 15.


**Figure 59.** Tree canopy coverage in UGS_6 CG (Source: i-Tree. Edited by the author)

**Table 15.** Summarised findings of taxa identification for UGS_6 CG

| **Taxa identification** | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 32 | 1 | 63 on site (11 young; 52 adult); 48 on the opposite sidewalks | 37% native; 12% endemic; 24% non-native; 21% established; 3% unknown; 3% unidentified |

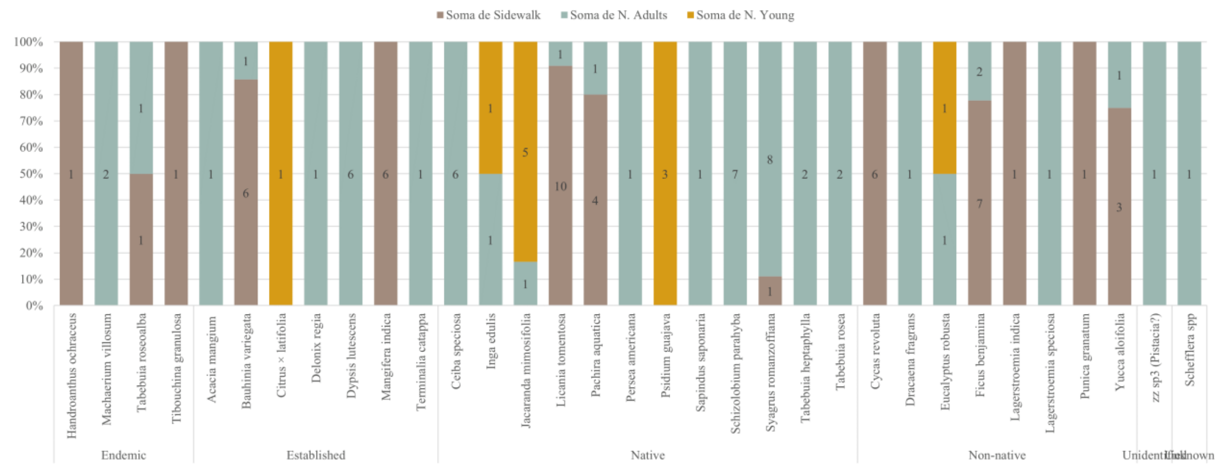


**Figure 60.** Taxa variety in UGS_6 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 17 families; highest concentration of 18% from *Fabaceae* | 29 genus; largest amount of 10% from *Licania* | Highest portion corresponds to 10% from *Licania tomentosa* | Medicinal: 52%<br>Edible fruits: 27%<br>Ornamental: 15%<br>Unknown: 3%<br>Unidentified: 3% | Medium |

**Further observations:** 3 dead trees; 4 trees felled between the years of site visit, being replaced by young edible fruit species; termite nests; furniture and infrastructure is broken or damaged; young seedlings were carefully protected, however the materials and structure used indicates being the work of local residents. The current situation of the site can be visualised in Figure 61 below.

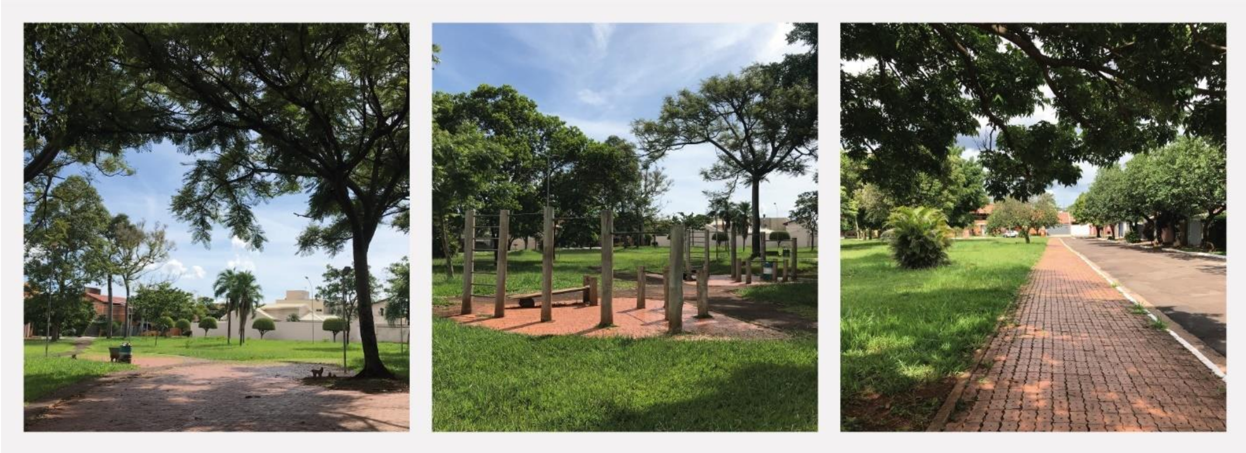

**Figure 61.** Photos from UGS_6 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_6 has a clear and defined landscape design, thus it indicated an overall average to good quality. Additionally, certain degree of biodiversity could be observed apart from the plants, with the presence of bird nests and insects. The square also presented a low noise level, probably due to the completely residential surroundings. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who were planting and protecting some young trees. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 62 below.

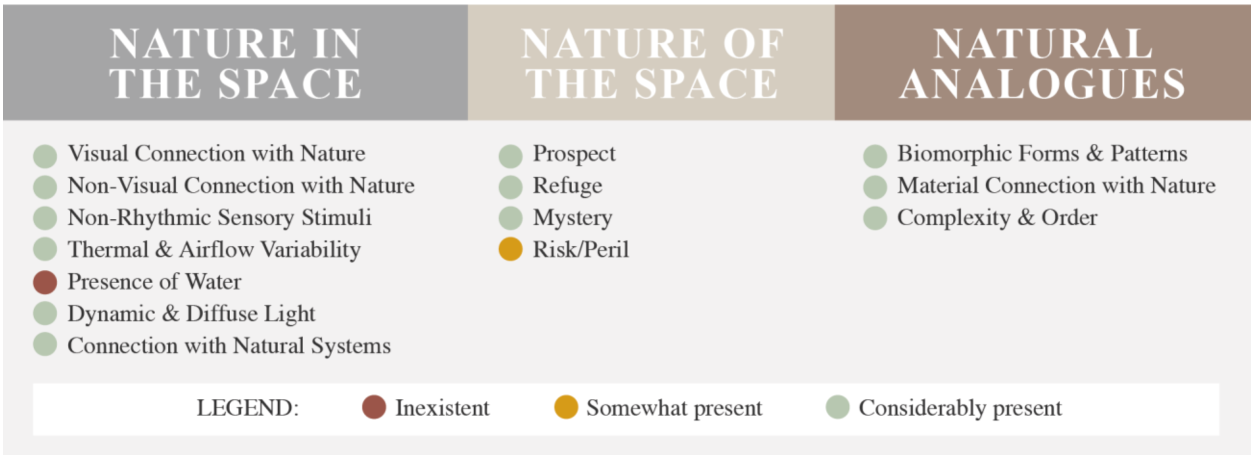


**Figure 62.** Biophilic patterns analysis of UGS_6 CG (Source: Author)

*Observations and suggestions*

This site presented two different designs in the last 20 years, and the latest one can be considered appropriate, providing a space for exercising, resting and contemplating nature. However, the quality of the infrastructure and furniture is precarious and in desperate need of restauration or substitution. The site can be considered biodiverse, since related to the 30/20/10 (%) rule it performed as 18/10/10 (%), even though the numbers are on the limit regarding species variety.

Furthermore, the plantation level is not ideal as it mainly consists of trees and grass. Further observations:

- **Strengths:** good canopy coverage; biodiverse to some extent; stewardship and interest from local residents; well defined functions.
- **Weaknesses:** maintenance; damaged furniture and infrastructure.
- **Opportunities:** biodiversity enhancement; increase/improve space use; create a drinkable water feature; improve plantation level.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat; broken benches can be hazardous.

**Table 16.** Suggestions for the study area UGS_6 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing more ground covers, especially for shady areas, and shrubs<br>- Introducing more and variable species, especially native and endemic<br>- Include drinkable water feature to support sports function | - Maintain an ‘openness’ and clear views, in order not to create unsafe atmospheres<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental and physical health<br>- Improved urban health<br>- Increased socio-economic values |

*4.2.3.8 UGS 7*

Located in the allotment ‘Jardim Autonomista’, UGS_7 is situated between the streets Praia de Ondina, Autonomista, Praia da Pituba and Praia Jangadeira, encompassing an area of 7,942.53 $m^2$. The first demarcation of the site can be seen in the 80’s decade. In contrast, in 1999 the site is clear and with spontaneous paths were starting to be created by passers-by. In 2008 the current “design” of the site can be seen, with a higher vegetation percentage. From 2013 to 2022 it is possible to see a slight canopy coverage increase due to the natural growth, and a slight decrease with the felling of a couple of tall trees between 2022 and 2013, and an interesting internal path configuration [Figure 63].


**Figure 63.** Historical overview maps of UGS_7 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_7 presents the overall aesthetic of a small park with a nature/garden like and contemplation character. The space use can be considered as crossing through and pet walking, where the users were identified as local residents who also use it as an extension of their own garden. Moreover, its immediate surroundings have a 100% residential use [Figure 64]. The traffic can be categorized as busy, with one of the limit streets being an arterial road (Autonomista). Additionally, there is one bus stops adjacent to the square, no cycling lanes or other means of public transportation, hence the accessibility is only by car, bus or on foot. Concerning the infrastructure, the site has only light poles and bollards, no water management aspects could be identified.


**Figure 64.** Map and photos of UGS_7 CG (Source: Author)

Regarding the planting design findings, there are 4 plantation levels: grass, perennial beds, shrubs and trees. The tree canopy coverage could be estimated to approximately 54.55% with a 5% error margin, whereas 45.45% belongs to non-tree land cover [Figure 65], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 41,875,700.32g Carbon sequestration and 153,544,234.63g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 17.


**Figure 65.** Tree canopy coverage in UGS_7 CG (Source: i-Tree. Edited by the author)

**Table 17.** Summarised findings of taxa identification for UGS_7 CG

| **Taxa identification** | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 37 | 1 | 172 on site (9 young; 163 adult); 14 on the opposite sidewalks | 37% native; 10% endemic; 24% non-native; 26% established; 3% unidentified |

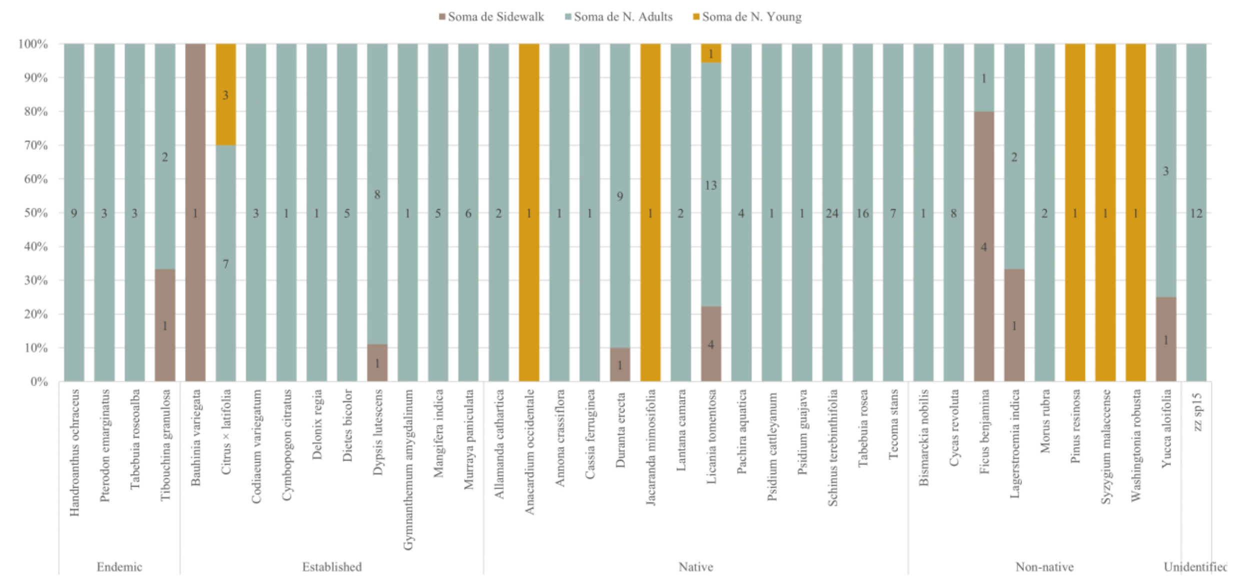


**Figure 66.** Taxa variety in UGS_7 CG (Source: Author)

| Biodiversity: family | Biodiversity: genus | Biodiversity: species | Unique values | Maintenance |
|---|---|---|---|---|
| 21 families; highest concentration of 19% from *Bignoniaceae* | 35 genus; largest amount of 13% from *Schinus* | Highest portion corresponds to 13% from *Schinus terebinthifolia* | Medicinal: 47%<br>Edible fruits: 21%<br>Ornamental: 16%<br>Aromatic: 8%<br>Condiment: 2%<br>Unidentified: 3% | Medium |
| **Further observations:** 3 dead trees; bird feeders; replanted adult trees taken from another site in the city; young seedlings were carefully protected, however the materials and structure used indicates being the work of local residents. The current situation of the site can be visualised in Figure 67 below. | | | | |

**Figure 67.** Photos from UGS_7 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_7 has a partial landscape design, thus it indicated an overall average quality. Additionally, certain degree of biodiversity could be observed apart from the plants, with the presence of birds and insects. The square also presented a medium noise level. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who were using the space as an extension of their own garden, planting new species and creating their own arrangements. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 68 below.

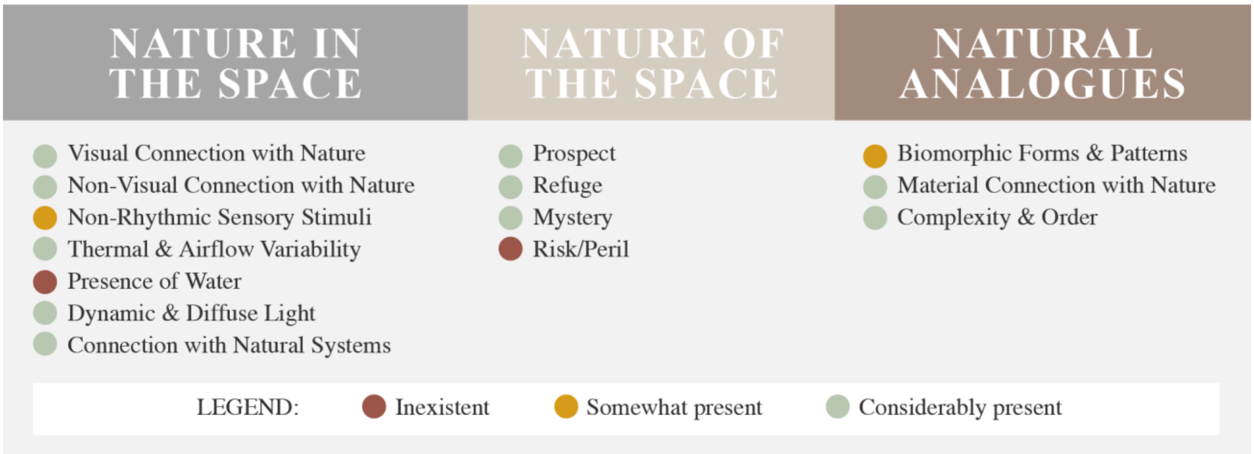


**Figure 68.** Biophilic patterns analysis of UGS_7 CG (Source: Author)

*Observations and suggestions*

Despite the fact that the analysis indicates an increase of vegetation in the past 40 years, the results presented a space lacking a proper landscape design, which is driving the residents to plant and design by themselves. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 19/13/13 (%), the numbers under the limit regarding family and genus, albeit over as of species variety. Further observations:

- **Strengths:** different plantation levels; biodiverse to some extent; stewardship and interest from local residents.
- **Weaknesses:** bollards 'blocks' and suggest the space should not be used; lack of furniture.
- **Opportunities:** biodiversity enhancement; increase/improve space use; create a space for contemplation.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat.

**Table 18.** Suggestions for the study area UGS_7 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Introducing more and variable species, especially native and endemic<br>- Create a contemplation space taking advantage of the nature-like atmosphere | - Maintain an 'openness' and clear views, in order not to create unsafe atmospheres<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Habitat enhancement<br>- Social education |

*4.2.3.9 UGS 8*

Located in the allotment 'Jardim Autonomista', UGS_8 is situated between the streets Praia das Castanheiras, Dr. Paulo Machado, Praia Negra and Tv. Boa Viagem, encompassing an area of 8,361.40 m$^2$. The first demarcation of the site can be seen in the 80's decade. In contrast, in 1999 the demarcation is clear, and the current landscape design is present, although without much of the vegetation. From 2008 to 2022 nothing much changed, except from the vegetation considerable growth [Figure 69].


**Figure 69.** Historical overview maps of UGS_8 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_8 presents the overall aesthetic of a small park with a nature/garden like and recreational character. The space use can be considered as walking/jogging, exercising and pet walking, where the users were identified as local residents and people from other neighbourhoods. Moreover, its immediate surroundings have a 90% residential use, with the remaining 10% representing commercial activities [Figure 70]. The traffic can be categorized as average, with one of the limit streets being a collector road (Dr. Paulo Machado). Additionally, there are no bus stops adjacent to the square, no cycling lanes, or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has a cement sidewalk, internal paved pathways, light poles, no water management aspects could be identified although sewage/drainage is present.

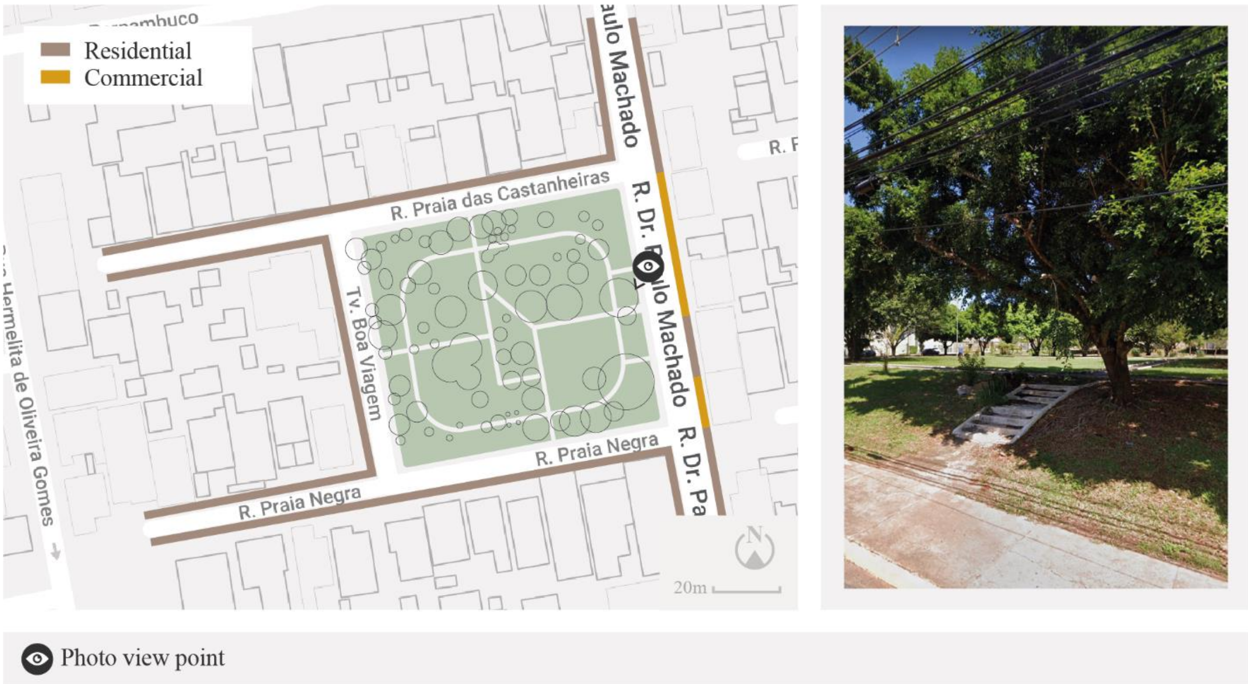


**Figure 70.** Map and photos of UGS_8 CG (Source: Author)

Regarding the planting design findings, there are 2 main plantation levels: grass and trees, with a subtle hint of perennial plants scattered. The tree canopy coverage could be estimated to approximately 63% with a 4.83% error margin, whereas 37% belongs to non-tree land cover [Figure 71], consisting of both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 48,923,204.95g Carbon sequestration and 179,385,085.20g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 19.


