[https://doi.org/10.21814/jus.5383]

Journal UMinho Science
Vol [03] | [2024]

[2975-951X]

ARTICLE

Studying Floristic Composition for the Conservation of Parque das Camélias (Braga Municipality) Biodiversity

BÁRBARA LAGES[a], ANA CASTRO[a], RENATO HENRIQUES[b], ANTÓNIO TEIXEIRA[a]*, HERNÂNI GERÓS[a]*

[a] CENTRE OF MOLECULAR AND ENVIRONMENTAL BIOLOGY, DEPARTMENT OF BIOLOGY, UNIVERSITY OF MINHO, GUALTAR CAMPUS, 4710-057, BRAGA, PORTUGAL
[b] INSTITUTE OF EARTH SCIENCES, DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF MINHO, GUALTAR CAMPUS, 4710-057, BRAGA, PORTUGAL

*Corresponding authors: antonio.teixeira@bio.uminho.pt; geros@bio.uminho.pt

Cite current issue: Bárbara Lages, Ana Castro, Renato Henriques, António Teixeira, Hernâni Gerós, “Studying Floristic Composition for the Conservation of Parque das Camélias (Braga Municipality) Biodiversity”, Journal UMinho Science, vol. [3] | [2024], 03-2024, [https://doi.org/10.21814/jus.5383].

RECEIVED: 2023-10-16
ACCEPTED: 2023-10-29
PUBLISHED: 2024-03-25

ABSTRACT

The conservation of biodiversity and the understanding of its distribution patterns play a crucial role in promoting effective land management. The present study aimed to identify herbaceous species in *Parque Urbano das Camélias* located in the city of Braga. The research was conducted as part of an ongoing collaboration between the School of Sciences at the University of Minho and the Municipal Council of Braga. The site was sampled using the quadrant method, employing a 1

m^2 measurement, to encompass 12 strategically selected locations throughout the park. The findings encompassed 28 distinct specimens, with identification achieved at the genus level for 27 and at the species level for 25. The study area harbors both native species from mainland Portugal and exotic species, with the Poaceae family being predominant, accounting for 50% of the identified individuals. Some of the species identified in the park include *Avena* spp., *Bromus madritensis*, and *Plantago lanceolata*. The study discusses preservation strategies and biodiversity enhancement for the *Parque Urbano das Camélias*.

KEYWORDS: Biodiversity, Conservation strategies, Floristic composition, Parque das Camélias.

1. INTRODUCTION

On 15 November 2022, the world population officially reached a significant milestone of eight billion people, whereas it was only 11 years ago that the mark of seven billion was reached [1]. The rise has been linked to an increased demand for resources, food, and energy [2], [3], leading to a growing pressure on the planet's natural resources and contributing to climate change. The corresponding alterations in Earth's surface and atmospheric composition present significant risks to humans and natural systems [4].

Urban areas are becoming the everyday environment for the majority of the global population [5]. Currently, in Portugal, about 67.9% of the population live in urban areas, a figure that is projected to increase to 71.4% in 2030 [6]. The continuous growth of urban areas, both in number and size, requires an increased demand for resources and energy, thus posing challenges to the well-being of the population [5] and serious barriers to public health [7] . Heat islands are defined by higher temperatures occurring in specific urban areas, resulting in increased thermal sensation and discomfort [8].

Making cities more eco-efficient, self-sustainable and resilient is a top priority, which involves reducing the carbon footprint through the utilization of renewable energy, implementing efficient waste recycling strategies, managing traffic and other related measures [2], [9]. In this regard, the ability of cities to supply ecosystem services stands for an increasingly important challenge [10] and the concept of smart cities has emerged, which integrates new technologies such as artificial intelligence (AI) in order to mitigate the problems generated by the population pressure in cities [11]. Within the framework of the Arqus European University Alliance, which unites nine comprehensive research universities deeply engaged in medium-sized cities (Granada, Graz, Leipzig, Lyon, Maynooth, Braga - UMinho, Padua, Vilnius and Wroclaw), top priority is given to Urban Twin (Climate – Digital/AI) Transition initiatives. These initiatives are achieved through a collection of "Arqus Living Labs" acting as a catalyst for innovative solutions to address Climate Change & Sustainable Development, AI & Digital Transformation.