**Figure 71.** Tree canopy coverage in UGS_8 CG (Source: i-Tree. Edited by the author)

**Table 19.** Summarised findings of taxa identification for UGS_8 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 64 | 6 | 124 on site (5 young; 119 adult); 57 on the opposite sidewalks | 38% native; 9% endemic; 25% non-native; 16% established; 1% invasive; 3% unknown; 9% unidentified |

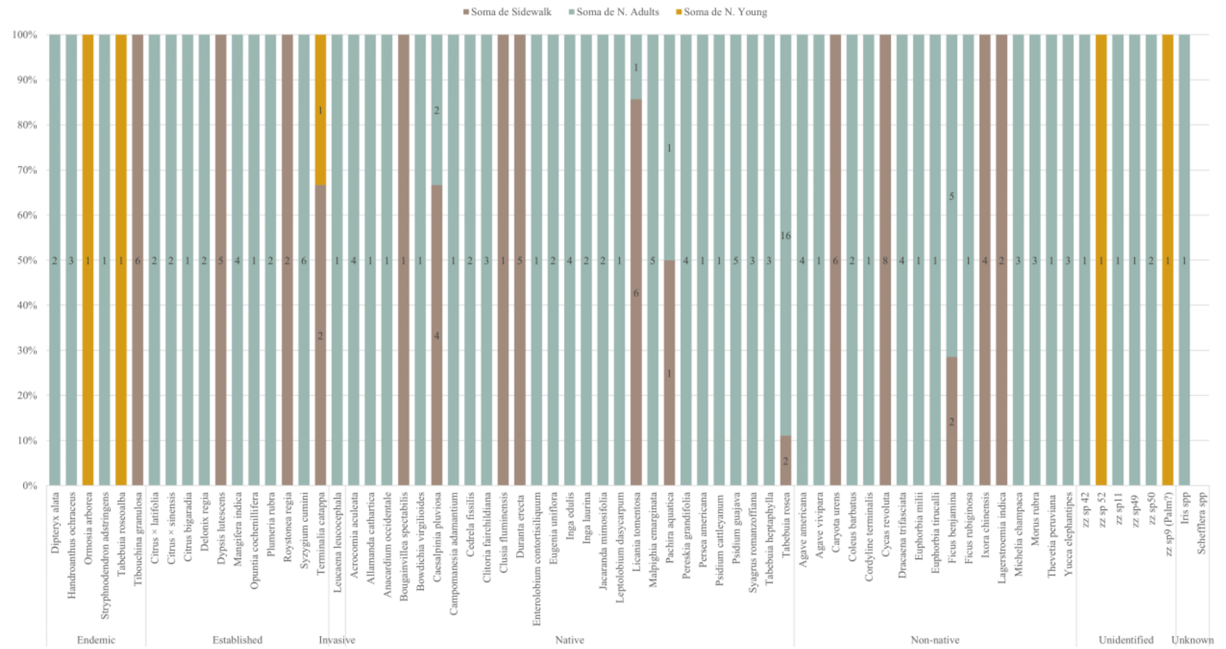


**Figure 72.** Taxa variety in UGS_8 CG (Source: Author)

| **Biodiversity: family** | **Biodiversity: genus** | **Biodiversity: species** | **Unique values** | **Maintenance** |
|---|---|---|---|---|
| 28 families; highest concentration of 14% from *Bignoniaceae* | 55 genus; largest amount of 11% from *Tabebuia* | Highest portion corresponds to 9% from *Tabebuia rosea* | Medicinal: 39%<br>Edible fruits: 27%<br>Other edible part: 3%<br>Ornamental: 13%<br>Cosmetics: 1%<br>Aromatic: 3%<br>Ecological restoration: 4%<br>Unknown: 1%<br>Unidentified: 9% | Ideal |

| |
|---|
| **Further observations:** *Stryphnodendron adstringens* with damaged bark, indicating medicinal use by locals; The *ficus* trees aggressive roots were starting to cause damage to the sidewalk; termite nests. The current situation of the site can be visualised in Figure 73 below. |

**Figure 73.** Photos from UGS_8 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_8 has a partial landscape design, thus it indicated an overall good quality. Additionally, certain degree of biodiversity could be observed apart from the plants, with the presence of bird and insects. The square also presented a medium noise level. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, planting and protecting some young trees. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 74 below.

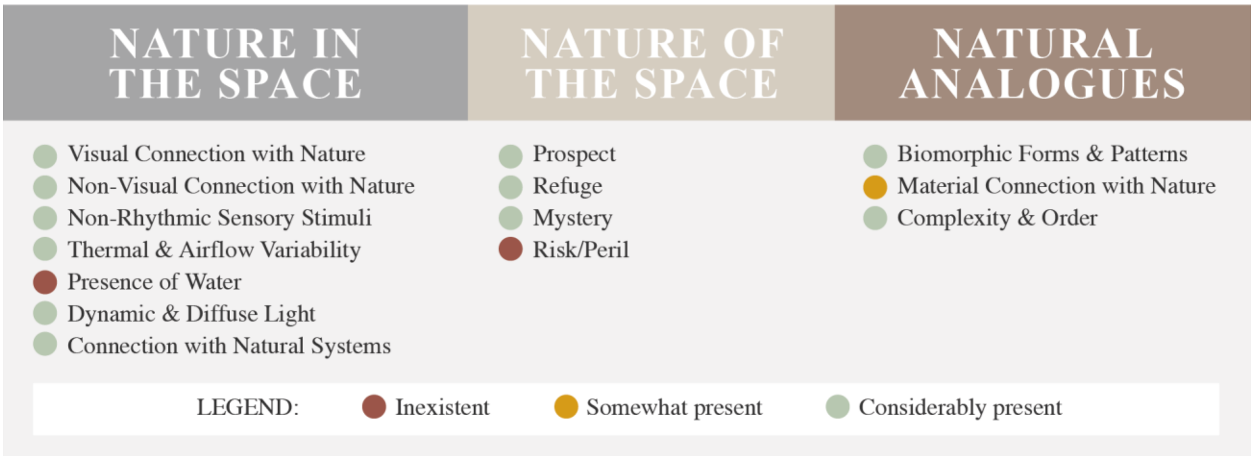


**Figure 74.** Biophilic patterns analysis of UGS_8 CG (Source: Author)

*Observations and suggestions*

Despite the fact that the analysis indicates an increase of vegetation in the past 40 years, the results presented a space lacking a well defined landscape design. For instance, internal paths and overall design suggest only a ‘pass through’ character. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 14/11/9 (%), the numbers are close to the limit regarding species variety. Furthermore, the plantation level is not ideal as it mainly consists of trees, grass and a few scattered perennials. Further observations:

- **Strengths:** good canopy coverage; biodiverse to some extent; stewardship and interest from local residents.
- **Weaknesses:** no well defined function/design; lack of furniture and infrastructure.
- **Opportunities:** biodiversity enhancement; increase/improve space use; create a water feature.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat; aggressive tree roots causing damages to sidewalks.

**Table 20.** Suggestions for the study area UGS_8 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing more ground covers, especially for shady areas, and shrubs<br>- Introducing more and variable species, especially native and endemic<br>- Propose a water feature<br>- Introduce urban furniture | - Maintain an ‘openness’ and clear views, in order not to create unsafe atmospheres<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Increased socio-economic values |

*4.2.3.10 UGS 9*

Located in the allotment ‘Jardim Autonomista’ and popularly known as Luiz Oscar Wielewicki square, UGS_9 is situated between the streets Praia de Itaparica, Autonomista, Praia de Itaipú and Cambuquira, encompassing an area of 9,411.76 $m^2$. The first demarcation of the site can be seen in the 80’s decade. In 1999 the demarcation is clear, a few small trees can be spotted and spontaneous paths were starting to be created by passers-by. From 2008 to 2022 nothing much changed, except from the vegetation considerable growth [Figure 75].


**Figure 75.** Historical overview maps of UGS_9 CG (Source: Web[2], Web[5], Web[6]. Edited by the author)

*Tangible aspects analysis - GSA*

The research findings for the tangible aspects show that UGS_9 presents the overall aesthetic of a small park, even though it is considered a square, with a nature/garden like character with no functions. The space use can be considered as crossing through, walking/jogging and pet walking, where the users were identified as local residents. Moreover, its immediate surroundings have a 100% residential use [Figure 76]. The traffic can be categorized as low, due to the location and two of the surrounding streets being dead-end ones. Additionally, there are no bus stops adjacent to the square, no cycling lanes, or other means of public transportation, hence the accessibility is only by car or on foot. Concerning the infrastructure, the site has a cement sidewalk and light poles, no water management aspects could be identified although sewage/drainage is present.


**Figure 76.** Map and photos of UGS_9 CG (Source: Author)

Regarding the planting design findings, there are 2 main plantation levels: grass and trees. The tree canopy coverage could be estimated to approximately 45% with a 4.97% error margin, whereas 55% belongs to non-tree land cover [Figure 77], consisting on both active and inactive surfaces. According to the i-Tree software calculations, these can present an estimated benefit of 39,123,209.12g Carbon sequestration and 143,451,766.69g of $CO_2$ equivalent. The findings related to taxa identification can be seen on table 21.

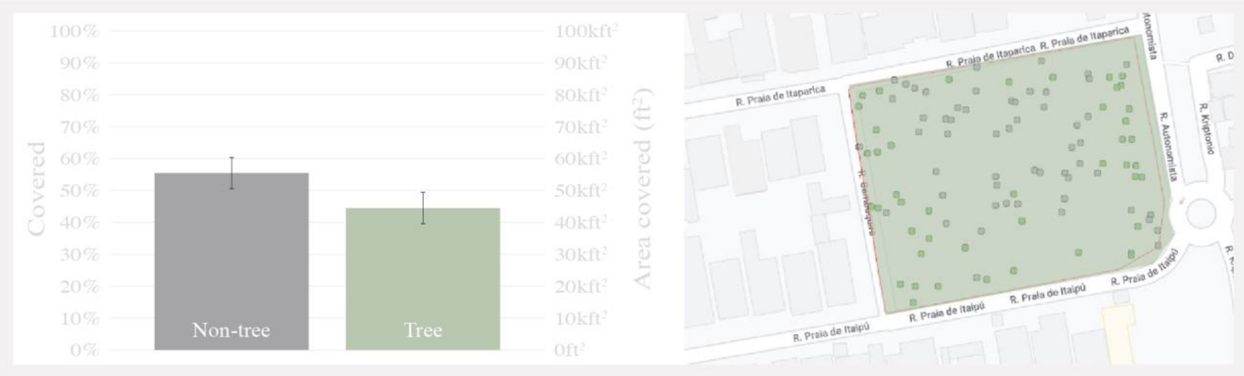


**Figure 77.** Tree canopy coverage in UGS_9 CG (Source: i-Tree. Edited by the author)

**Table 21.** Summarised findings of taxa identification for UGS_9 CG

| Taxa identification | | | |
|---|---|---|---|
| **Species: identified** | **Species: unidentified** | **Specimens** | **Native range situation** |
| 70 | 7 | 152 on site (34 young; 118 adult); 76 on the opposite sidewalks | 31% native; 13% endemic; 29% non-native; 17% established; 3% invasive; 1% unknown; 9% unidentified |

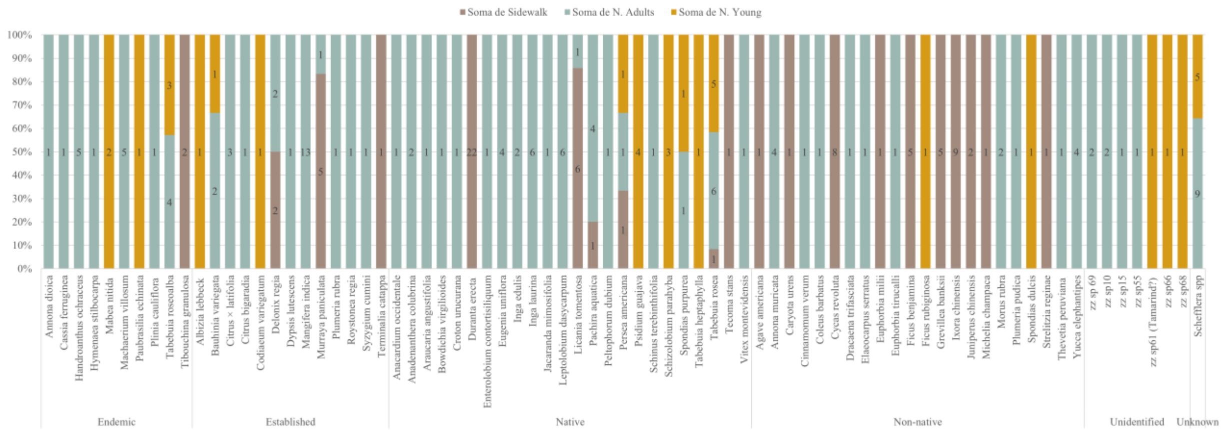


**Figure 78.** Taxa variety in UGS_9 CG (Source: Author)

| Biodiversity: family | Biodiversity: genus | Biodiversity: species | Unique values | Maintenance |
|---|---|---|---|---|
| 28 families; highest concentration of 17% from *Fabaceae* | 61 genus; largest amount of 10% from *Duranta* | Highest portion corresponds to 10% from *Duranta erecta* | Medicinal: 39%<br>Edible fruits: 27%<br>Other edible part: 1%<br>Ornamental: 14%<br>Aromatic: 3%<br>Condiment: 3%<br>Ecological restoration: 3%<br>Unknown: 1%<br>Unidentified: 9% | Ideal |
| **Further observations:** lack of furniture, such as garbage bins and benches; lack of functions; young seedlings were carefully protected, however the materials and structure used indicates being the work of local residents; damaged sidewalks with outgrowing vegetation; termite nests. The current situation of the site can be visualised in Figure 79 below. | | | | |

**Figure 79.** Photos from UGS_9 CG (Source: Author)

*Intangible aspects analysis - BDA*

The research findings for the intangible aspects, together with the tangible ones presented previously, show that UGS_9 has no landscape design, thus it indicated an overall average quality. Additionally, certain degree of biodiversity could be observed apart from the plants, with the presence of bird and insects. The square also presented a low noise level with a tranquil atmosphere. Moreover, the empirical observations pointed to a high sense of stewardship by the local residents, who were planting and protecting some young trees. Regarding the 14 biophilic patters, the presence and average of each one can be seen on Figure 80 below.

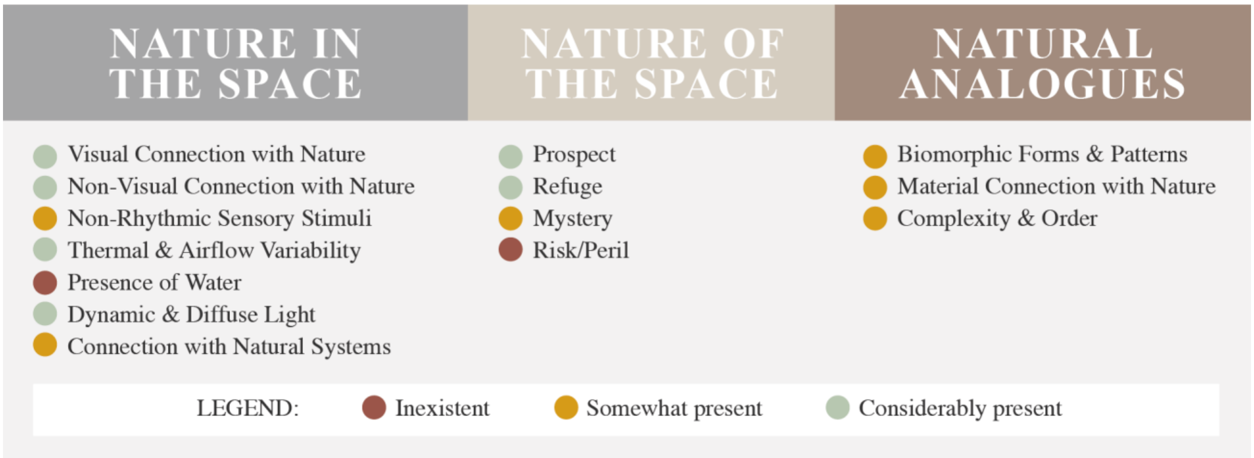


**Figure 80.** Biophilic patterns analysis of UGS_9 CG (Source: Author)

*Observations and suggestions*

Despite the fact that the analysis indicates an increase of vegetation in the past 40 years, the results presented a space lacking a proper landscape design. For instance, there are four paths leading to a circular paved area at the middle of the site, where there is nothing apart from open paved space. Even though the site can be somewhat considered biodiverse, since related to the 30/20/10 (%) rule it performed as 17/10/10 (%), the numbers are on the limit regarding species variety, albeit under as of family and genus. Furthermore, the plantation level is not ideal as it mainly consists of trees and grass, since the shrubs are mostly located in the surrounding sidewalks and not on the site itself. Further observations:

- **Strengths:** biodiverse to some extent; stewardship and interest from local residents.
- **Weaknesses:** lack of furniture and functions.
- **Opportunities:** biodiversity enhancement; increase/improve space use; create a water feature; plantation level improvement.
- **Threats:** local residents deliberately planting random species can create an imbalanced habitat; damaged sidewalks.

**Table 22.** Suggestions for the study area UGS_9 CG

| Tangible & intangible elements to be created/improved | Aspects to take into consideration | Benefits to urban health and social well-being |
|---|---|---|
| - Increasing plantation level by introducing shrubs and different species<br>- Introducing more and variable species, especially native and endemic<br>- Propose functions and urban furniture<br>- Create water feature | - Maintain an ‘openness’ and clear views, in order not to create unsafe atmospheres<br>- Participatory actions to include and instruct local residents, taking advantage of their already existing interest | - Improve space experience<br>- Higher benefits related to mental health<br>- Improved urban health<br>- Increased socio-economic values |

## 4.3 Summarized results and discussion

As previously stated in this research, the main objective of the case studies is not to make a comparative analysis between Budapest and Campo Grande, but rather study selected urban greenspaces from both, having the Hungarian capital as an example of best practice strategies that could be beneficial and applicable to Campo Grande. The results will be presented as follows: the tangible and the intangible aspects findings, including the social survey performed online

### *4.3.1 Tangible results*

Consisting of the more technical aspects of the analysis and based on the green system approach, counting with the systematic site evaluation, vegetation identification and heatmap study, the results are summarised in the table below.

**Table 23.** Tangible results of Budapest and Campo Grande, highlighting the greenspaces which performed better in each category

| | **Budapest** | **Campo Grande** |
|---|---|---|
| **Plantation level** | All three greenspaces presented a varied plantation level, with **UGS_2 and UGS_3** being the best ones as all five categories were present. | The majority of selected greenspaces did not present a good plantation level as they consists of mainly grass and trees. However, **UGS_7** presented four out of the five categories. |
| **Canopy coverage** | **UGS_2** presented the higher canopy coverage, with approximately 69%. However, it is worth mentioning that having a greater canopy coverage is not necessarily the best solution. Even though higher canopy coverage is more valuable since there is no other vegetation category that provides as much ecosystem services as trees, having uniform canopy or depending on the canopy shape it can lead to an obstruction of the connection between the air below the canopy and the air above, lacking an adequate circulation. Therefore, such scenario is not greatly beneficial for cooling and ventilation of the filtered air masses. In this perspective, having greenspaces that vary in canopy coverage shape and diversity can be a positive factor (Aram et al., 2019). | In contrast, Campo Grande is a tropical city with a high amount of sunlight and heat throughout the year, therefore a higher percentage in canopy coverage is essential. In this perspective, **UGS_2** has more optimal conditions presenting approximately 77% of canopy coverage. |
| **Quantity of identified species and individuals** | **UGS_1** was the site with the higher number of species, where 26 species and 147 individuals were accounted for. However, the amount of individuals is not a determinant factor as this can vary greatly depending on the size of the site. | The site that presented the highest number of species was **UGS_9** with 70 identified and 152 individuals, whereas **UGS_7** presented a higher number of individuals with 172. |
| **Native range situation** | The site with the higher percentage of native species is **UGS_3** with 53%. The other two sites have both established and non-native species as a majority. | In the Brazilian case study, besides prioritizing native species, being endemic is also of high importance. I discovered that all nine UGSs presented a majority of native species, representing an overall of 39% of the identified species. |

| | | |
|---|---|---|
| | Overall, between the three UGSs 39% of the identified species were native, 31% non-native, 17% established, 7% unidentified and 6% unknown. Nevertheless, this can be due to the fact that the location of Hungary, in relation to Europe, the veracity of precise endemism can be unsure. | Additionally, 23% represents non-native species, 18% established, 10% endemic, 6% unidentified, 3% unknown and 1% were invasive.<br><br>In this respect, **UGS_1** presented the highest percentage of native taxa with 55%, whereas **UGS_9** has the higher rate of endemic species representing 13%. |
| **Biodiversity** | None of the studied sites presented an optimal biodiversity, based on the 30/20/10 rule. However, **UGS_2** performed well with an average of 20/20/20. | Overall, it can be observed that all nine greenspaces are biodiverse to some extent, with the exception of UGS_4. Nevertheless, **UGS_5** presented a great ratio with 23/12/7. |
| **Unique values** | In all three greenspaces the highest value identified was 'medicinal', whereas the most desirable one, according to this research, is 'edible fruit'. Overall, **UGS_1** performed better as it presented 6 different unique values amongst the existing taxa, but **UGS_3** presented the highest ratio of 'edible fruit' representing 27%. | In all nine greenspaces the highest value identified was 'medicinal', in addition to all sites containing 'edible fruit' as well. Overall, **UGS_2** performed better as it presented 8 different unique values amongst the existing taxa, but **UGS_4** presented the highest ratio of 'edible fruit' representing 34%. This is extremely significant as the analysis also showed that the people do consume the fruits seasonally and are planting more and more fruit trees.<br><br>This can also be confirmed by my personal experiences of growing up eating/collecting fruits such as mango (*Mangifera indica*), acerola (*Malpighia emarginata*), guava (*Psidium guajava*) and siriguela (*Spondias purpura*) straight from the trees, as did my friends, neighbours and family. |
| **Maintenance** | **All three sites** were well maintained and were assessed as 'ideal' in terms of maintenance. | Unfortunately, maintenance of urban greenspaces are a public issue in Campo Grande, therefore a neglect of such was identified in most sites. Nevertheless, **UGS_5**, **UGS_8** and **UGS_9** were assessed as 'ideal'. |
| **Infrastructure** | **All three sites** presented appropriate infrastructure. | The majority of sites presented only really basic infrastructure, such as having light poles. Urban furniture such as benches was found in some sites, however they were all destroyed, therefore only the remains were present. In this perspective, **UGS_3** performed better, presenting the most appropriate infrastructure. |
| **Functions** | Each site presented a different character and atmosphere, and **all of them are multifunctional.** | Unfortunately these neighbourhood greenspaces usually have no functions and consist only of random vegetation, which is the case of most sites analysed. Nevertheless, having no functions is not a negative factor since the city needs different spaces with varied characters and atmospheres if they have at least the |

| | | |
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| | | basics, such as benches for resting. The site that presented clear functions, aligned with the infrastructure needed was **UGS_3**, a site designed for the purpose of exercising. |
| **Water management** | **All three sites** presented appropriate water management solutions. | Considering the hot and dry climate, it was surprising not to find any irrigation system in all nine greenspaces. Therefore, the sites that performed the least worst were **UGS_2, UGS_3, UGS_4, UGS_6, UGS_8 and UGS_9**, since these at least have a sewage/drainage system present. |

#### *4.3.1.1 Site use survey*

The data collected from the site use survey [Appendix B] alone would not be optimal, considering the ratio of users interviewed/number of inhabitants per area (a total of 90 people were interviewed, 10 in each UGS), therefore the drawing and analysis of heatmaps for each UGS was also conducted. Combing the data from both methods, the results show that the UGSs with no or little landscape design, lack of functions, inexistent or damaged infrastructure and low levels of maintenance resulted in decreased space use.

The demographic profile amongst users from all nine UGSs, shows that the majority of the participants are between the ages of 30 and 39, representing 55% of the answers. Nevertheless, the results show a somewhat diverse age group since all categories were chosen. Regarding gender, 70% are male and 30% female. 91% of the participants said they like visiting greenspaces in general, although only 20% said they use these greenspaces. For instance, the sites with less use and satisfaction from the users were UGS_1, UGS_2, UGS_5, UGS_7 and UGS_9, where there are no functions whatsoever. In contrast, for UGS_3 and UGS_8 these answers were 80% and 92%, respectively, to which the people wrote they use it for exercising. This is a clear indication that this is due to them having better infrastructure and presence of functions.

Considering biodiversity and aesthetics, the sites presented an overall blend aesthetics that can be related to the sites not being used much. For instance, only 3% of the interviewed people said they use UGS_1, 5% use UGS_2, 14% use UGS_5, 12% use UGS_7 and 8% use UGS_9 (% are related to each UGS and not an average of all nine sites). Additionally, the overall landscape design quality of the sites was rated as ‘not enough’, the amount of vegetation as ‘enough’, however the diversity of vegetation was rated as ‘not enough’. Regarding the aspects that would make the people use those spaces more, answers such as ‘having more benches, lighting, functions, better aesthetics and maintenance’ were repeatedly given. Moreover, 75% of the participants said they would be interested in participatory actions for greenspace improvement.

Regarding the questions related to the unique values of plants, the results showed that 85% of the people interviewed grew up eating/collecting fruits from public trees, 95% said they still do so when encountering a fruit tree in the city, and 99% replied that they would greatly appreciate having more fruit trees in the urban environment. The species that were most cited are: mango (*Mangifera indica*), acerola (*Malpighia emarginata*), guava (*Psidium guajava*) and siriguela (*Spondias purpura*). Furthermore, fruit trees are a great source of food for birds and other animals (Myczko et al., 2013; Walther et al., 2018) that can still be found in urban environments, and Campo Grande is one of the few remaining cities where exotic birds can be seen flying around freely and nesting in urban trees, which is the case of the blue macaw (*Anodorhynchus hyacinthinus*) and yellow macaw (*Orthopsittaca manilatus*) (Calderan et al., 2021; Guedes Corrêa & Guedes, 2006).

*4.3.2 Intangible results*

Consisting of more social aspects of the analysis and based on the biophilic design approach, the results are summarised in the table below.

**Table 24.** Intangible results of Budapest and Campo Grande, highlighting the greenspaces which performed better in each category

| | Budapest | Campo Grande |
|---|---|---|
| **Design** | **All three sites** presented great landscape design. However, the best can be considered **UGS_1** due to its more interesting and dynamic character, due to the playfulness of the vegetation and terrain. | The reality of the studied greenspaces in Campo Grande is that the majority has no design, sometimes presenting some partial aspects such having only pathways marked. Nevertheless, three sites contain a landscape design, with the best being **UGS_3.** It is worth mentioning that UGS_4 has an excellent landscape design, but it can not be considered as optimal due to what became of it resulting from the lack of maintenance. |
| **Overall quality** | Overall, **all three sites** presented good/excellent quality. Nevertheless, due to the fact that **UGS_3** was just very recently being renovated, it can be considered the best in this category. | Only two greenspaces were assessed as having a good quality, but **UGS_3** presented the most optimal conditions and is therefore the better option for this category. |
| **Ownership/ stewardship** (Community involvement) | The results showed that stewardship can be happen due to completely different reasons. In Budapest, **UGS_2 and UGS_3** presented a higher sense of ownership since the community was involved in the early stages of planning, resulting in space people like, use and take ownership of. | In contrast, in Campo Grande the sense of stewardship came from the opposite reason, from the local government and professionals not involving them, therefore they take action by themselves. **All nine sites** presented evidence of citizens planting new species and taking care of the existing ones, as an extensions of their own gardens. Additionally, in **UGS_1** people installed trash bins and bird feeders made by themselves due to the lack of them. |
| **Noise level** | **UGS_1** was assessed as having 'low' noise levels, and this can be due to the fact of the vegetation buffer and the terrain levelling. | UGS_4, UGS_5, UGS_6 and UGS_9 was assessed as having 'low' noise levels. However, **UGS_7** can be considered the one with the lowest, since due to the lack of functions there is a serene and quiet atmosphere to the site. |

| | | |
|---|---|---|
| **Other biodiversity observations** | Apart from the biodiversity in taxa, the presence of birds and insects were assessed. **In all three sites** these could be observed. | **In all nine sites** these could be observed. |
| **Biophilic patterns** | The 14 biophilic patterns could be observed in **all three sites,** although in different levels. For this reason, **UGS_1** presented the highest, or more desirable ratio. | By assessing the presence of the biophilic patterns a concerning fact came to light: **none of the sites have water features, of any kind.** Being located in a tropical climate with extreme heat waves, this is not only and aesthetical issue but rather a hazard to people's health. Other than that, UGS_4 and UGS_6 presented 13 of the patterns, with **UGS_6** showing the better ratio. |

#### *4.3.2.1 Social survey*

Much has been argued on this thesis regarding the value of urban greenspaces and their positive impact on urban health and social well-being. In order to prove this concept and the hypotheses and questions presented on chapter 1.4, and as a part of the intangible aspects analysed based on the biophilic approach, an online social survey was developed with a questionnaire [Appendix C] that was completed by 290 participants from various countries. As a key element to assess/understand urban greenspaces and the biophilic connection to people in general, and not site specific to the UGS studied in the previous sub-chapter, the results are presented in this sub-chapter and as part of the biophilic design approach.

The demographic profile shows that the majority of the participants are between the ages of 30 and 39, representing 42.07% of the answers. Nevertheless, the results show a somewhat diverse age group since all categories were chosen. Regarding gender, 68.62% identified themselves as female, and 31.33% as male. Location wise, the participants are from 30 different nationalities with the majority being Brazilians and consisting of 68.97%, and Hungarians taking the second place representing 13.45%. Seeing that the focus of this research is these two countries, this outcome was expected, however it is very enriching to have people from all over the world since the aspects analysed are not space bound and are internationally significant. Moreover, from the 30 countries the respondents live in 69 different cities, with the majority being from Campo Grande (27.24%) and Budapest (25.17%).

When asked ‘how much do you like going to urban greenspaces?’, the vast majority (85.86%) chose the option ‘A lot’ whereas no one chose the ‘I don’t like’, showing that there is no dislike to visiting urban greenspaces. Regarding to the frequency of visiting such, 44.14% chose ‘1 - 2 times a week’, 34.83% ‘Rarely/occasionally’, 13.10% ‘3 - 4 times a week’, 6.90% ‘More than 4 times a week’ and 1.03% said they never do. Trying to understand what would motivate people to go more often, with this multiple choice question the options showed that: 48.72% would visit greenspaces more often if they had more time, 34.34% if they had greenspaces closer to their houses and 15.08% if they felt safer. With the open question option, participants also proposed that: If climate was better (0.70%), Probably not (0.46%), I had more activity options there (0.23%), If there was a more private (intimate) greenspace nearby (0.23%) and If public playful activities were available and if they were cleaner (0.23%). Furthermore, 39% usually goes accompanied by friends, 32% by family and 29% goes alone. The most voted activity was ‘walking’ with 22.62%, and on Figure 81 it is possible to see the other options proposed, as well as the ones added by the participants.

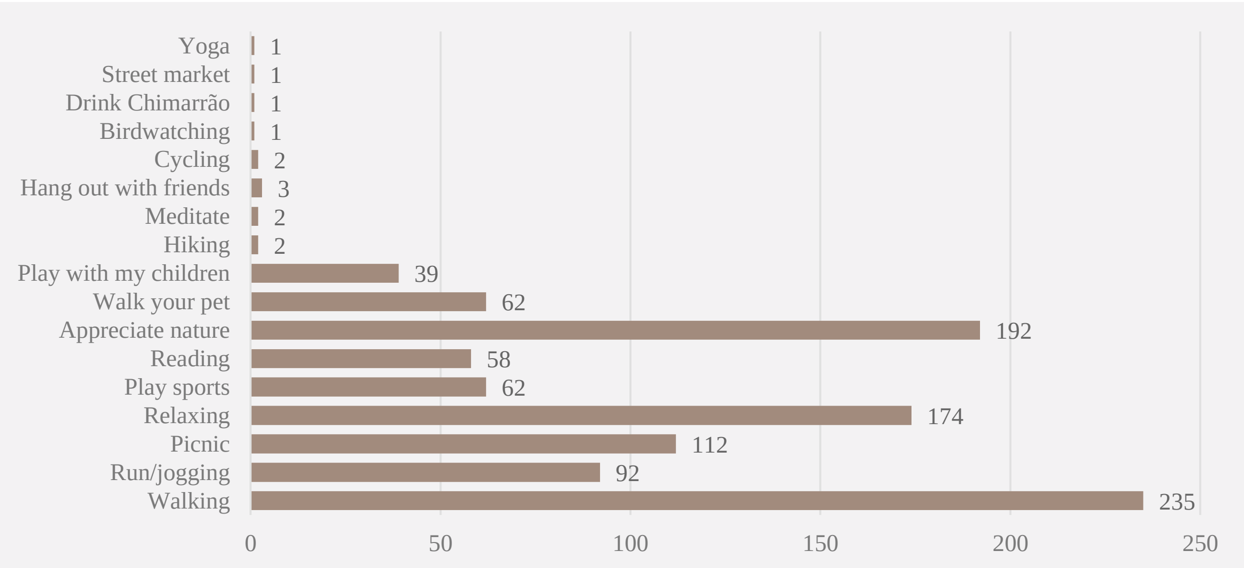


**Figure 81.** Activities performed by participants of social survey, in urban greenspaces (Source: Author)

When it comes to how people feel when they are in contact with nature in the urban greenspaces, the category most chosen was ‘Calmer and more relaxed’ representing 22.68% of the votes. One very unique and interesting option that was entered by a participant was the feeling of ‘Being part of a bigger picture’, which indirectly confirms the feeling of biophilia. Further options can be seen on Figure 82.

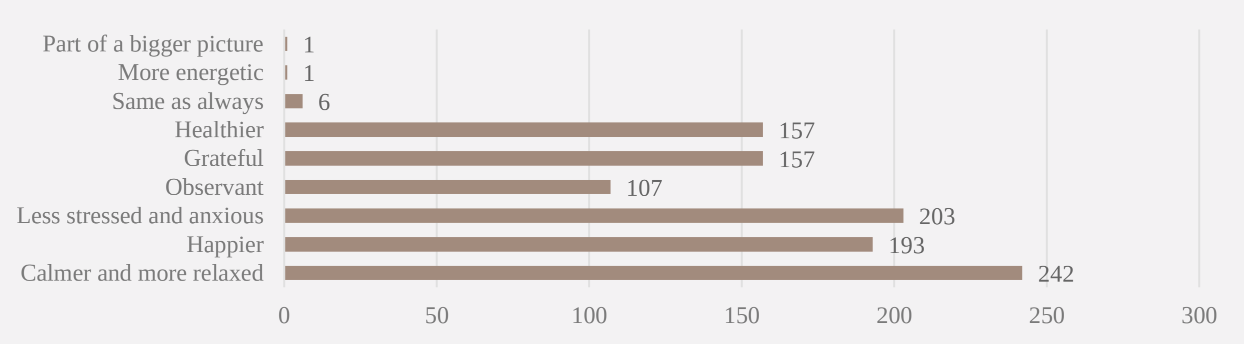


**Figure 82.** How participants feel being in contact with nature in urban greenspaces (Source: Author)

Concerning how people perceive and experience the greenspaces, when asked ‘Do you tend to pay attention to the plants around you?’, 73% replied yes, 22% sometimes, 3% no and 2% replied no, but would like to. The participants were also asked to classify their satisfaction about six criteria in relation to the greenspaces in their neighbourhoods and cities. In general the results people are overall satisfied with the maintenance, biodiversity, recreational activities and amount of vegetation, whereas they are slightly satisfied with the overall design and character and amount of greenspaces near them. The complete assessment can be visualised on the graphic below [Figure 83].

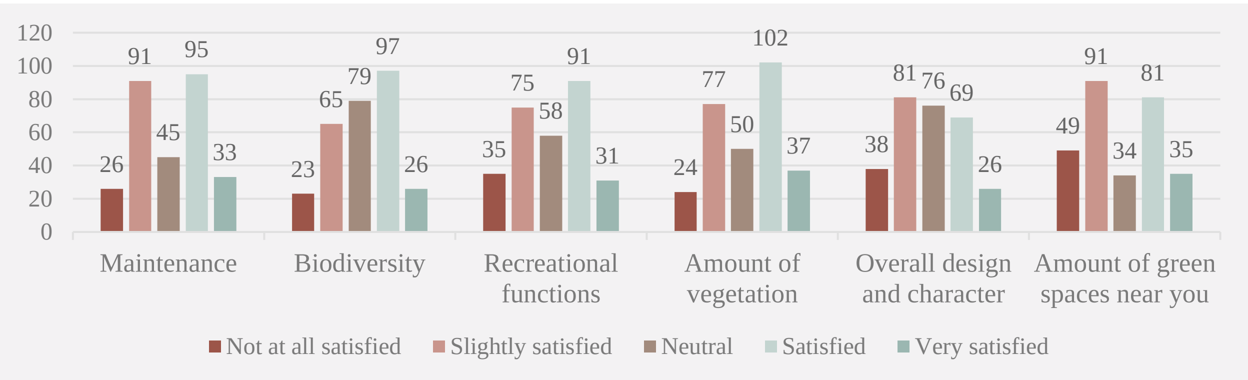


**Figure 83.** Graph showing how participants feel about different criteria of greenspaces (Source: Author)

As mentioned previously, due to the unusual circumstances from the past years it is essential to factor in the effect of the pandemic. In this perspective, the participants were if they increased their visit frequency to urban greenspaces during/after the pandemic, to which 57% said yes, 23% no and 20% regarded as not relevant. In addition, the following question ‘do you believe greenspaces are essential in urban environments (cities)?’ presented an outstanding result of 99.31% votes for yes and only 0.69% votes for no, with zero votes for no and not relevant. To finalise the questionnaire and to investigate their interest on getting involved in participatory design or other community involvement, the results for the question ‘Would you participate in community activities to improve your neighbourhood's greenspaces?’ show that 57% of the participants would like to get involved, 22% voted maybe and 21% would not. These results reinforce the suggestions the biophilia hypothesis.

*4.3.3 Discussion*

According to the results presented, it can be said that overall, the studied urban greenspaces in Budapest presented a satisfactory assessment of both tangible and intangible aspects, providing valuable insights and tools to be used as reference in the UGSs of Campo Grande. In contrast, the urban greenspaces in Campo Grande presented many issues, deficiencies, and challenges, therefore also accommodating improvement possibilities.

The learnings from the *tangible aspects* of analysis suggests that the examples from Budapest show the benefits of having professional landscape projects for its UGSs. Having good infrastructure, biodiversity, multiple functions, appropriate maintenance and all the other aspects presented thus far, are an indication of the high space use and appreciation by the users. Having the community working together with participatory design actions, can also be an indicator of the aforementioned. Multiple studies that presented similar results, hence strengthen this argument, also presented increased park use after considering the factors mentioned (Cohen et al., 2009; Gibson et al., 2019; Kelly et al., 2022; Veitch et al., 2012b; Zhang & Zhou, 2018).