In urban areas, most of the population engage with nature by enjoying parks and green areas within cities (Norton *et al*., 2016), resulting in a higher quality of life [12]. In a social dimension, they allow citizens to interact with nature as a form of leisure and promoting physical and mental health [12], [13]. In addition, economic benefits derive from attracting tourists, which include job creation and cost reduction related to pollution [12], [13]. From an environmental perspective, these sites serve as heat mitigation areas by increasing albedo and evapotranspiration, providing a cooling sensation. In parallel, they act as biodiversity reservoirs, serving as habitats that contribute to air and water purification, wind and noise filtration, thereby creating a healthier microclimate [13].

Human activities contribute to the fragmentation and destruction of natural ecosystems, facilitate the introduction of non-native species, and degrade and alter ecosystem processes, leading to a reduction in the diversity of the natural landscape [2], [5]. In this context, it becomes imperative to seek solutions for the re-naturalisation of green areas within urban environments, with one of the most significant strategies being the utilization of native species. Native species are better adapted to local conditions due to their characteristics [14]. However, studies have shown that the market offers a limited quantity and quality of native seeds [15], [16], which has hindered the success of ecosystem restoration projects.

Based on the 2021 Census [17], the Municipality of Braga was one of the few in the country to show an increase in resident population, culminating in increased urbanistic pressure. According to the Land Use and Occupancy Chart, Braga council had approximately 68% of green surfaces, equivalent to 12476 hectares of land (Land Occupancy Monitoring [18] (Figure 1).

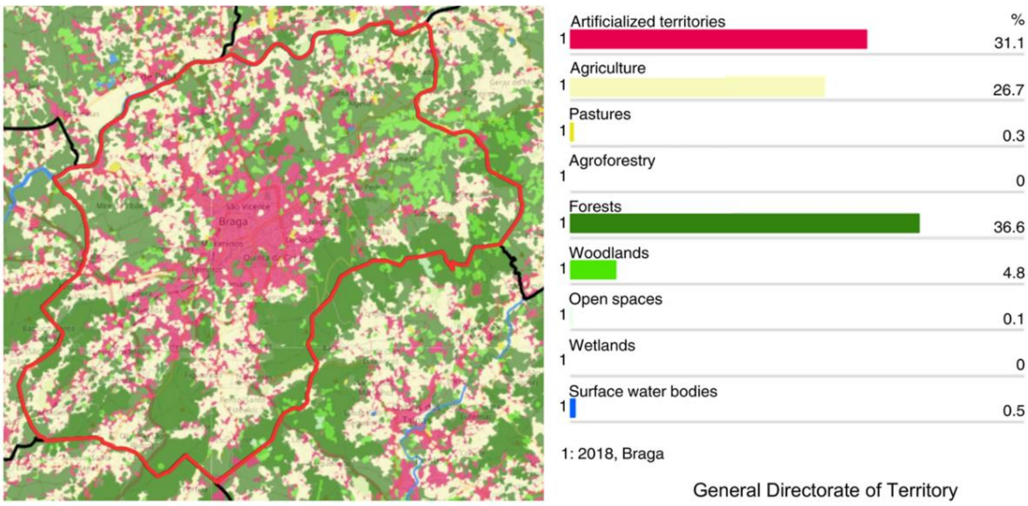

Figure 1 — Land Use and Occupation Chart (COScid) for the Braga Council, delimited by a line in red, in 2018, with the corresponding color legend. As shown, there is a greater artificialized area in the central area of the Council.