The UGSs studied in Campo Grande presented the issues created by neglected and/or unplanned urban greenspaces, such as littering, vandalism, inadequate maintenance, incorrect plant species, lack of basic infrastructure and functions, leading to low or no space use. This can be concluded from the results of both the site assessment criteria [Appendix A] and the learnings from the site use questionnaire [Appendix B]. In order for them to provide the desired optimal benefits for the city and community, a landscape architectural project is needed to reflect all the criteria presented in this study. Diminishing usage barriers, such as lack of functions, poor connectivity to the city, insufficient lighting, infrastructure, and maintenance, can ensure greater park use. A study conducted in Germany concluded that greenspace planning should be able to diminish these barriers to ensure park use opportunities for city dwellers (Kabisch et al., 2021). Further studies that presented similar results are (Addas, 2022; Kelly et al., 2022; Vaughan et al., 2018).

Resulting from the planting design findings, the native range of species can be considered positive results, since all nine UGSs presented a majority of native species representing an overall of 39% of the identified taxa. Apart from being more adapted to the local environmental conditions, require less maintenance, promote ecological balance and interactions with native wildlife, be more resilient to pests, diseases, and climate variations, native plant species serve as superior food sources for urban birds, and better accommodates both human and bird habitats(Mohamad et al., 2013). Nevertheless, amongst them only 10% were endemic, which gives us the opportunity to direct more focus on increasing this ratio with the plants from the Cerrado. Owing to that, a list of species to be avoided in the UGSs of Campo Grande was elaborated and can be found on Appendix D, and a comprehensive list of suggested species to be used can be seen on Appendix E. A further list that resulted from the sites analysis comprises all the current planted species in each nine UGSs and could serve as literature reference for future research on the topic [Appendix G].

Regarding the learnings from the *intangible aspects* of analysis, including the findings from social surveys, it can be said that having the biophilic patterns help enrich the space, bringing it closer to the user and connecting to all the senses. Similar to other research projects where these aspects were evaluated using similar methods (Beatley et al., n.d.; M. R. Hunter & Luck, 2013; Naidoo & Fisher, 2011; Shanahan, Fuller, et al., 2015; Sustainable Cities Initiative, n.d.), since the UGSs in Budapest presented these patterns in their design, it can be speculated that they are a factor that created a better overall space experience, which can indicate increased physical and psychological benefits, as suggested by the literature as well.

Owing to this, it is viable to assume that proposing a landscape design project and inserting the missing biophilic patterns and enhancing the existing ones in the UGSs in Campo Grande could be a key element to improve the greenspaces and connect them further to the user. The UGSs that presented a higher level of design and presence of biophilic patterns, also presented higher park use. Similar studies also suggests that biophilic design and planning can be considered a useful paradigm, and can increase park use (Hami et al., 2014; Reeve et al., 2015; Totaforti, 2020).

Differing from the aforementioned projects that were applied in multiple cities, my research for this moment focuses only on Campo Grande, but with the potential to be replicated in other Brazilian cities as well, by adapting the needed factors. Nevertheless, my findings presented similarities to the other studies, since they all concluded that urban greenspaces that incorporate features of nature, such as vegetation, water bodies, and wildlife, have a positive impact on human well-being, social cohesion, and overall quality of life in cities; Well-maintained, easily accessible, visible UGSs, and connected to other parts of the city with features that encourage social interaction and physical activity, are more likely to be used and valued by residents; Community engagement and participation in the planning and management of urban greenspaces can ensure their long-term sustainability and effectiveness in enhancing the connection between cities and nature.

# 5. CONCLUSIONS AND RECOMMENDATIONS

*"Every time you think of a city, you have to think green, green, green. Every time you see a concrete jungle, you must find open spaces. And when you find open spaces, make it so people can get to them."* - Eduardo Paes, politician.

Initially, the sole focus of this research was on the greenspaces of the Brazilian case study of Campo Grande. However, with time and maturity the direction changed and included the Hungarian city of Budapest. Instead of doing a comparative analysis of both cities and UGSs, the case study of Budapest would englobe a perspective of best practices, whereas Campo Grande would be the place for applied strategies. Nevertheless, considering their differences and to acquire better results the same assessment criteria was applied to both cities. The two cities present different climate and weather conditions, have been through different scenarios of urban development and possess an overall different character. However, as presented in the previous chapters, they can be associated through some factors, such as social and socio-political facts, challenges and changes related to environmental constant mutations, similarities in temperature during summer, tolerance to certain species, among others. Regarding urban greenspaces, the differences between size, profile and space use between UGSs in Budapest and Campo Grande became evident throughout this research. Therefore, the strategies and approaches being utilised and applied in Budapest could be proposed in Campo Grande, by refining and selecting the relevant applicable aspects.

The examples from Budapest show that the city gives attention and importance to the matter of having more and better greenspaces in the city, always seeking to improve existing ones as well. For instance, all sites analysed have been redesign/rehabilitated in the past decade. As a result, the researched sites presented great landscape designs with appropriate planting design. Furthermore, by creating multifunctional places with a participatory approach, people help create optimal spaces and take ownership of the place, making use of it to the fullest, as was the case of UGS_2 and UGS_3. Another important factor is the need to rethink the urban spaces and connections, integrating greenspaces to the urban fabric in pursuit of more sustainable spaces and increased urban health. As presented, the 9$^{th}$ district of Budapest was a pioneer in the 80s by addressing these issues. Moreover, by seeing the space with the biophilic lenses as well and assessing the presence of the 14 biophilic patterns, we can measure the complexity and quality of a project, which will further attract users and provide the optimal benefits a greenspace should. Nevertheless, there is no perfect design or place as there will always be something to improve and make it better. The analysed sites in Budapest could benefit of a greater biodiversity as showed in the results.

In great contrast, the examples from Campo Grande suggest that the government is not investing much in urban greenspace creation and integration. Even though the city is considered one of the most vegetated in the country and it is praised by having a lot of trees, a green infrastructure and network approach is missing and/or is being neglected. The results presented that these 'neighbourhood' typology of greenspaces is often neglected and consists of mostly grass and trees, with the few places that are named ‘squares’ by the local government having usually only a partial design, which means that they have a few paved pathways and light poles, the bare minimum. The planting design lacks variety in levels and biodiversity. All these arguments could be confirmed by the heatmap and site use survey results. By not hiring professionals to create a proper landscape project, and if/when they do the community is not involved, the citizens are taking ownership of these public urban greenspaces and using them as an extension of their gardens, planting new species and taking care of the existing ones. Even though it is inspiring to see the population reacting, together with the lack of adequate levels of maintenance, gap in the local literature and information regarding appropriate plants for urban environments, this can be a hazard, hence the list of species to be used and to be avoided elaborated in this research [Appendix D and E]. Furthermore, the lack of water presence in all nine studied sites is extremely concerning, reflecting further on the negligence and need for action. On the other hand, the greenspaces examined accommodate abounding improvement possibilities. According to Gisseli Giraldelli, a biologist and superintendent of surveillance and environmental management of Campo Grande, the aim for the city is to be a biophilic and biodiverse city that can work similarly to a biodiversity corridor. Thereby, the city will offer better life conditions to all its habitants, human or not (Tucker, 2021). This is entirely aligned to the goals and objectives presented on this study, in addition to reassuring the importance of inserting a biophilic and interdisciplinary approach during planning, implementation and care to the current methods and tools.

From the data collected in the social survey, it can be said that the results corroborate the arguments posed in this research regarding the importance of urban greenspaces not only to urban health but to social well-being as well. By having a multicultural group of participants, it was proved that people’s connection to nature is not bound by culture, although it can vary in some respects, the overall feelings and needs can be considered rather universal. Furthermore, even though the current literature focuses on the benefits of physical health, the results from the survey presented higher votes for mental health aspects, such as participants being more relaxed, calmer, happier, less anxious, and so on, thus reverberating the biophilia hypothesis. These, however, do not refute the need for deeper psychological and chemical analysis of the effects on human body, but it is an indication that is also present in multiple studies presented in the literature review chapter. Moreover, results also show that people do pay attention to their surroundings and to the vegetation, in addition to showing interest on learning more, having more and better greenspaces near them and getting involver in the decision making and design through community activities.

### 5.1 Recommendations for further research

Even though this research acknowledges that since landscape architecture, site analysis and social survey is not an exact science, results might be biased, the implications of this study are promising and of great significance to the urban environment. In seeking to understand the greenspaces from a planting design and biophilic perspective, the used method and strategy suggestions can be replicated in other urban greenspaces by making the necessary adjustments. In the case of Campo Grande, the aim is to provide the tools and knowledge that could be used and applied in further greenspaces, both compact and linear, therefore integrating them more to the urban fabric and strengthening the green infrastructure and network, in addition to integrating the community in the decision-making process as well.

As it is expected in academia, there were limitations to this study, such as time, budget, access to researched area and the extreme events of the COVID-19 pandemic, to cite a few. Nevertheless, this leave abounds opportunities for further research. A next step could be to further elaborate the analysis method based on the green system and biophilic design approaches. For the technical aspects it would be valuable to include a machine-based assessment of the trees, for an example, to deeper understand their current situation in order to propose more assertive strategies to improve urban health. On the other hand, related to the biophilia hypothesis and the benefits to social well-being, it would require a higher interdisciplinary approach since it involves much of the psychological aspects. Creating a team to perform controlled experiments to understand how people use and perceive the space around them in more detail, as well as the level of biodiversity they can catch while in contact with nature, would provide invaluable data and insights.

Another important further step of this research and that relates to the goal of making information available for the population of Campo Grande, would be to design a book or a web-page, since it is much simpler to produce and disseminate, with a longer suggested plant species list, together with photographs and graphs that can easily show each plant’s characteristics, such as native range, size, flowering season, fruit season, maintenance required, among other aspects. In connection to this, a bolder idea is to partner with front end developers and create an application to map out fruit trees within the city, where people could find their exact location and fruiting season, diminishing waste and especially helping those with less economic power to enjoy some fruits.

In conclusion, together with the master’s study, this research was an attempt to better understand urban greenspaces in order to propose strategies that could enhance urban health and social well-being, reconnect these spaces to the urban fabric and local culture, involve and instruct the communities, focusing on the Brazilian city of Campo Grande as a case study, therefore moving towards a greener and more liveable city.

# 6. NEW SCIENTIFIC FINDINGS

*"Research is creating new knowledge."* - Neil Armstrong.

The most relevant new scientific results of the present dissertation can be summarized in the following 9 theses:

**Thesis 1:** *Literature gap on the Brazilian case study, and the hazards associated with it*

After researching more than two hundreds scholar works on both national and international literature, plans and directives from Campo Grande, I found a significant knowledge gap concerning planting design and vegetation use in the city. As a result, the use of some species is creating multiple issues and hazards.

For instance, *Ficus benjamina, Licania tomentosa* and *Delonix regia* were identified in, respectively, 7, 9 and 8 out of the nine UGSs, and due to their extremely aggressive roots presented damages to the sites. Furthermore, they were common street trees in the past, and are nowadays causing major damages to the roads and electrical system, therefore having to be removed or pruned drastically. Apart from the danger to human lives, these are causing significant economic impacts as well and has been recognized by the local government as one of the main problems of urban tree planting. Owing to this, I developed a list of species that should be avoided for urban use in Campo Grande and it can be found on Appendix D.

**Thesis 2:** *Appropriate vegetation awareness and use for a better urban environment*

Information can contribute to growth. Seeking to shorten the gap in the local literature of Campo Grande, I developed a comprehensive, detailed list of the current vegetation from all nine studied UGSs, which can be found on Appendix G.

Furthermore, as a result of this research I constructed a list of suggested plant species that can be safely introduced to the urban landscape of Campo Grande, focusing on native and endemic species of the Cerrado, which are resilient and adaptable to the urban environment. This list can be found on Appendix E.

**Thesis 3:** *Interdisciplinarity as a key factor in favour of urban health and social well-being*

By applying the analytical method I created (chapters 3.1 and 3.2), which entails both the physical and social factors of assessment, my findings indicates the interconnectivity of the whole, meaning that only having vegetation is not enough for an UGS to thrive and provide their optimal benefits. For that, the combination of factors should coexist in some level of harmony.

The UGSs from Budapest that presented positive overall results from all assessed categories, also showed a higher level of use and involvement by the community, that can be related to the landscape projects and participatory design strategies applied. The sites where participatory actions were used, such as the example of Bakáts tér and Kerekerdő park, presented outstanding results.. On the other hand, I found that the UGSs from Campo Grande were not in their optimal states, albeit the ones which presented better conditions in both the green system and biophilic criteria, indicated higher use and involvement by the local community. For instance, the sites with less use and satisfaction from the users were UGS_1, UGS_2, UGS_5, UGS_7 and UGS_9, where there are no functions or infrastructure such as benches, only vegetation. From this I can conclude that planning UGSs with an interdisciplinarity approach can greatly affect the positive benefits they can provide to urban health and social well-being.

**Thesis 4:** *The importance of functionality for space use*

The analysed greenspaces of Budapest, together with many other studied examples from different cities/countries, showed that multifunctionality is one of the most important aspects of a site. However, having at least two different activities can already represent an increased use. This finding became evident by the results I gathered from the case studies of both cities. To promote social well-being, people need to be able to use UGSs, and I found that the UGS in Campo Grande which presented only vegetation and no other attraction factors, such as functions, were not being used by people.

The majority of analysed UGSs in Campo Grande lack functionality, oftentimes not even providing the basic function of resting, due to the lack of infrastructure and urban furniture, as was the case of UGS_1, UGS_2, UGS_5, UGS_6, UGS_7 and UGS_9. The absence of use can lead to vandalised, neglected and unsafe spaces, as it was the case for UGS_1. Furthermore, the results from the social and site use surveys reinforce this finding, where the majority of respondents wrote they would visit more urban greenspaces if ‘they felt safer’, ‘had more activity options available there’ and ‘if the spaces were cleaner’. Moreover, participants said they were not completely satisfied with the recreational functions of the urban greenspaces in their cities, and would like to be involved in participatory actions for space improvement.

**Thesis 5:** *Aesthetical and biodiverse urban greenspace for increase in use and benefits*

In the literature chapter I presented studies which corroborate my argument that higher biodiversity and aesthetic values is directly relates to the increase in use of urban greenspaces, and the experienced benefits one can get from them.

I discovered that the UGSs from Campo Grande showed a lack of a proper landscape design project, functions, biodiversity and overall blend aesthetics can be related to the sites not being used much. For instance, only 3% of the interviewed people said they use UGS_1, 5% use UGS_2, 14% use UGS_5, 12% use UGS_7 and 8% use UGS_9 (% are related to each UGS and not an average of all nine sites). Additionally, in all nine UGS the users wrote that ‘having better aesthetic’ would encourage them to use these spaces. Regarding biodiversity, all nine greenspaces are biodiverse to some extent, except for UGS_4. Nevertheless, there are mainly two level of vegetation consisting of grass and trees, and according to the survey users assessed the overall landscape design quality of the sites as 'not enough', the amount of vegetation as 'enough', however the diversity of vegetation was rated as 'not enough'.

**Thesis 6:** *Only having vegetation is not enough for a good urban greenspace*

During this dissertation I argued that being a greenspace only is not enough, and many are the aspects that need to be taken into consideration for the site to be considered well suited and provide the optimal benefits they can.

Firstly, I confirmed that the quality of being green or having vegetation is not enough by finding that even though the UGSs in Campo Grande are far bigger in size, therefore having more green coverage than the UGSs in Budapest, the population is not making much use of the sites. Secondly, the lack of an appropriate planting design is impeding the greenspaces to provide the optimal benefits a greenspace can. Even though the overall result regarding biodiversity showed that all nine UGSs in Campo Grande are somewhat biodiverse, based on my applied methodology and social survey data, there is no landscape design is most sites, and no planting design in all of them, where there are mainly two levels of vegetation: trees and grass. I discovered that this results in a boring and not diverse space according to the users, in addition to providing poor environmental biodiversity, whereas having more shrub species, perennials and groundcovers can greatly enhance these aspects. Finally, I found that the biophilia hypothesis can be also confirmed by this research, since in all nine UGS in Campo Grande I found the sense of stewardship/ownership by the local citizens, where by noticing this lack o biodiversity and planting design, they started treating the sites as an extension of their own gardens, planting a few perennials and shrub species by themselves, in addition to caring for the maintenance as well, as seen on UGS_1, UGS_2, UGS_7 and UGS_9.

**Thesis 7:** *Unique values as a part of local culture*

Based on the fruit tree species I found on the nine UGSs and data collected from personal interviews [Appendix B], I confirmed that this is a common and appreciated activity by the residents. My results showed that eating fruits from urban trees is embedded in the local culture of Campo Grande, since the vast majority of interviewees grew up eating/collecting fruits from public trees, still do so nowadays and affirm that they would greatly appreciate having more fruit trees in the urban environment. The species that were most cited are: mango (*Mangifera indica*), acerola (*Malpighia emarginata*), guava (*Psidium guajava*) and siriguela (*Spondias purpura*). Furthermore, fruit trees are a great source of food for birds, hence in order to maintain the urban bird population it is necessary to continue planting fruit-bearing taxa. Campo Grande is one of the few remaining cities where exotic native birds can be seen flying around freely and nesting on urban trees.

Owing to this, I decided to analyse the unique values of each identified species as well. My findings showed that in all nine UGSs the majority of species presented medicinal values, with the overall number between the nine being 41%. Moreover, in UGS_8 I found indications that the local residents were using the bark of *Stryphnodendron adstringens* for medicinal purposes. The second highest rated value was having edible fruits, where between the nine UGSs 23% of the identified species presented this unique value. In addition to these, I further discovered that in all nine greenspaces the local population was planting and protecting seedlings/small trees from fruit species, with the most common being mango (*Mangifera indica*), acerola (*Malpighia emarginata*), guava (*Psidium guajava*), limão-taiti/tahiti-lime (*Citrus* × *latifolia*) and limão-rosa/mandarin-lime (*Citrus bigaradia*). Furthermore, the remaining unique values identified represent 18% of ornamental species, 4% aromatic, 4% condiment, 4% ecological restoration, 3% other edible parts, 2% cosmetics and 1% unknown.

**Thesis 8:** *The importance of prioritizing native and endemic species*

Then innumerable benefits of native species were already heavily discussed in this research. Therefore, my findings from the UGSs of Budapest, I discovered that only UGS_3 has the majority of species being native, with the other two sites having both established and non-native species as a majority. Overall, between the three UGSs 39% of the identified taxa were native, 31% non-native, 17% established, 7% unidentified and 6% unknown. Nevertheless, this can be due to the fact that the precise geographical endemism of European species can be biased.

On the other hand, the results from the UGSs of Campo Grande I found that all nine UGSs presented a majority of native species, representing an overall of 39% of the identified taxa [Appendix G]. Additionally, 23% represents non-native species, 18% established, 10% endemic, 6% unidentified, 3% unknown and 1% were invasive. Individually, UGS_1 presented the highest percentage of native taxa with 55%, and UGS_9 the higher rate of endemic taxa with 13%. These results can be considered positive, however further steps should go in the direction of inserting even more native and, especially, endemic species in future projects and/or interventions, enhancing the unique biome of the Cerrado.

**Thesis 9:** *Factoring users' opinions for better urban greenspace understanding and planning*

From the heatmaps and site surveys I conducted with 90 people in Campo Grande, I could discover if and how the citizens were using those greenspaces, what were their opinions, feelings, needs and suggestions. I found that most UGSs did not have any functions or infrastructure, factors that were directly related to the use ratio obtained by the survey. The results regarding landscape design and vegetation were rated as 'not enough'. Additionally, my argument regarding the importance of participatory actions corroborated with the answers, since 75% participants said they would be interested in such actions for greenspace improvement.

Adding a more global perspective, my social survey performed with 290 people worldwide showed that the majority of people enjoy and do visit UGSs for multiple activities, in addition to experiencing positive and calming effects during and after this contact with nature. Moreover, 57% of people said they started visiting UGSs more often since/during the pandemic. When it comes to vegetation, 73% replied they do pay attention to the plants around them. An outstanding 99.31% o people believe greenspaces are essential in cities, and 57% of the participants would like to get involved in participatory actions, and 22% voted maybe.

## SUMMARY

Society evolved from a group of nomads, hunters and collectors surviving from what they could gather from nature. With the domestication of fire about 300,000 years ago, and the Agricultural Revolution with the domestication of plants and animals that happened around 12,000 years ago, came the first permanent settlements (Harari, 2014). During the 19th century, the Industrial Revolution intensifies urbanization by attracting a larger number of people to the urban centres, therefore creating and/or enhancing urban pressure. Nowadays cities are becoming congested and polluted in an ever-increasing pace (Blanco et al., 2009) due to the unremitting and disorganized urbanization processes, thus the need of urban greenspaces for better urban health and social well-being.

Owing to the aforementioned, this PhD research aimed to understand the effects of urban greenspaces to urban health and social well-being, focusing on how vegetation is a key factor. In order to address the hypothesis that greenery alone is not enough and highlighting the need of appropriate planning, design and community involvement, we presented many research findings related to the benefits provided by urban greenspaces. Moreover, we further argued that the biophilia hypothesis is of utmost importance and, in connection to the more technical aspects, it can assist to providing psychological benefits and enhancing social well-being. In order to better address the posed research questions and hypotheses, we developed a methodology strongly established on existing national and international literature, in addition to creating a systematic analysis method based on the green system and biophilic design approaches, addressing both technical and social aspects of evaluation in order to go beyond a common site analysis. This assessment method was applied in two case studies, from selected greenspaces in Budapest - Hungary and Campo Grande - Brazil.

The greenspaces of Budapest would be analysed as a form of examples or best practices. From the three urban greenspaces selected, we discovered that since they all have a well-structured and executed landscape project with varied vegetation, multiple functions, safety, among other aspects, the sites are well integrated within the city and local culture. Therefore, the sites are being heavily used and appreciated by the local residents, hence a great sense of stewardship. In contrast, from the nine urban greenspaces analysed in Campo Grande we found multiple issues, such as the lack of landscape design, poor infrastructure, lack of urban furniture and functions, lack of a well planned and diverse planting design, among other aspects. As a result, these created unused and disconnected spaces, potentially posing hazardous situations and atmospheres. Nevertheless, a great sense of stewardship was noticed from the local residents, seeing that they are using the spaces as an extension of their own gardens, which even though it is a positive finding, it can create an imbalanced environment without proper information and guiding. Despite the aforementioned, the greenspaces presented great improvement possibilities, especially by using an interdisciplinary and participatory approach.

In conclusion, the implications of this study can be considered promising and of great significance to the urban environment of Campo Grande. By providing strategies for creating better urban

greenspaces, the benefits to urban health and social well-being would be optimised. Furthermore, assessing greenspaces from a planting design and biophilic design perspective can be an innovative and successful tool to be replicated in other urban greenspaces by making the necessary adjustments. From doing so, greenspaces can be better integrated in the urban fabric thus strengthening green infrastructure and network. In addition, by contributing to the literature gap and making the information available to all citizens, moving towards healthier urban environments is a certainty.

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# APPENDICES

## Appendix A

Site analysis assessment form.

Urban greenspaces analysis assessment form

Green area name:_____________________________________________ Date:________________

*Green system approach (Tangible aspects)*

Accessibility | Aesthetics | Infrastructure | Maintenance & Management method (Roué-Le Gall A., 2015.)

• Overall aesthetic (estética geral): ___ Square (praça) ___ Park (parque)

• Character (caráter): ___ Nature/Garden like, no functions (natureza/jardim, sem funções)

___ Contemplation (contemplação) ___ Recreation (recreação/lazer) - Type (tipo): ___ Playground (parquinho) ___ Sports (esportes) ___ Other (outros):

• Use (uso):

• Users (usuários):

• Infrastructure (infraestrutura): ___ Sidewalk (calçada) ___ Paved pathways (caminhos pavimentados) ___ Light poles (poste de luz) ___ Benches (bancos) ___ Other (outros):

• Accessibility (acessibilidade): ___ Car (carro) ___ Bus (Ônibus) ___ Bikelane (ciclovia)

• Maintenance level (manutenção): ___ Low (baixo) ___ Medium (médio) ___ Ideal ___ High (alto)

• Water management (gerência de água): ___ Irrigation (irrigação) ___ Sewage/drainage (esgoto/drenagem) ___ Rain water catchment (captação de água da chuva)

• Plantation level: ___ Grass ___ Groundcovers ___ Perennial beds ___ Shrubs ___ Trees

• Applied planting design aspects (table with detailed species assessment)

*Biophilic Design approach (Intangible aspects)*

Nature in the space | Nature of the space | Natural analogues

• Is there a design (existe design)? ___ Yes (sim) ___ No (não) ___ Partially (parcial)

• Overall quality (qualidade geral): ___ Terrible ___ Bad ___ Average ___ Good ___ Excellent

• Ownership/stewardship (sentimento de propriedade/pertencimento): ___Yes (sim) ___ No (não)

___ Can't say (não e possível dizer)

• Noise level (nível de barulho): ___ Low (baixo) ___ Medium (médio) ___ High (alto)

• Biodiversity observations (Observações da biodiversidade): ___ Birds (pássaros) ___ Insects (insetos) ___ Others (outros):

• Which of the 14 biophilic design patterns are present? Likert scale parameter for each pattern:

___ Inexistent ___ Somewhat present ___ Considerably present

** The other aspects of biophilic design are to be analysed through the questionnaires!*

## Appendix B

Social questionnaire regarding space use, performed on site.

*Related to each UGS:*

1. **Age** (Until 18 years old; Between 18 and 29 years old; Between 30 and 39 years old; Between 40 and 49 years old; Between 50 and 59 years old; Between 60 and 69 years old; 70 or more)
2. **Gender** (Female; Male; Prefer not to say; Other)
3. **Do you like visiting greenspaces in general?** (Yes; No)
4. **Do you use this greenspace?** (Yes; No)
5. **What is the frequency you use this greenspace?** (Never; Sometimes; Regularly)
6. **For what do you use this space?** (Open answer)
7. **How would you rate the landscape design quality of this site?** (Not enough; Enough; Exaggerated)
8. **How would you rate the amount of vegetation here?** (Not enough; Enough; Exaggerated)
9. **What do you think about the diversity of vegetation, both related to plant species and plant level (shrubs, trees, etc)?** (Not enough; Enough; Exaggerated)
10. **What aspects would make you use this space more? (e.g., If there was furniture, etc)** (Open answer)
11. **Would you be interested in participatory actions for greenspace improvement?** (Yes; No)

*Related to the unique values of plants (e.g. fruit trees):*

12. **Did you grow up eating/collecting fruits from street/public fruit trees?** (Yes; No)
13. **Do you (still) collect and consume fruits from public fruit trees?** (Yes; No)
14. **Would appreciate having more fruit trees in the urban environment?** (Yes; No)
15. **What are the fruits (tree species) that you most encounter in this city?** (Open answer)

**<u>Appendix C</u>**

Social questionnaire performed online.

*Greenspaces in urban environments*

Greenspaces are parks, squares, greenways, etc. The goal of this form is to better understand the role of greenspaces in our cities, and how we interact with them.

16. **Age** (Until 18 years old; Between 18 and 29 years old; Between 30 and 39 years old; Between 40 and 49 years old; Between 50 and 59 years old; Between 60 and 69 years old; 70 or more)
17. **Gender** (Female; Male; Prefer not to say; Other)
18. **In which city do you live?** (Open answer)
19. **What is your nationality?** (Open answer)
20. **How much do you like going to greenspaces?** (A lot; A little; Neutral; I don't like)
21. **How often do you go?** (Never; Rarely/occasionally; 1 - 2 times a week; 3 - 4 times a week; More than 4 times a week)
22. **Would you go more often if... (choose all relevant options)** (You had more time; You felt safer; You had greenspaces closer to your house; Other)
23. **Do you usually go...** (Alone; With friends; With family)
24. **What activities do you do there? (Choose all relevant options)** (Walking; Run/jogging; Picnic; Relaxing; Play sports; Reading; Appreciate nature; Walk your pet; Play with my children; Other)
25. **How do you feel when you're in contact with nature? (Choose all relevant options)** (Same as always; Calmer and more relaxed; Happier; Less stressed and anxious; Observant; Grateful; Healthier; Other)
26. **Do you tend to pay attention to the plants around you?** (Yes; No; Sometimes; No, but I would like to)
27. **How satisfied are you with the following aspects of the urban greenspaces of your city:** ***Maintenance; Biodiversity; Recreational functions; Amount of vegetation; Overall design and character; Amount of greenspaces near you*** (scale answer: Not at all satisfied; Slightly satisfied; Neutral; Satisfied; Very satisfied)
28. **Did you go more to greenspaces during/after the pandemic started?** (Yes; No; Not relevant)
29. **Do you believe greenspaces are essential in urban environments (cities)?** (Yes; No; Maybe; Not relevant)
30. **Would you participate in community activities to improve your neighbourhood's greenspaces?** (Yes; No; Maybe)

## Appendix D

**Table 25.** List of species to be avoided in the urban environment of Campo Grande.

| Scientific name | Common name (in Portuguese) | Threat |
|---|---|---|
| *Agave sp.* | Agávea | Thorns on the leaves |
| *Caesalpinea pulcherrima* | Flamboyant-mirim | Toxic seed, aggressive roots |
| *Citrus sp.* | Citrus | Presence of thorns |
| *Euphorbia cotinifolia L.* | Leiteiro-vermelho | Toxic sap |
| *Euphorbia milii* | Coroa-de-cristo | With thorns and toxic |
| *Euphorbia pulcherrima Willd. Ex Klotzsch* | Bico-de-papagaio | Invasive |
| *Ficus sp.* | Ficus | Latex, aggressive roots |
| *Holocalix balansae* | Alecrim-de-campinas | Toxic plant |
| *Holocalix balansae* | Alecrim-decampinas | Toxic plant |
| *Hura crepitans* | Assacu | Thorns on the stem |
| *Leucaena leucocephala* | árvore-do-conflito, leucena | Invasive |
| *Licania tomentosa* | Oiti | Latex, aggressive roots |
| *Ligustrum lucidum W. T. Aiton* | Alfenheiro-do-Japão | Invasive, toxic substances |
| *Melia azedarach L* | Cinamomo | Invasive |
| *Nerium olenader* | Espirradeira | Toxic plant |
| *Pereskia gradifolia* | Ora-pro-nóbis | Thorns on the stem |
| *Platanus x acerifolia (Aiton) Willd.* | Plátano | Invasive |
| *Plumeria rubra* | Jasmin-manga | Toxic plant |
| *Ricinus communis* | Mamona | Invasive and toxic |
| *Schinus brasiliensis March. ex Cabrera* | Aroeira-bugreiro | Toxic |
| *Schinus molle L* | Aroeira-salsa (chorão) | Drooping branches |
| *Schinus terebinthifolia* | Aoreira vermelha | Extreme growth |
| *Schinus therebinthifolius Raddi* | Aroeira-vermelha | Extreme growth |
| *Thevetia peruviana* | Chapéu-de-napoleão | Toxic plant |
| *Thunbergia laurifolia* | Azulzinha, Tumbérgia-azul | Invasive |

## Appendix E

**Table 26.** List of suggested plant species for the urban environment of Campo Grande, focusing on trees appropriate for squares and parks.

| **Scientific name** | **Common name (in Portuguese)** |
|---|---|
| *Albizia hasslerii* | Farinha seca |
| *Allopylus edullis* | Chal-chal ou fruto-de-pombo |
| *Anadenanthera falcata* and *A. peregrina* | Angico-vermelho |
| *Andira cuiabensis* | Morcegueira, angelim-do-cerrado |
| *Andira sp* | Angelim |
| *Aspidosperma macrocarpon* | Guatambu-do-cerrado |
| *Averrhoa carambola* | Caramboleira |
| *Bombacopsis glabra* | Castanha-do-maranhão |
| *Caesalpinia echinata* | Pau-brasil |
| *Caesalpinia ferrea* | Pau-ferro |
| *Caesalpinia peltophoroides* | Sibipiruna |
| *Calycophyllun spuruceanum* | Pau-mulato |
| *Cariniana legalis* | Jequitibá |
| *Cássia grandis* | Cássia rosa |
| *Cecropia pachystachia* | Embaúva |
| *Cedrela fissilis* | Cedro |
| *Chorisia speciosa* | Paineira |
| *Clitoria fairchildiana* | Sombreiro |
| *Copaifera langsdorffii* | Copaíba |
| *Cordia trichotoma* | Louro-pardo |
| *Cybistax antisyphilitica* | Ipê verde |
| *Delonix regia* | Flamboyant |
| *Dimorphandra mollis* | Falso-barbatimão, cinzeiro |
| *Dipteryx alata* | Cumbaru |
| *Enterolobium contortisiliquum* | Orelha-de-negro, tamboril |
| *Erytrina speciosa* | Suinã |
| *Eugenia involucrata* | Cerejeira |
| *Eugenia uniflora* | Pitangueira |
| *Hymenaea courbaril* | Jatobá |
| *Ingá sp* | Ingá |
| *Jacarandá cuspidifolia* | Jacarandá |
| *Koelreuteria bipinnata* | Árvore-da-china |
| *Lafoensia pacari* | Dedaleira |
| *Licania tomentosa* | Oiti |
| *Malpighia glabra* | Acerola |
| *Melia azedarach* | Cinamomo |
| *Michelia champaca* | Magnólia |
| *Muntingia calabura* | Calabura, cereja-do-paraná |
| *Myracroduon urundeuva* | Aroeira |
| *Ormosia arborea* | Olho-de-cabra |
| *Pachira aquatica* | Monguba |
| *Psidium guajava* | Goiabeira |
| *Pterogine nitens* | Amendoim-bravo |
| *Qualea grandiflora* | Pau-terra-grande |
| *Qualea parviflora* | Pau-terra, pau-terrinha |
| *Rapanea umbelata* | Pau-pombo, capororoca |
| *Sapindus saponácea* | Saboneteira |
| *Schefflera morototoni* | Mandiocão |
| *Schinus terebinthifolius* | Aroeirinha, aroeira-pimenta |

| | |
|---|---|
| *Spathodea nilotica* | Espatódea |
| *Spondias macrocarpa* | Cajá |
| *Spondias velunosa* | Cajá-mirim |
| *Sterculia striata* | Manduvi |
| *Stryphnodendron adstringens* | Barbatimão |
| *Tabebuia avellanedae* | Ipê roxo |
| *Tabebuia chrysotricha* | Ipê amarelo |
| *Tabebuia roseo-alba* | Ipê branco |
| *Talisia esculenta* | Pitomba |
| *Tamarindus indica* | Tamarineiro |
| *Tapirira guianensis* | Cupiúba, pau-pombo |
| *Terminalia argentea* | Capitão-do-mato |
| *Terminalia brasiliensis* | Merendiba |
| *Terminalia catappa* | Sete-copas |
| *Tipuana tipu* | Tipuana |
| *Vitex cymosa* | Tarumã |
| *Vochysia bifalcata* | Pau-de-tucano |
| *Vochysia sp.* | Cambará |

## Appendix F

**Table 27.** Plant list of identified species from the UGS in Budapest, elaborated by the author

| UGS | Scientific name | Family | Genus | Common name (EN) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_1 | *Aesculus hippocastanum* | *Sapindaceae* | *Aesculus* | Horse chestnut | Europe | Native | Medicinal | | Seeds | | 2 | | |
| UGS_1 | *Carpinus betulus* | *Betulaceae* | *Carpinus* | Hornbeam | Europe, Asia | Native | Medicinal | | Leaves | | 5 | | |
| UGS_1 | *Catalpa bignonioides* | *Bignoniaceae* | *Catalpa* | Catalpa, cigartree, Indian-bean-tree | North America | Established | Medicinal | | Seeds, Bark, Pods | | 2 | | |
| UGS_1 | *Cedrus atlantica* | *Pinaceae* | *Cedrus* | Atlas Cedar | North Africa | Non-native | Cosmetics | Medicinal | Leaves, Bark | | 7 | | |
| UGS_1 | *Chamaecyparis lawsoniana* | *Cupressaceae* | *Chamaecyparis* | Port Orford cedar, Lawson cypress | North America | Non-native | Medicinal | | Leaves | | 5 | | |
| UGS_1 | *Cornus sericea* | *Cornaceae* | *Cornus* | Red osier, dogwood | North America | Non-native | Medicinal | | Bark, Roots | | 5 | | |
| UGS_1 | *Corylus colurna* | *Betulaceae* | *Corylus* | Turkish hazel | Europe, Asia | Native | Medicinal | | Seeds | | 11 | | |
| UGS_1 | *Cotoneaster microphyllus* | *Rosaceae* | *Cotoneaster* | Small-leaved cotoneaster | Asia | Established | Medicinal | | Seeds | | 1 | | |
| UGS_1 | *Fraxinus excelsior* | *Oleaceae* | *Fraxinus* | Ash tree | Europe | Native | Medicinal | | Seeds, Fruit | | 44 | | |
| UGS_1 | *Hibiscus syriacus* | *Malvaceae* | *Hibiscus* | Rose of sharon, rose mallow | Korea, China | Non-native | Medicinal | | Leaves, Flower | | 5 | | |
| UGS_1 | *Koelreuteria paniculata* | *Sapindaceae* | *Koelreuteria* | Goldenrain tree, varnish tree | Asia | Established | Edible | Medicinal | Berry, Leaves, Flower, Shoot | | 9 | | |
| UGS_1 | *Lonicera symphoricarpos* | *Caprifoliaceae* | *Lonicera* | Coralberry, buckbrush, Snowberry | North America | Non-native | Ecological restoration | | | Toxic | 1 | | |
| UGS_1 | *Lycium barbarum* | *Solanaceae* | *Lycium* | Chinese wolfberry, Goji berry | Europe, China | Native | Medicinal | | Berry | | 7 | | |
| UGS_1 | *Malus sylvestris* | *Rosaceae* | *Malus* | European crab apple | Europe | Native | Edible fruit | Medicinal | Fruit, Bark | | 1 | | |
| UGS_1 | *Morus alba* | *Moraceae* | *Morus* | White mulberry, common mulberry | Europe, Asia | Native | Edible fruit | Medicinal | Fruit, Bark | | 2 | | |
| UGS_1 | *Picea abies* | *Pinaceae* | *Picea* | Norway spruce, European spruce | Europe | Native | Medicinal | | Leaves | | 3 | | |
| UGS_1 | *Picea pungens 'Koster'* | *Pinaceae* | *Picea* | Colorado Spruce | Unknown | Unknown | Medicinal | | Leaves | | 2 | | |
| UGS_1 | *Populus nigra 'Italica'* | *Salicaceae* | *Populus* | Black poplar | Unknown | Unknown | Medicinal | | Buds | | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_1 | *Prunus cerasifera 'Nigra'* | *Rosaceae* | *Prunus* | Myrobalan plum, Cherry plum | Unknown | Unknown | Edible fruit | | Fruit | | 8 | | |
| UGS_1 | *Prunus serrulata* | *Rosaceae* | *Prunus* | Cherry tree | Japan | Non-native | Edible fruit | Medicinal | Fruit | | 2 | | |
| UGS_1 | *Pyracantha coccinea* | *Rosaceae* | *Pyracantha* | Firethorn | Europe, Asia | Native | Edible fruit | Medicinal | Fruit, Flower, Leaves | | 1 | | |
| UGS_1 | *Robinia pseudoacacia* | *Fabaceae* | *Robinia* | Black locust | North America | Non-native | Medicinal | | Flower, Bark, Roots | Invasive | 1 | | |
| UGS_1 | *Spiraea japonica* | *Rosaceae* | *Spiraea* | Japanese meadowseet | Japan | Non-native | Medicinal | | Fruit, Leaves, Roots | | 4 | | |
| UGS_1 | *Thuja plicata* | *Cupressaceae* | *Thuja* | Pacific redcedar, giant arborvitae | North America | Non-native | Medicinal | | Leaves | | 2 | | |
| UGS_1 | *Tilia cordata* | *Malvaceae* | *Tilia* | Linden, little-leaf, pry tree | Europe | Native | Medicinal | | Flower | | 11 | | |
| UGS_1 | *Vinca major* | *Apocynaceae* | *Vinca* | Bigleaf periwinkle | Mediterranean | Non-native | Medicinal | | Whole plant | Toxic | 2 | | |
| UGS_1 | *sp 16* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 2 | | |
| UGS_2 | *Acer negundo* | *Sapindaceae* | *Acer* | Box elder, Manitova maple | North America | Non-native | Medicinal | | Leaves, Bark | | 8 | | |
| UGS_2 | *Acer pseudoplatanus* | *Sapindaceae* | *Acer* | Sycamore maple | Europe, Asia | Native | Medicinal | | Bark, Sap | | 1 | | |
| UGS_2 | *Catalpa bignonioides* | *Bignoniaceae* | *Catalpa* | Catalpa, cigartree, Indian-bean-tree | North America | Established | Medicinal | | Seeds, Bark, Pods | | 8 | | |
| UGS_2 | *Celtis occidentalis* | *Cannabaceae* | *Celtis* | Common hackberry | North America | Established | Edible fruit | Medicinal | Fruit, Bark | | 17 | | 1 |
| UGS_2 | *Fraxinus excelsior* | *Oleaceae* | *Fraxinus* | Ash tree | Europe | Native | Medicinal | | Seeds, Fruit | | 4 | | 10 |
| UGS_2 | *Ginkgo biloba* | *Ginkgoaceae* | *Ginkgo* | Maidenhair tree | China | Non-native | Medicinal | | Leaves, Nuts | Fruit smell | 2 | | |
| UGS_2 | *Koelreuteria paniculata* | *Sapindaceae* | *Koelreuteria* | Goldenrain tree, varnish tree | Asia | Established | Edible | Medicinal | Berry, Leaves, Flower, Shoot | | 6 | | |
| UGS_2 | *Prunus serrulata* | *Rosaceae* | *Prunus* | Cherry tree | Japan | Non-native | Edible fruit | Medicinal | Fruit | | 5 | | |
| UGS_2 | *Robinia pseudoacacia* | *Fabaceae* | *Robinia* | Black locust | North America | Non-native | Medicinal | | Flower, Bark, Roots | Invasive | 2 | | |
| UGS_2 | *Tilia cordata* | *Malvaceae* | *Tilia* | Linden, little-leaf, pry tree | Europe | Native | Medicinal | | Flower | | 10 | | |
| UGS_2 | *sp 5* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 9 | | |
| UGS_2 | *sp 6* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 8 | | |
| UGS_3 | *Acer pseudoplatanus* | *Sapindaceae* | *Acer* | Sycamore maple | Europe, Asia | Native | Medicinal | | Bark, Sap | | | | 1 |