Currently, the municipality of Braga presents fifty-three zones of green areas [19]. In collaboration with the Braga City Council, this project involved conducting a floristic survey of the herbaceous species in the *Parque Urbano das Camélias*. The main goal was to implement conservation strategies for the plant species and, as part of a larger initiative in partnership with the BioCampus group of

UMinho, to promote the significance of urban parks and wild flora for the environment and quality of life through environmental education. The current study aligns with the context of Arqus Urban Twin (Climate – Digital/AI) Transition initiatives and the goals of the Interreg Sudoe project "Fleurs Locales" (https://fleurslocales.eu/en/home-eng/). The project aimed to explore strategies for the restoration of biodiversity using native species in diverse biogeographical regions of the southwestern Europe.

2. MATERIALS AND METHODS

2.1. Study area

The floristic survey project focused on the study area of *Parque Urbano das Camélia*s, situated in the municipality of Braga, in the north-western region of mainland Portugal. (41.5379087, -8.4233527). This region is characterised by a temperate climate with Mediterranean characteristics and with Atlantic influence with rainy winter and dry and not very hot summers, having well-defined seasons, with a relative humidity of 80% due to the humid air masses [20]. The climatological normals for Braga for the daily average air temperature is 15°C and the average total precipitation amount is 1452.1 mm [21]. The site totals approximately 2.5 hectares. The area of interest, in turn, is separated into two zones due to the existence of a school in the centre, but they are connected to each other (Figure 2).

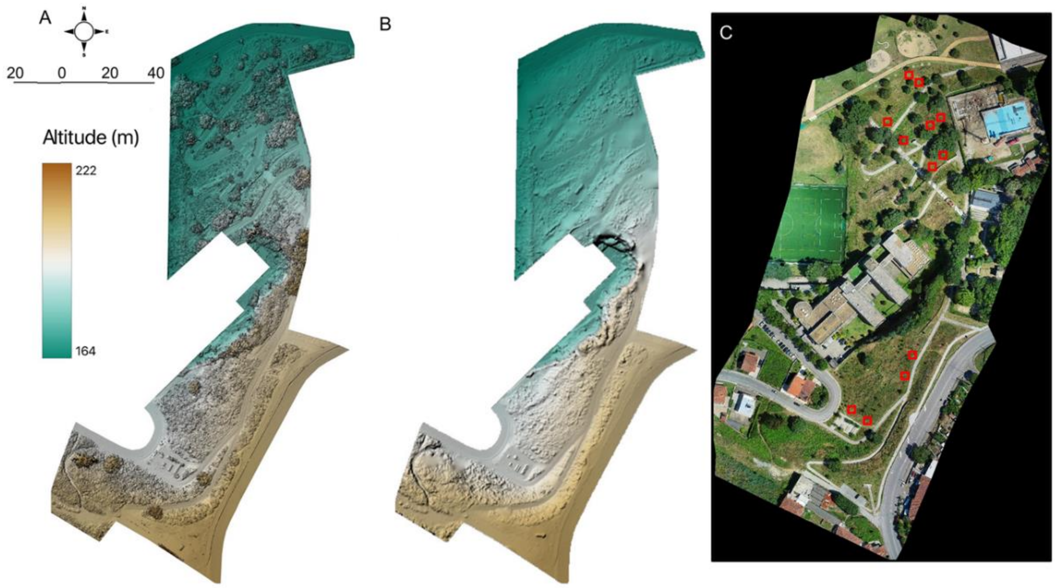

Figure 2 — Digital surface model (MDS) and digital terrain model (DTM) and aerial photograph of the *Parque Urbano das Camélias (*A, B and C respectively). Sampling points used in the floristic survey are indicate as red squares.