| UGS | Scientific name | Family | Genus | Common name (EN) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_3 | *Aesculus hippocastanum* | *Sapindaceae* | *Aesculus* | Horse chestnut | Europe | Native | Medicinal | | Seeds | | 1 | | |
| UGS_3 | *Betula pendula* | *Betulaceae* | *Betula* | Silver birch, European white birch | Europe, Asia | Native | Medicinal | | Bark | | 7 | | |
| UGS_3 | *Celtis occidentalis* | *Cannabaceae* | *Celtis* | Common hackberry | North America | Established | Edible fruit | Medicinal | Fruit, Bark | | 17 | | 5 |
| UGS_3 | *Fraxinus excelsior* | *Oleaceae* | *Fraxinus* | Ash tree | Europe | Native | Medicinal | | Seeds, Fruit | | 5 | | 7 |
| UGS_3 | *Hibiscus syriacus* | *Malvaceae* | *Hibiscus* | Rose of sharon, rose mallow | Korea, China | Non-native | Medicinal | | Leaves, Flower | | 4 | | |
| UGS_3 | *Koelreuteria paniculata* | *Sapindaceae* | *Koelreuteria* | Goldenrain tree, varnish tree | Asia | Established | Edible | Medicinal | Berry, Leaves, Flower, Shoot | | 4 | | |
| UGS_3 | *Malus sylvestris* | *Rosaceae* | *Malus* | European crab apple | Europe | Native | Edible fruit | Medicinal | Fruit, Bark | | 2 | | |
| UGS_3 | *Morus alba* | *Moraceae* | *Morus* | White mulberry, common mulberry | Europe, Asia | Native | Edible fruit | Medicinal | Fruit, Bark | | | | 1 |
| UGS_3 | *Platanus × hispanica* | *Platanaceae* | *Platanus* | London plane, Sycamore | Europe | Native | Ornamental | Ornamental | | | 2 | | 3 |
| UGS_3 | *Prunus serrulata* | *Rosaceae* | *Prunus* | Cherry tree | Japan | Non-native | Edible fruit | Medicinal | Fruit | | | | 2 |
| UGS_3 | *Robinia pseudoacacia* | *Fabaceae* | *Robinia* | Black locust | North America | Non-native | Medicinal | Medicinal | Flower, Bark, Roots | Invasive | 5 | | |
| UGS_3 | *Sophora japonica* | *Fabaceae* | *Sophora* | Japanese pagoda tree | Asia | Established | Medicinal | Medicinal | Flower, Buds | | 1 | | |
| UGS_3 | *Tilia cordata* | *Malvaceae* | *Tilia* | Linden, little-leaf, pry tree | Europe | Native | Medicinal | Medicinal | Flower | | 7 | | 7 |
| UGS_3 | *sp 9* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 8 | | |

## Appendix G

**Table 28.** Plant list of identified species from the UGS in Campo Grande, elaborated by the author

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_1 | *Albizia lebbeck* | *Fabaceae* | *Albizia* | Albízia, coração-de-negro, faveiro | Asia | Established | Medicinal | | Seeds, Leaves | | 3 | | |
| UGS_1 | *Anadenanthera macrocarpa* | *Fabaceae* | *Anadenanthera* | Angico vermelho | Brazil | Native | Medicinal | | Fruit, Bark, Sap | | 1 | | |
| UGS_1 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaves, Roots | | 1 | | |
| UGS_1 | *Bixa orellana* | *Bixaceae* | *Bixa* | Urucum, Açafroa | Central America, South America | Native | Condiment | Medicinal, Dye | Seeds, Leaves | | 1 | | |
| UGS_1 | *Carapa guianensis* | *Meliaceae* | *Carapa* | Andiroba, crabwood | Brazil | Native | Cosmetics | Medicinal | Fruit, Bark, Seeds | | 1 | | |
| UGS_1 | *Casimiroa sapota* | *Rutaceae* | *Casimiroa* | Sapota branca | Mexico, Guatemala | Non-native | Medicinal | | Seeds, Leaves, Bark | | 2 | | |
| UGS_1 | *Ceiba speciosa* | *Malvaceae* | *Ceiba* | Paineira | Brazil, Bolivia | Native | Medicinal | | Bark, Sap | Trunk thorns | 2 | | |
| UGS_1 | *Cestrum nocturnum* | *Solanaceae* | *Cestrum* | Dama da Noite | North America, Central America, South America | Native | Aromatic | Cosmetics | Flower | Allergenic | 1 | | |
| UGS_1 | *Clitoria fairchildiana* | *Fabaceae* | *Clitoria* | Pigeonwings, Sombreiro, sombra-de-vaca | Brazil | Native | Medicinal | | Petals | | 1 | | |
| UGS_1 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 1 | | |
| UGS_1 | *Dipteryx alata* | *Fabaceae* | *Dipteryx* | Cumbaru, Baru | Brazil | Endemic | Medicinal | | Fruit, Bark, Seeds | | 1 | 1 | |
| UGS_1 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | 1 | | |
| UGS_1 | *Eugenia uniflora* | *Myrtaceae* | *Eugenia* | Pitanga, Suriname cherry, Brazilian cherry | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 2 | | |
| UGS_1 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 3 | | 1 |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_1 | *Ficus lutea* | *Moraceae* | *Ficus* | Giant-leaved fig | Africa | Non-native | Edible fruit | | Fruit, Sap | Aggressive roots | 2 | | |
| UGS_1 | *Guarea guidonia* | *Meliaceae* | *Guarea* | Muskwood, carrapeta-verdadeira, Jataúba | Africa, North America, South America | Native | Edible fruit | Medicinal | | | 1 | | |
| UGS_1 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | Medicinal | Bark | | 7 | | |
| UGS_1 | *Hymenaea courbaril* | *Fabaceae* | *Hymenaea* | Jatobá | Brazil | Native | Condiment | Ritualistic | Seeds, Sap | | 1 | | |
| UGS_1 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 1 | | |
| UGS_1 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 4 | | 1 |
| UGS_1 | *Musa spp* | *Musaceae* | *Musa* | Banana | Unknown | Unknown | Edible fruit | Medicinal | Whole plant | | 2 | | |
| UGS_1 | *Philodendron bipinnatifidum* | *Araceae* | *Philodendron* | Guaimbê, Banana-do-mato, Imbê | Brazil | Native | Edible fruit | Medicinal | Fruit, Stem, Leaves, Roots | | 1 | | |
| UGS_1 | *Phoenix reclinata* | *Arecaceae* | *Phoenix* | Tamareira do Senegal | North Africa, Madagascar | Non-native | Ornamental | | | Thorns | 1 | | |
| UGS_1 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 2 | | 1 |
| UGS_1 | *Schinus terebinthifolia* | *Anacardiaceae* | *Schinus* | Brazilian peppertree, aroeira | South America | Native | Condiment | Medicinal | Fruit, Seeds, Bark | | 1 | | |
| UGS_1 | *Syagrus romanzoffiana* | *Arecaceae* | *Syagrus* | Queen palm, Giriba, Jerivá | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Flower, Bark, Heart of palm | | 1 | | |
| UGS_1 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 5 | | |
| UGS_1 | *Tecoma stans* | *Bignoniaceae* | *Tecoma* | Ipê de jardim, yellow elder, sinos amarelos | North America, Central America, South America | Native | Medicinal | | Leaves | | 2 | | |
| UGS_1 | *sp13* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_1 | *sp29* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | 1 | |
| UGS_1 | *sp7* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | 1 | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_2 | *Adenanthera pavonina* | *Fabaceae* | *Adenanthera* | Carolina, carolina tento, falso pau-brasil | Central America | Non-native | Medicinal | | Bark | | 2 | | |
| UGS_2 | *Albizia lebbeck* | *Fabaceae* | *Albizia* | Albízia, coração-de-negro, faveiro | Asia | Established | Medicinal | | Seeds, Leaves | | 9 | | |
| UGS_2 | *Aloe arborescens* | *Asphodelaceae* | *Aloe* | Candelabra aloe, Aloe vera | South Africa | Non-native | Cosmetics | Medicinal | Leaves | | 12 | | |
| UGS_2 | *Araucaria angustifolia* | *Araucariaceae* | *Araucaria* | Pinhão, Pinheiro-do-paraná | Brazil | Native | Edible fruit | Medicinal | Leaves, Seeds, Bark, Sap | | 1 | | |
| UGS_2 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaves, Roots | | | | 2 |
| UGS_2 | *Ceiba speciosa* | *Malvaceae* | *Ceiba* | Paineira | Brazil, Bolivia | Native | Medicinal | | Bark, Sap | Trunk thorns | 1 | | |
| UGS_2 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | 1 | | |
| UGS_2 | *Clitoria fairchildiana* | *Fabaceae* | *Clitoria* | Pigeonwings, Sombreiro, sombra-de-vaca | Brazil | Native | Medicinal | | Petals | | 2 | | |
| UGS_2 | *Coccoloba uvifera* | *Polygonaceae* | *Coccoloba* | Sea grape | Tropical America, Caribbean | Non-native | Medicinal | | Fruit, Seeds, Leaves, Bark, Roots | | 1 | | |
| UGS_2 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | | | 2 |
| UGS_2 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 3 | | |
| UGS_2 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | 1 | | |
| UGS_2 | *Grevillea banksii* | *Proteaceae* | *Grevillea* | Grevilha-anã, Dwarf silky oak | Australia | Non-native | Ornamental | | | Toxic, Allergenic | | | 2 |
| UGS_2 | *Gymnanthemum amygdalinum* | *Asteraceae* | *Gymnanthemum* | Boldo, Alumã | Tropical Africa | Established | Medicinal | | Leaves | Toxic??? Amygdalin is toxic | 3 | | |
| UGS_2 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 3 | | 1 |
| UGS_2 | *Leucaena leucocephala* | *Fabaceae* | *Leucaena* | River tamarind, leucena | North/Central America, | Invasive | Edible | | Pulp | | | 3 | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_2 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | | | 1 |
| UGS_2 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 1 | 2 | |
| UGS_2 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | 1 | | |
| UGS_2 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 13 | | 1 |
| UGS_2 | *Peltophorum dubium* | *Fabaceae* | *Peltophorum* | Canafístula, Angico-amarelo | South America | Native | Ecological restoration | | | | 3 | | |
| UGS_2 | *Plinia cauliflora* | *Myrtaceae* | *Plinia* | Jaboticaba, Brazilian grapetree | Brazil | Endemic | Edible fruit | | Fruit | | 1 | | |
| UGS_2 | *Plumeria rubra* | *Apocynaceae* | *Plumeria* | Plumeria, Jasmim-manga | Latin America, Central America | Established | Aromatic | Medicinal, Ritualistic | Flower, Leaves, Sap | Toxic, Allergenic | | | 2 |
| UGS_2 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | 2 | |
| UGS_2 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | 4 | | |
| UGS_2 | *Schinus molle* | *Anacardiaceae* | *Schinus* | Aroeira Salsa, Peppertree | South America | Native | Condiment | Medicinal | Fruit, Seeds, Leaves, Bark | | | | 1 |
| UGS_2 | *Spondias purpurea* | *Anacardiaceae* | *Spondias* | Ciriguela, Spanish plum | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Sap | Falling fruits, Aggressive roots | 1 | | 1 |
| UGS_2 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | 6 | | |
| UGS_2 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 3 | | |
| UGS_2 | *Tecoma stans* | *Bignoniaceae* | *Tecoma* | Ipê de jardim, yellow elder, sinos amarelos | North America, Central America, South America | Native | Medicinal | | Leaves | | 1 | | 1 |
| UGS_2 | *Thevetia peruviana* | *Apocynaceae* | *Thevetia* | Chapéu-de-Napoleão; Thevetia | Central America | Non-native | Medicinal | | Fruit, Leaves | | | | 1 |
| UGS_2 | *Tradescantia pallida* | *Commelinaceae* | *Tradescantia* | Trapoeraba roxa, Purple-heart | Mexico | Non-native | Ornamental | | | | 2 | | |
| UGS_2 | *sp (Pine?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | | 2 |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_2 | *sp (Thuja?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_3 | *Agave americana* | *Asparagaceae* | *Agave* | Agave, Century plant, American aloe | North America | Non-native | Medicinal | | Leaves | | 10 | | 1 |
| UGS_3 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaves, Roots | | 4 | 1 | |
| UGS_3 | *Caryota urens* | *Arecaceae* | *Caryota* | Pameira Rabo de peixe, Jaggery palm | Asia | Non-native | Medicinal | | Leaves, Flower, Sap | | 5 | | |
| UGS_3 | *Clitoria fairchildiana* | *Fabaceae* | *Clitoria* | Pigeonwings, Sombreiro, sombra-de-vaca | Brazil | Native | Medicinal | | Petals | | 2 | | |
| UGS_3 | *Clusia fluminensis* | *Clusiaceae* | *Clusia* | Autograph tree,Clúsia, Mangue-da-praia | Brazil | Native | Ornamental | | | | 1 | | |
| UGS_3 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | | | 1 |
| UGS_3 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | | | 1 |
| UGS_3 | *Dypsis decaryi* | *Arecaceae* | *Dypsis* | Triangle palm | Madagascar | Non-native | Ornamental | | | | 1 | | |
| UGS_3 | *Euphorbia tirucalli* | *Euphorbiaceae* | *Euphorbia* | Pau-pelado, Coroa-de-cristo; Pencil tree | Africa | Non-native | Medicinal | | Stems, Sap | Toxic | 1 | | |
| UGS_3 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 2 | | 2 |
| UGS_3 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 3 | 4 | |
| UGS_3 | *Hibiscus rosa-sinensis* | *Malvaceae* | *Hibiscus* | Chinese hibiscus, Rose mallow, Hibisco | Asia | Established | Edible | Medicinal | Flower | | 1 | | |
| UGS_3 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 4 | | 7 |
| UGS_3 | *Malpighia emarginata* | *Malpighiaceae* | *Malpighia* | Acerola, Guarani cherry, Wild crepe myrtle | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Sap | | | 1 | |
| UGS_3 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Aggressive roots | 2 | 1 | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_3 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | 1 | | |
| UGS_3 | *Musa spp* | *Musaceae* | *Musa* | Banana | Unknown | Unknown | Edible fruit | Medicinal | Whole plant | | 1 | 2 | |
| UGS_3 | *Psidium cattleyanum* | *Myrtaceae* | *Psidium* | Araçá, Strawberry guava | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_3 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | | |
| UGS_3 | *Roystonea regia* | *Arecaceae* | *Roystonea* | Cuban royal palm | Central America | Established | Ornamental | | | | | | 1 |
| UGS_3 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | 1 | | |
| UGS_3 | *Syzygium cumini* | *Myrtaceae* | *Syzygium* | Java Plum, Jambolão, Jamelão | India | Established | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark | | 1 | | |
| UGS_3 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 4 | 1 | 2 |
| UGS_3 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | | | 2 |
| UGS_4 | *Bougainvillea spectabilis* | *Nyctaginaceae* | *Bougainvillea* | Primavera, buganvília, paper flower | Brazil | Native | Medicinal | | | | 4 | | |
| UGS_4 | *Caesalpinia pulcherrima* | *Fabaceae* | *Caesalpinia* | Peacock Flower, Flamboyant-mirim | Tropical America | Native | Medicinal | | Leaves, Roots | | | | 1 |
| UGS_4 | *Caryota urens* | *Arecaceae* | *Caryota* | Pameira Rabo de peixe, Jaggery palm | Asia | Non-native | Medicinal | | Leaves, Flower, Sap | | 1 | | |
| UGS_4 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | | 1 | |
| UGS_4 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | 30 | | |
| UGS_4 | *Eugenia uniflora* | *Myrtaceae* | *Eugenia* | Pitanga, Suriname cherry, Brazilian cherry | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_4 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 5 | | |
| UGS_4 | *Inga edulis* | *Fabaceae* | *Inga* | Ice cream-bean, Ingá | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | Aggressive roots | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_4 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | 1 | | |
| UGS_4 | *Leucaena leucocephala* | *Fabaceae* | *Leucaena* | River tamarind, árvore-do-conflito, leucena | North America, Central America | Invasive | Edible | | Pulp | | 2 | 1 | |
| UGS_4 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 3 | | 1 |
| UGS_4 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 2 | 4 | |
| UGS_4 | *Plumeria rubra* | *Apocynaceae* | *Plumeria* | Plumeria, Jasmim-manga | Latin America, Central America | Established | Aromatic | Medicinal, Ritualistic | Flower, Leaves, Sap | Toxic, Allergenic | 3 | | 1 |
| UGS_4 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | 1 | |
| UGS_4 | *Punica granatum* | *Lythraceae* | *Punica* | Pomegranate, Romã | Mediterranean | Non-native | Edible fruit | Medicinal | Fruit, Flower, Leaves, Stem | | | 1 | |
| UGS_4 | *Ricinus communis* | *Euphorbiaceae* | *Ricinus* | Mamona, Castor bean | Tropical Africa | Invasive | Medicinal | | Seeds | Toxic | 1 | | |
| UGS_4 | *Syagrus romanzoffiana* | *Arecaceae* | *Syagrus* | Queen palm, Giriba, Jerivá | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Flower, Bark, Heart of palm | | 1 | | |
| UGS_4 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | | 1 | |
| UGS_4 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 6 | 1 | |
| UGS_4 | *Tecoma stans* | *Bignoniaceae* | *Tecoma* | Ipê de jardim, yellow elder, sinos amarelos | North America, Central America, South America | Native | Medicinal | | Leaves | | | | 1 |
| UGS_4 | *Thevetia peruviana* | *Apocynaceae* | *Thevetia* | Chapéu-de-Napoleão; Thevetia | Central America | Non-native | Medicinal | | Fruit, Leaves | | | | 1 |
| UGS_4 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_4 | *Tibouchina granulosa 'Kathleen'* | *Melastomataceae* | *Tibouchina* | Quaresmeira rosa | Brazil | Native | Ornamental | | | | 2 | | |
| UGS_4 | *sp4* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 2 | | |
| UGS_5 | *Albizia lebbeck* | *Fabaceae* | *Albizia* | Albízia, coração-de-negro, faveiro | Asia | Established | Medicinal | | Seeds, Leaves | | 4 | | 2 |
| UGS_5 | *Anacardium occidentale* | *Anacardiaceae* | *Anacardium* | Cajueiro, cashew | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark, Sap | | 4 | | |
| UGS_5 | *Anadenanthera macrocarpa* | *Fabaceae* | *Anadenanthera* | Angico vermelho | Brazil | Native | Medicinal | | Fruit, Bark, Sap | | 5 | | |
| UGS_5 | *Caryota urens* | *Arecaceae* | *Caryota* | Pameira Rabo de peixe, Jaggery palm | Asia | Non-native | Medicinal | | Leaves, Flower, Sap | | 1 | | 1 |
| UGS_5 | *Clusia fluminensis* | *Clusiaceae* | *Clusia* | Autograph tree,Clúsia, Mangue-da-praia | Brazil | Native | Ornamental | | | | | | 1 |
| UGS_5 | *Coccoloba uvifera* | *Polygonaceae* | *Coccoloba* | Sea grape | Tropical America, Caribbean | Non-native | Medicinal | | Fruit, Seeds, Leaves, Bark, Roots | | 1 | | |
| UGS_5 | *Curatella americana* | *Dilleniaceae* | *Curatella* | Wild cashew, sambaíba, sandpaper tree | Central America, South America | Native | Medicinal | | Leaves | | 1 | | |
| UGS_5 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | 3 | | 2 |
| UGS_5 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 2 | | 2 |
| UGS_5 | *Dypsis decaryi* | *Arecaceae* | *Dypsis* | Triangle palm | Madagascar | Non-native | Ornamental | | | | | | 4 |
| UGS_5 | *Dypsis lutescens* | *Arecaceae* | *Dypsis* | Areca Bambu, golden cane palm | Madagascar | Established | Ornamental | | | | 3 | | |
| UGS_5 | *Eugenia uniflora* | *Myrtaceae* | *Eugenia* | Pitanga, Suriname cherry, Brazilian cherry | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_5 | *Euphorbia tirucalli* | *Euphorbiaceae* | *Euphorbia* | Pau-pelado, Coroa-de-cristo; Pencil tree | Africa | Non-native | Medicinal | | Stems, Sap | Toxic | 3 | | |
| UGS_5 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 5 | | 4 |
| UGS_5 | *Ficus guaraniticas* | *Moraceae* | *Ficus* | Figueira branca | South America | Native | Ornamental | | | Aggressive roots | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_5 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 2 | 1 | |
| UGS_5 | *Hymenaea stilbocarpa* | *Fabaceae* | *Hymenaea* | Jatobá-do-Cerrado | Brazil | Endemic | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 2 | | |
| UGS_5 | *Inga edulis* | *Fabaceae* | *Inga* | Ice cream-bean, Ingá | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | Aggressive roots | 1 | 1 | |
| UGS_5 | *Jacaranda micrantha* | *Bignoniaceae* | *Jacaranda* | Caroba, jacarandá-branco | South America | Native | Medicinal | | Leaves, Bark | | 1 | | |
| UGS_5 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | 8 | | |
| UGS_5 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | | | 7 |
| UGS_5 | *Malpighia emarginata* | *Malpighiaceae* | *Malpighia* | Acerola, Guarani cherry, Wild crepe myrtle | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Sap | | 1 | | |
| UGS_5 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | | | 4 |
| UGS_5 | *Mimosa spp* | *Fabaceae* | *Mimosa* | | Unknown | Unknown | Unknown | | | | | 2 | |
| UGS_5 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | | 1 | |
| UGS_5 | *Ormosia arborea* | *Fabaceae* | *Ormosia* | Tento, olho-de-cabra | Brazil | Endemic | Ecological restoration | Medicinal | Seeds | | 1 | | |
| UGS_5 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 2 | | 2 |
| UGS_5 | *Persea americana* | *Lauraceae* | *Persea* | Avocado, Abacateiro | Central America, South America | Native | Edible fruit | | | | 1 | | |
| UGS_5 | *Pinus resinosa* | *Pinaceae* | *Pinus* | Red pine | North America | Non-native | Medicinal | | Leaves, Bark | | 1 | | |
| UGS_5 | *Platycladus orientalis* | *Cupressaceae* | *Platycladus* | Chinese thuja | Asia | Non-native | Medicinal | | Leaves | | 1 | | |
| UGS_5 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | | 1 |
| UGS_5 | *Qualea grandiflora* | *Vochysiaceae* | *Qualea* | Pau terra, Clove | Brazil, Cerrado | Endemic | Medicinal | | Leaves | | 3 | | |
| UGS_5 | *Sansevieria zeylanica* | *Asparagaceae* | *Sansevieria* | Snake plany | Asia | Non-native | Medicinal | | Leaves | | 1 | | |
| UGS_5 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_5 | *Schinus molle* | *Anacardiaceae* | *Schinus* | Aroeira Salsa, Peppertree | South America | Native | Condiment | Medicinal | Fruit, Seeds, Leaves, Bark | | | | 1 |
| UGS_5 | *Spathodea campanulata* | *Bignoniaceae* | *Spathodea* | African tulip tree, mijinho, mijadeira | Africa | Established | Medicinal | | Bark | | 1 | | |
| UGS_5 | *Spondias mombin* | *Anacardiaceae* | *Spondias* | Cajá, yellow mombin, hog plum | Tropical Americas | Native | Edible fruit | Medicinal | Flower, Leaves | | 1 | | |
| UGS_5 | *Spondias purpurea* | *Anacardiaceae* | *Spondias* | Ciriguela, Spanish plum | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Sap | Falling fruits, Aggressive roots | 1 | 1 | |
| UGS_5 | *Syagrus romanzoffiana* | *Arecaceae* | *Syagrus* | Queen palm, Giriba, Jerivá | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Flower, Bark, Heart of palm | | 1 | | |
| UGS_5 | *Syzygium cumini* | *Myrtaceae* | *Syzygium* | Java Plum, Jambolão, Jamelão | India | Established | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark | | 1 | | |
| UGS_5 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | 3 | 1 | |
| UGS_5 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 5 | 2 | |
| UGS_5 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 2 | | 2 |
| UGS_5 | *Thunbergia laurifolia* | *Acanthaceae* | *Thunbergia* | Blue trumpet vine, Azulzinha, Tumbérgia-azul | India, Thailand | Invasive | Medicinal | | Leaves | | 1 | | |
| UGS_5 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | | | 1 |
| UGS_5 | *Yucca aloifolia* | *Asparagaceae* | *Yucca* | Aloe yucca | Central America, North America | Non-native | Ornamental | | Leaves | | | | 1 |
| UGS_5 | *sp 16 (Ozoroa insignis?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_5 | *sp22 (Acacia?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_6 | *Acacia mangium* | *Fabaceae* | *Acacia* | Acácia-australiana, black wattle | Australia | Established | Ornamental | | | Invasive | 1 | | |
| UGS_6 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaf, Roots | | 1 | | 6 |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_6 | *Ceiba speciosa* | *Malvaceae* | *Ceiba* | Paineira | Brazil, Bolivia | Native | Medicinal | | Bark, Sap | Trunk thorns | 6 | | |
| UGS_6 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | | 1 | |
| UGS_6 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | | | 6 |
| UGS_6 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 1 | | |
| UGS_6 | *Dracaena fragrans* | *Asparagaceae* | *Dracaena* | Dracena | Africa | Non-native | Ornamental | | | | 1 | | |
| UGS_6 | *Dypsis lutescens* | *Arecaceae* | *Dypsis* | Areca Bambu, golden cane palm | Madagascar | Established | Ornamental | | | | 6 | | |
| UGS_6 | *Eucalyptus robusta* | *Myrtaceae* | *Eucalyptus* | Eucalipto; swamp mahogany | Australia | Non-native | Medicinal | | Leaves | | 1 | 1 | |
| UGS_6 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 2 | | 7 |
| UGS_6 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | | | 1 |
| UGS_6 | *Inga edulis* | *Fabaceae* | *Inga* | Ice cream-bean, Ingá | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | Aggressive roots | 1 | 1 | |
| UGS_6 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | 1 | 5 | |
| UGS_6 | *Lagerstroemia indica* | *Lythraceae* | *Lagerstroemia* | Resedá, Crepe myrtle | Asia | Non-native | Medicinal | | Leaves | | | | 1 |
| UGS_6 | *Lagerstroemia speciosa* | *Lythraceae* | *Lagerstroemia* | Giant crepe-myrtle; pride of India | Southern Asia | Non-native | Medicinal | | Leaves | | 1 | | |
| UGS_6 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 1 | | 10 |
| UGS_6 | *Machaerium villosum* | *Fabaceae* | *Machaerium* | Jacaranda do cerrado | Brazil | Endemic | Ornamental | | | | 2 | | |
| UGS_6 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | | | 6 |
| UGS_6 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 1 | | 4 |
| UGS_6 | *Persea americana* | *Lauraceae* | *Persea* | Avocado, Abacateiro | Central America, South America | Native | Edible fruit | | | | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_6 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | | 3 | |
| UGS_6 | *Punica granatum* | *Lythraceae* | *Punica* | Pomegranate, Romã | Mediterranean | Non-native | Edible fruit | Medicinal | Fruit, Flower, Leaves, Stem | | | | 1 |
| UGS_6 | *Sapindus saponaria* | *Sapindaceae* | *Sapindus* | Saboeiro, western soapberry | Central America, South America | Native | Medicinal | | Fruit, Seeds, Bark, Roots | | 1 | | |
| UGS_6 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | 1 | | |
| UGS_6 | *Schizolobium parahyba* | *Fabaceae* | *Schizolobium* | Guapuruvu, ficheiro, Brazilian fern tree | Central America, South America | Native | Medicinal | | Leaves | Toxic | 7 | | |
| UGS_6 | *Syagrus romanzoffiana* | *Arecaceae* | *Syagrus* | Queen palm, Giriba, Jerivá | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Flower, Bark, Heart of palm | | 8 | | 1 |
| UGS_6 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | 2 | | |
| UGS_6 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 2 | | |
| UGS_6 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 1 | | 1 |
| UGS_6 | *Terminalia catappa* | *Combretaceae* | *Terminalia* | Amendoeira da India; tropical almond, Sete copas | Asia | Established | Medicinal | | Bark | | 1 | | |
| UGS_6 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | | | 1 |
| UGS_6 | *Yucca aloifolia* | *Asparagaceae* | *Yucca* | Aloe yucca | Central America, North America | Non-native | Ornamental | | Leaves | | 1 | | 3 |
| UGS_6 | *sp3 (Pistacia?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_7 | *Allamanda cathartica* | *Apocynaceae* | *Allamanda* | Alamanda, dedal-de-dama | Brazil | Native | Ornamental | | | Toxic | 2 | | |
| UGS_7 | *Anacardium occidentale* | *Anacardiaceae* | *Anacardium* | Cajueiro, cashew | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark, Sap | | | 1 | |
| UGS_7 | *Annona crassiflora* | *Annonaceae* | *Annona* | Marolo, Ariticum do Cerrado | Brazil | Native | Medicinal | | Fruit, Seeds, Leaves, Bark | | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_7 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaves, Roots | | | | 1 |
| UGS_7 | *Bismarckia nobilis* | *Arecaceae* | *Bismarckia* | Palmeira azul, Silver palm tree | Madagascar | Non-native | Ornamental | | | | 1 | | |
| UGS_7 | *Cassia ferruginea* | *Fabaceae* | *Cassia* | Chuva de ouro | Brazil | Native | Aromatic | Medicinal | Fruit, Flower, Leaves | | 1 | | |
| UGS_7 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | 7 | 3 | |
| UGS_7 | *Codiaeum variegatum* | *Euphorbiaceae* | *Codiaeum* | Croton, miracle shrub | Asia | Established | Medicinal | | Seeds | | 3 | | |
| UGS_7 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | 8 | | |
| UGS_7 | *Cymbopogon citratus* | *Poaceae* | *Cymbopogon* | Capim cidreira, capim limão, lemon grass | Asia | Established | Aromatic | Medicinal | Leaves | | 1 | | |
| UGS_7 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 1 | | |
| UGS_7 | *Dietes bicolor* | *Iridaceae* | *Dietes* | Moreia, African lilly | South Africa | Established | Ornamental | | | | 5 | | |
| UGS_7 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | 9 | | 1 |
| UGS_7 | *Dypsis lutescens* | *Arecaceae* | *Dypsis* | Areca Bambu, golden cane palm | Madagascar | Established | Ornamental | | | | 8 | | 1 |
| UGS_7 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 1 | | 4 |
| UGS_7 | *Gymnanthemum amygdalinum* | *Asteraceae* | *Gymnanthemum* | Boldo, Alumã | Tropical Africa | Established | Medicinal | | Leaves | | 1 | | |
| UGS_7 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 9 | | |
| UGS_7 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | | 1 | |
| UGS_7 | *Lagerstroemia indica* | *Lythraceae* | *Lagerstroemia* | Resedá, Crepe myrtle | Asia | Non-native | Medicinal | | Leaves | | 2 | | 1 |
| UGS_7 | *Lantana camara* | *Verbenaceae* | *Lantana* | Cambará | Central/South America, South | Native | Aromatic | Medicinal | Leaf, Flower, Bark, Roots | | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_7 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 13 | 1 | 4 |
| UGS_7 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 5 | | |
| UGS_7 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | 2 | | |
| UGS_7 | *Murraya paniculata* | *Rutaceae* | *Murraya* | Murta, dama da noite | India | Established | Edible | Medicinal | Flower, Leaves | | 6 | | |
| UGS_7 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 4 | | |
| UGS_7 | *Pinus resinosa* | *Pinaceae* | *Pinus* | Red pine | North America | Non-native | Medicinal | | Leaves, Bark | | | 1 | |
| UGS_7 | *Psidium cattleyanum* | *Myrtaceae* | *Psidium* | Araçá, Strawberry guava | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_7 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | | |
| UGS_7 | *Pterodon emarginatus* | *Fabaceae* | *Pterodon* | Sucupira | Brazil, Cerrado | Endemic | Medicinal | | Fruit, Seeds | | 3 | | |
| UGS_7 | *Schinus terebinthifolia* | *Anacardiaceae* | *Schinus* | Brazilian peppertree, aroeira | South America | Native | Condiment | Medicinal | Fruit, Seeds, Bark | | 24 | | |
| UGS_7 | *Syzygium malaccense* | *Myrtaceae* | *Syzygium* | Jambo, jambo-da-índia | Asia | Non-native | Medicinal | | Leaves, Bark | | | 1 | |
| UGS_7 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 16 | | |
| UGS_7 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 3 | | |
| UGS_7 | *Tecoma stans* | *Bignoniaceae* | *Tecoma* | Ipê de jardim, yellow elder, sinos amarelos | North America, Central America, South America | Native | Medicinal | | Leaves | | 7 | | |
| UGS_7 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | 2 | | 1 |
| UGS_7 | *Washingtonia robusta* | *Arecaceae* | *Washingtonia* | Palmeira Washingtonia | North America | Non-native | Ornamental | | | | | 1 | |
| UGS_7 | *Yucca aloifolia* | *Asparagaceae* | *Yucca* | Aloe yucca | Central America, North America | Non-native | Ornamental | | Leaves | | 3 | | 1 |
| UGS_7 | *sp15* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 12 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_8 | *Acrocomia aculeata* | *Arecaceae* | *Acrocomia* | Bocaiuva, macaúba palm | Central America, North America | Native | Edible fruit | | Fruit, Seeds | | 4 | | |
| UGS_8 | *Agave americana* | *Asparagaceae* | *Agave* | Agave, Century plant, American aloe | North America | Non-native | Medicinal | | Leaves | | 4 | | |
| UGS_8 | *Agave vivipara* | *Asparagaceae* | *Agave* | Piteira do Caribe, variegated caribbean agav | Central America, Mexico | Non-native | Medicinal | | Leaves, Flower, Stalk, Sap | | 1 | | |
| UGS_8 | *Allamanda cathartica* | *Apocynaceae* | *Allamanda* | Alamanda, dedal-de-dama | Brazil | Native | Ornamental | | | Toxic | 1 | | |
| UGS_8 | *Anacardium occidentale* | *Anacardiaceae* | *Anacardium* | Cajueiro, cashew | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark, Sap | | 1 | | |
| UGS_8 | *Bougainvillea spectabilis* | *Nyctaginaceae* | *Bougainvillea* | Primavera, buganvília, paper flower | Brazil | Native | Medicinal | | | | | | 1 |
| UGS_8 | *Bowdichia virgilioides* | *Fabaceae* | *Bowdichia* | Sucupira preta, tatabu | Brazil | Native | Medicinal | | Seeds | | 1 | | |
| UGS_8 | *Caesalpinia pluviosa* | *Fabaceae* | *Caesalpinia* | Sibipiruna, momoqui | Brazil | Native | Ecological restoration | Medicinal | Bark, Branches | | 2 | | 4 |
| UGS_8 | *Campomanesia adamantium* | *Myrtaceae* | *Campomanesia* | Guavira, gabiroba | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_8 | *Caryota urens* | *Arecaceae* | *Caryota* | Pameira Rabo de peixe, Jaggery palm | Asia | Non-native | Medicinal | | Leaves, Flower, Sap | | | | 6 |
| UGS_8 | *Cedrela fissilis* | *Meliaceae* | *Cedrela* | Cedro Rosa, Acaju-catinga | Brazil | Native | Ecological restoration | Medicinal | Leaves | | 2 | | |
| UGS_8 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | 2 | | |
| UGS_8 | *Citrus × sinensis* | *Rutaceae* | *Citrus* | Sweet orange, laranja | Asia | Established | Edible fruit | Medicinal | Fruit, Leaves | | 2 | | |
| UGS_8 | *Citrus bigaradia* | *Rutaceae* | *Citrus* | Limão-rosa, mandarin-lime, bitter orange | Asia | Established | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_8 | *Clitoria fairchildiana* | *Fabaceae* | *Clitoria* | Pigeonwings, Sombreiro, sombra-de-vaca | Brazil | Native | Medicinal | | Petals | | 3 | | |
| UGS_8 | *Clusia fluminensis* | *Clusiaceae* | *Clusia* | Autograph tree,Clúsia, Mangue-da-praia | Brazil | Native | Ornamental | | | | | | 1 |
| UGS_8 | *Coleus barbatus* | *Lamiaceae* | *Coleus* | False Boldo, boldo brasileiro | India | Non-native | Ornamental | | | | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_8 | *Cordyline terminalis* | *Asparagaceae* | *Cordyline* | Dracena Vermelha | Asia | Non-native | Ornamental | | | | 1 | | |
| UGS_8 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | | | 8 |
| UGS_8 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 2 | | |
| UGS_8 | *Dipteryx alata* | *Fabaceae* | *Dipteryx* | Cumbaru, Baru | Brazil | Endemic | Medicinal | | Fruit, Bark, Seeds | | 2 | | |
| UGS_8 | *Dracaena trifasciata* | *Asparagaceae* | *Dracaena* | Espada de São Jorge, mother-in-law's tongue | Africa | Non-native | Ornamental | | | | 4 | | |
| UGS_8 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | | | 5 |
| UGS_8 | *Dypsis lutescens* | *Arecaceae* | *Dypsis* | Areca Bambu, golden cane palm | Madagascar | Established | Ornamental | | | | | | 5 |
| UGS_8 | *Enterolobium contortisiliquum* | *Fabaceae* | *Enterolobium* | Earpod tree, Ximbuva, Timburi | Brazil | Native | Medicinal | | Fruit, Bark, Roots | Aggressive roots | 1 | | |
| UGS_8 | *Eugenia uniflora* | *Myrtaceae* | *Eugenia* | Pitanga, Suriname cherry, Brazilian cherry | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 2 | | |
| UGS_8 | *Euphorbia milii* | *Euphorbiaceae* | *Euphorbia* | Coroa de Cristo, crown of thorns | Madagascar | Non-native | Medicinal | | Leaves | Toxic, Thorns | 1 | | |
| UGS_8 | *Euphorbia tirucalli* | *Euphorbiaceae* | *Euphorbia* | Pau-pelado, Coroa-de-cristo; Pencil tree | Africa | Non-native | Medicinal | | Stems, Sap | Toxic | 1 | | |
| UGS_8 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | 5 | | 2 |
| UGS_8 | *Ficus rubiginosa* | *Moraceae* | *Ficus* | Figueira, rusty fig | Australia | Non-native | Medicinal | | Leaves | Aggressive roots | 1 | | |
| UGS_8 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 3 | | |
| UGS_8 | *Inga edulis* | *Fabaceae* | *Inga* | Ice cream-bean, Ingá | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | Aggressive roots | 4 | | |
| UGS_8 | *Inga laurina* | *Fabaceae* | *Inga* | Ingá branco, ingá-mirim | Latin America | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_8 | *Iris spp* | *Iridaceae* | *Iris* | Iris, Fleur-de-Lys, Sword lily | Unknown | Unknown | Ornamental | | | | 1 | | |
| UGS_8 | *Ixora chinensis* | *Rubiaceae* | *Ixora* | Ixora Chineza, Chinese ixora | China | Non-native | Medicinal | | Flower | | | | 4 |
| UGS_8 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | 2 | | |
| UGS_8 | *Lagerstroemia indica* | *Lythraceae* | *Lagerstroemia* | Resedá, Crepe myrtle | Asia | Non-native | Medicinal | | Leaves | | | | 2 |
| UGS_8 | *Leptolobium dasycarpum* | *Fabaceae* | *Leptolobium* | Perobinha, pau-para-tudo | South America | Native | Medicinal | | Bark | | 1 | | |
| UGS_8 | *Leucaena leucocephala* | *Fabaceae* | *Leucaena* | River tamarind, árvore-do-conflito, leucena | North America, Central America | Invasive | Edible | | Pulp | | 1 | | |
| UGS_8 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 1 | | 6 |
| UGS_8 | *Malpighia emarginata* | *Malpighiaceae* | *Malpighia* | Acerola, Guarani cherry, Wild crepe myrtle | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Sap | | 5 | | |
| UGS_8 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 4 | | |
| UGS_8 | *Michelia champaca* | *Magnoliaceae* | *Michelia* | Magnolia amarela, champak | India | Non-native | Aromatic | Cosmetics | Flower | | 3 | | |
| UGS_8 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | 3 | | |
| UGS_8 | *Opuntia cochenillifera* | *Cactaceae* | *Opuntia* | Palma, Cochineal cactus | Mexico | Established | Medicinal | | Leaves | | 1 | | |
| UGS_8 | *Ormosia arborea* | *Fabaceae* | *Ormosia* | Tento, olho-de-cabra | Brazil | Endemic | Ecological restoration | Medicinal | Seeds | | | 1 | |
| UGS_8 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 1 | | 1 |
| UGS_8 | *Pereskia grandifolia* | *Lauraceae* | *Pereskia* | Ora-pro-nóbis | Brazil | Native | Edible | | Leaves | | 4 | | |
| UGS_8 | *Persea americana* | *Lauraceae* | *Persea* | Avocado, Abacateiro | Central America, South America | Native | Edible fruit | | | | 1 | | |
| UGS_8 | *Plumeria rubra* | *Apocynaceae* | *Plumeria* | Plumeria, Jasmim-manga | Latin America, Central America | Established | Aromatic | Medicinal, Ritualistic | Flower, Leaves, Sap | Toxic, Allergenic | 2 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_8 | *Psidium cattleyanum* | *Myrtaceae* | *Psidium* | Araçá, Strawberry guava | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_8 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 5 | | |
| UGS_8 | *Roystonea regia* | *Arecaceae* | *Roystonea* | Cuban royal palm | Central America | Established | Ornamental | | | | | | 2 |
| UGS_8 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | | | |
| UGS_8 | *Stryphnodendron adstringens* | *Fabaceae* | *Stryphnodendron* | Barbatimão | Brazil | Endemic | Cosmetics | Medicinal | Bark | | 1 | | |
| UGS_8 | *Syagrus romanzoffiana* | *Arecaceae* | *Syagrus* | Queen palm, Giriba, Jerivá | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Flower, Bark, Heart of palm | | 3 | | |
| UGS_8 | *Syzygium cumini* | *Myrtaceae* | *Syzygium* | Java Plum, Jambolão, Jamelão | India | Established | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark | | 6 | | |
| UGS_8 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | 3 | | |
| UGS_8 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 16 | | 2 |
| UGS_8 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | | 1 | |
| UGS_8 | *Terminalia catappa* | *Combretaceae* | *Terminalia* | Amendoeira da India; tropical almond, Sete copas | Asia | Established | Medicinal | | Bark | | | 1 | 2 |
| UGS_8 | *Thevetia peruviana* | *Apocynaceae* | *Thevetia* | Chapéu-de-Napoleão; Thevetia | Central America | Non-native | Medicinal | | Fruit, Leaves | | 1 | | |
| UGS_8 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | | | 6 |
| UGS_8 | *Yucca elephantipes* | *Asparagaceae* | *Yucca* | Yuca | Mexico | Non-native | Ornamental | | | | 3 | | |
| UGS_8 | *sp 42* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_8 | *sp 52* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | 1 | |
| UGS_8 | *sp11* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_8 | *sp49* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_8 | *sp50* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 2 | | |
| UGS_8 | *sp9 (Palm?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | 1 | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_9 | *Agave americana* | *Asparagaceae* | *Agave* | Agave, Century plant, American aloe | North America | Non-native | Medicinal | | Leaves | | | | 1 |
| UGS_9 | *Albizia lebbeck* | *Fabaceae* | *Albizia* | Albízia, coração-de-negro, faveiro | Asia | Established | Medicinal | | Seeds, Leaves | | | 1 | |
| UGS_9 | *Anacardium occidentale* | *Anacardiaceae* | *Anacardium* | Cajueiro, cashew | Brazil | Native | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark, Sap | | 1 | | |
| UGS_9 | *Anadenanthera colubrina* | *Fabaceae* | *Anadenanthera* | Angico Branco, vilca, Mamica-de-porca | Central America, South America | Native | Medicinal | | Bark, Sap | | 2 | | |
| UGS_9 | *Annona dioica* | *Annonaceae* | *Annona* | Marolinho, araticum-do-Cerrado | Brazil | Endemic | Edible fruit | | Fruit | | 1 | | |
| UGS_9 | *Annona muricata* | *Annonaceae* | *Annona* | Graviola, soursop | Central America | Non-native | Edible fruit | Medicinal | Fruit, Leaves | | 4 | | |
| UGS_9 | *Araucaria angustifolia* | *Araucariaceae* | *Araucaria* | Pinhão, Pinheiro-do-paraná | Brazil | Native | Edible fruit | Medicinal | Leaves, Seeds, Bark, Sap | | 1 | | |
| UGS_9 | *Bauhinia variegata* | *Fabaceae* | *Bauhinia* | Orchid tree, Pata-de-vaca | Asia | Established | Medicinal | | Flower, Leaves, Roots | | 2 | 1 | |
| UGS_9 | *Bowdichia virgilioides* | *Fabaceae* | *Bowdichia* | Sucupira preta, tatabu | Brazil | Native | Medicinal | | Seeds | | 1 | | |
| UGS_9 | *Caryota urens* | *Arecaceae* | *Caryota* | Pameira Rabo de peixe, Jaggery palm | Asia | Non-native | Medicinal | | Leaves, Flower, Sap | | | | 1 |
| UGS_9 | *Cassia ferruginea* | *Fabaceae* | *Cassia* | Chuva de ouro | Brazil | Endemic | Ornamental | | | | 1 | | |
| UGS_9 | *Cinnamomum verum* | *Lauraceae* | *Cinnamomum* | Canela, true cinnamon | Sri Lanka | Non-native | Condiment | Medicinal | Bark | | 1 | | |
| UGS_9 | *Citrus × latifolia* | *Rutaceae* | *Citrus* | Limão-taiti | Tahiti | Established | Edible fruit | Medicinal | Fruit | Thorns | 3 | | |
| UGS_9 | *Citrus bigaradia* | *Rutaceae* | *Citrus* | Limão-rosa, mandarin-lime, bitter orange | Asia | Established | Edible fruit | Medicinal | Fruit, Leaves | | 1 | | |
| UGS_9 | *Codiaeum variegatum* | *Euphorbiaceae* | *Codiaeum* | Croton, miracle shrub | Asia | Established | Medicinal | | Seeds | | | 1 | |
| UGS_9 | *Coleus barbatus* | *Lamiaceae* | *Coleus* | False Boldo, boldo brasileiro | India | Non-native | Ornamental | | | | 1 | | |
| UGS_9 | *Croton urucurana* | *Euphorbiaceae* | *Croton* | Sagra d'água | Brazil | Native | Medicinal | | Leaves | | 1 | | |
| UGS_9 | *Cycas revoluta* | *Cycadaceae* | *Cycas* | Cica, Palma sago, Oliba | Japan | Non-native | Medicinal | | Fruit, Leaves, Seeds, Shoots | Toxic | | | 8 |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_9 | *Delonix regia* | *Fabaceae* | *Delonix* | Flamboyant, peacock tree | Madagascar | Established | Medicinal | | Flower, Fruit,Seeds, Bark | Aggressive roots, Low branches | 2 | | 2 |
| UGS_9 | *Dracaena trifasciata* | *Asparagaceae* | *Dracaena* | Espada de São Jorge, mother-in-law's tongue | Africa | Non-native | Ornamental | | | | 1 | | |
| UGS_9 | *Duranta erecta* | *Verbenaceae* | *Duranta* | Brazilian skyflower, duranta, Pingo de ouro | Central America, South America | Native | Medicinal | | | | | | 22 |
| UGS_9 | *Dypsis lutescens* | *Arecaceae* | *Dypsis* | Areca Bambu, golden cane palm | Madagascar | Established | Ornamental | | | | 1 | | |
| UGS_9 | *Elaeocarpus serratus* | *Elaeocarpaceae* | *Elaeocarpus* | Azeitona de ceilão | Asia | Non-native | Medicinal | | Leaves | | 1 | | |
| UGS_9 | *Enterolobium contortisiliquum* | *Fabaceae* | *Enterolobium* | Earpod tree, Ximbuva, Timburi | Brazil | Native | Medicinal | | Fruit, Bark, Roots | Aggressive roots | 1 | | |
| UGS_9 | *Eugenia uniflora* | *Myrtaceae* | *Eugenia* | Pitanga, Suriname cherry, Brazilian cherry | South America | Native | Edible fruit | Medicinal | Fruit, Leaves | | 4 | | |
| UGS_9 | *Euphorbia milii* | *Euphorbiaceae* | *Euphorbia* | Coroa de Cristo, crown of thorns | Madagascar | Non-native | Medicinal | | Leaves | Toxic, Thorns | | | 1 |
| UGS_9 | *Euphorbia tirucalli* | *Euphorbiaceae* | *Euphorbia* | Pau-pelado, Coroa-de-cristo; Pencil tree | Africa | Non-native | Medicinal | | Stems, Sap | Toxic | 1 | | |
| UGS_9 | *Ficus benjamina* | *Moraceae* | *Ficus* | Weeping fig, figueira | Asia | Non-native | Medicinal | | Fruit | Aggressive roots | | | 5 |
| UGS_9 | *Ficus rubiginosa* | *Moraceae* | *Ficus* | Figueira, rusty fig | Australia | Non-native | Medicinal | | Leaves | Aggressive roots | | 1 | |
| UGS_9 | *Grevillea banksii* | *Proteaceae* | *Grevillea* | Grevilha-anã, Dwarf silky oak | Australia | Non-native | Ornamental | | | Toxic, Allergenic | | | 5 |
| UGS_9 | *Handroanthus ochraceus* | *Bignoniaceae* | *Handroanthus* | Ipê amarelo do cerrado | South America, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 5 | | |
| UGS_9 | *Hymenaea stilbocarpa* | *Fabaceae* | *Hymenaea* | Jatobá-do-Cerrado | Brazil | Endemic | Edible fruit | Medicinal | Fruit, Leaves, Bark | | 1 | | |
| UGS_9 | *Inga edulis* | *Fabaceae* | *Inga* | Ice cream-bean, Ingá | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | Aggressive roots | 2 | | |
| UGS_9 | *Inga laurina* | *Fabaceae* | *Inga* | Ingá branco, ingá-mirim | Latin America | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 6 | | |
| UGS_9 | *Ixora chinensis* | *Rubiaceae* | *Ixora* | Ixora Chineza, Chinese ixora | China | Non-native | Medicinal | | Flower | | | | 9 |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_9 | *Jacaranda mimosifolia* | *Bignoniaceae* | *Jacaranda* | Jacaranda, Fern tree, Jacarandá mimoso | Brazil | Native | Medicinal | | Leaves, Flower, Bark, Roots | | 1 | | |
| UGS_9 | *Juniperus chinensis* | *Cupressaceae* | *Juniperus* | Pinheiro kaizuka | China | Non-native | Medicinal | | Berry | | | | 2 |
| UGS_9 | *Leptolobium dasycarpum* | *Fabaceae* | *Leptolobium* | Perobinha, pau-para-tudo | South America | Native | Medicinal | | Bark | | 6 | | |
| UGS_9 | *Licania tomentosa* | *Chrysobalanaceae* | *Licania* | Oiti | Brazil | Native | Edible fruit | Medicinal | Fruit | Aggressive roots | 1 | | 6 |
| UGS_9 | *Mabea nitida* | *Euphorbiaceae* | *Mabea* | Seringaí, Taquari | Brazil | Endemic | Ornamental | | | | | 2 | |
| UGS_9 | *Machaerium villosum* | *Fabaceae* | *Machaerium* | Jacaranda do cerrado | Brazil | Endemic | Ornamental | | | | 5 | | |
| UGS_9 | *Mangifera indica* | *Anacardiaceae* | *Mangifera* | Mango, Mangueira | India | Established | Edible fruit | Medicinal | Fruit, Bark, Flower | Falling fruits, Aggressive roots | 13 | | |
| UGS_9 | *Michelia champaca* | *Magnoliaceae* | *Michelia* | Magnolia amarela, champak | India | Non-native | Aromatic | Cosmetics | Flower | | | | 1 |
| UGS_9 | *Morus rubra* | *Moraceae* | *Morus* | Amora, Mulberry | North America | Non-native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Roots | | 2 | | |
| UGS_9 | *Murraya paniculata* | *Rutaceae* | *Murraya* | Murta, dama da noite | India | Established | Edible | Medicinal | Flower, Leaves | | 1 | | 5 |
| UGS_9 | *Pachira aquatica* | *Malvaceae* | *Pachira* | Munguba, Cacau-selvagem | South America | Native | Edible fruit | | Seeds | | 4 | | 1 |
| UGS_9 | *Paubrasilia echinata* | *Fabaceae* | *Paubrasilia* | Pau-Brasil | Brazil | Endemic | Ecological restoration | Medicinal | Bark | | | 1 | |
| UGS_9 | *Peltophorum dubium* | *Fabaceae* | *Peltophorum* | Canafístula, Angico-amarelo | South America | Native | Ecological restoration | | | | 1 | | |
| UGS_9 | *Persea americana* | *Lauraceae* | *Persea* | Avocado, Abacateiro | Central America, South America | Native | Edible fruit | | | | 1 | 1 | 1 |
| UGS_9 | *Plinia cauliflora* | *Myrtaceae* | *Plinia* | Jaboticaba, Brazilian grapetree | Brazil | Endemic | Edible fruit | | Fruit | | 1 | | |
| UGS_9 | *Plumeria pudica* | *Apocynaceae* | *Plumeria* | Jasmim do Caribe, Véu de Noiva, Bridal Bouquet | Central America | Non-native | Ornamental | | | Toxic, Allergenic | 1 | | |
| UGS_9 | *Plumeria rubra* | *Apocynaceae* | *Plumeria* | Plumeria, Jasmim-manga | Latin America, Central America | Established | Aromatic | Medicinal, Ritualistic | Flower, Leaves, Sap | Toxic, Allergenic | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_9 | *Psidium guajava* | *Myrtaceae* | *Psidium* | Guava, Goiaba | Central America, South America | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark | | | 4 | |
| UGS_9 | *Roystonea regia* | *Arecaceae* | *Roystonea* | Cuban royal palm | Central America | Established | Ornamental | | | | 1 | | |
| UGS_9 | *Schefflera spp* | *Araliaceae* | *Schefflera* | Octopus tree | Unknown | Unknown | Unknown | | | | 9 | 5 | |
| UGS_9 | *Schinus terebinthifolia* | *Anacardiaceae* | *Schinus* | Brazilian peppertree, aroeira | South America | Native | Condiment | Medicinal | Fruit, Seeds, Bark | | 1 | | |
| UGS_9 | *Schizolobium parahyba* | *Fabaceae* | *Schizolobium* | Guapuruvu, ficheiro, Brazilian fern tree | Central America, South America | Native | Medicinal | | Leaves | Toxic | | 3 | |
| UGS_9 | *Spondias dulcis* | *Anacardiaceae* | *Spondias* | Cajá-manga | Oceania | Non-native | Edible fruit | Medicinal | Fruit | | | 1 | |
| UGS_9 | *Spondias purpurea* | *Anacardiaceae* | *Spondias* | Ciriguela, Spanish plum | Brazil | Native | Edible fruit | Medicinal | Fruit, Leaves, Bark, Sap | Falling fruits, Aggressive roots | 1 | 1 | |
| UGS_9 | *Strelitzia reginae* | *Strelitziaceae* | *Strelitzia* | Bird of paradise, crane flower | Sout Africa | Non-native | Ornamental | | | | | | 1 |
| UGS_9 | *Syzygium cumini* | *Myrtaceae* | *Syzygium* | Java Plum, Jambolão, Jamelão | India | Established | Edible fruit | Medicinal | Fruit, Seeds, Leaves, Bark | | 1 | | |
| UGS_9 | *Tabebuia heptaphylla* | *Bignoniaceae* | *Tabebuia* | Pink trumpet tree, Ipê Roxo | South America | Native | Medicinal | | Leaves | | | 1 | |
| UGS_9 | *Tabebuia rosea* | *Bignoniaceae* | *Tabebuia* | Ipê rosa | Central America, South America | Native | Medicinal | | Flower, Leaves, Roots | | 6 | 5 | 1 |
| UGS_9 | *Tabebuia roseoalba* | *Bignoniaceae* | *Tabebuia* | White ipê, Ipê-branco | Brazil, Cerrado, Pantanal | Endemic | Medicinal | | Bark | | 4 | 3 | |
| UGS_9 | *Tecoma stans* | *Bignoniaceae* | *Tecoma* | Ipê de jardim, yellow elder, sinos amarelos | North America, Central America, South America | Native | Medicinal | | Leaves | | | | 1 |
| UGS_9 | *Terminalia catappa* | *Combretaceae* | *Terminalia* | Amendoeira da India; tropical almond, Sete copas | Asia | Established | Medicinal | | Bark | | | | 1 |
| UGS_9 | *Thevetia peruviana* | *Apocynaceae* | *Thevetia* | Chapéu-de-Napoleão; Thevetia | Central America | Non-native | Medicinal | | Fruit, Leaves | | 1 | | |

| UGS | Scientific name | Family | Genus | Common name (EN and/or PT) | Native range | Situation | Unique value | Other values | Usable parts | Threats | N. Adults | N. Young | Sidewalk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGS_9 | *Tibouchina granulosa* | *Melastomataceae* | *Tibouchina* | Quaresmeira roxa | Brazil | Endemic | Medicinal | | Leaves | | | | 2 |
| UGS_9 | *Vitex montevidensis* | *Lamiaceae* | *Vitex* | Tarumã, azeitona do mato | Brazil | Native | Edible fruit | Ecological restoration | Fruit | | 1 | | |
| UGS_9 | *Yucca elephantipes* | *Asparagaceae* | *Yucca* | Yuca | Mexico | Non-native | Ornamental | | | | 4 | | |
| UGS_9 | *sp 69* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 2 | | |
| UGS_9 | *sp10* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 2 | | |
| UGS_9 | *sp15* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_9 | *sp55* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | 1 | | |
| UGS_9 | *sp61 (Tamarind?)* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | 1 | |
| UGS_9 | *sp66* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | 1 | |
| UGS_9 | *sp68* | *Unidentified* | *Unidentified* | | Unidentified | Unidentified | Unidentified | | | | | 1 | |

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