2.2. Experimental design

The park was mapped using aerial photography obtained with an unmanned aerial vehicle (UAV), model Phantom 4 RTK. The coordinates of the crucial point of each photograph were calibrated using GNSS-RTK, using the GNSS RENEP national differential positioning network. The antenna used for this calculation was the RENEP antenna in Braga, which baseline distance was about 1.5 kilometres to the study area. The flight plan was made with the MapPilot application, using a 75% frontal and lateral overlap on the photographs. The flight altitude was 60 metres above the topographic surface. A flight pattern parallel to the topographic surface was drawn up, with the drone's altitude conditioned by NASA's SRTM model (with a ground sampling distance of 30m/pixel). This type of flight ensures a consistent ground sampling distance throughout the surveyed area. The average flight speed was 4.4 m/s. A total of 151 photographs were taken, covering an area of approximately 5.14 ha. The obtained images were processed using the photogrammetry software Agisoft Metashape 2.0.2, obtaining an RGB orthomosaic, with a ground sampling distance (GSD) of 1.5cm/pixel, and a digital surface model (DSM) with the same GSD of the orthomosaic. These two products provide the exact coordinates, including the vegetation canopy and the surrounding area, as well as a set of morphological parameters of the terrain, such as altimetry and slope. The obtained images were visualised and analysed using the open-source Geographic Information System (GIS) QGIS, version 3.28.

A dense point cloud was also obtained using photogrammetric processing. The point cloud was classified to detect the points that correspond to the topographic surface. These points were then interpolated to obtain the digital terrain model (DTM). Bearing in mind that the difference between the DTM and the DSM in the study area is fundamentally due to undergrowth and tree vegetation, both were subtracted to detect the tree patches and their respective height (Figure 2A, B).

Given the characteristics of the terrain and the uniformity in habitats, the quadrant method (1 x 1 m) was used for the floristic survey. The study took place during spring (May 2023), when most species are in flowering time. Twelve representative locations of the park were selected: sunny and shadow zones influenced by distinct characteristics (zones with the presence of trees or zones mainly dominated by herbaceous species) (Figure 2C). In each selected location, specimens in the quadrant were counted and identified up to the genus level and, when possible, up to the species level. Species were identified using online identification platforms and herbaria ["BioDiversity4All"(https://www.biodiversity4all.org/); "Flora-on" (https://flora-on.pt/); "UTAD Botanical Garden" (https://jb.utad.pt/)] and dichotomous keys like "Flora Iberica" (Castroviejo, S. (1986-2012). Finally, photographs were taken of all specimens and samples were collected to posterior identification confirmation. The results were treated using Microsoft Excel (Microsoft Corporation) and R (version 4.2.2).

3. RESULTS

3.1. Study area, terrain morphology and vegetation height

The study area is characterised by lowland vegetation, with some native tree species, such as cork oaks, stone pines, strawberry trees and also some exotic and invasive species of *Acacea* sp. and

Ailanthus sp. Positioned as a leisure zone in the city centre, it experiences a daily influx of visitors, who inadvertently contribute to the degradation of its ecological balance. Trampling, pollution, the presence of pets and the proximity of a busy road that borders the park are among the notable stressors this natural enclave contends with.

The digital terrain model (DTM) primarily focuses on the natural terrain, providing elevation and slope information, while digital surface model (DSM) encompasses all above-ground features, offering a comprehensive view of topographic surface and vegetation canopy (Figure 2A and B). Based on the DTM analysis, the study area has a minimum altitude of 164 metres and a maximum altitude of approximately 210.5 metres (Figure 2A and B). The slope analysis results reveal a prevalent northwest orientation, with most slopes facing the west and north quadrants (Figure S1). A low-resolution 3d visualisation of the study area is available at the following link: https://sketchfab.com/models/55bc4808a60a4cfc9ca84d5b944fe409/embed.

To determine the presence and height of vegetation, including both herbaceous and arboreal species, the Digital Surface Model (DSM) was subtracted from the Digital Terrain Model (DTM). The resulting images in Figure S2A and B illustrate that the park is a diverse mix of herbaceous plants and trees, providing a characterization of the study area with a combination of understory and open field features as observed above.

3.2· Accumulation curve of the species in the twelve surveyed plots

In the present study, the accumulation curve method was employed to evaluate both the effectiveness of the sampling efforts and the species richness of a habitat. Figure 3 shows the accumulated number of sampled specimens in the plots and the relative abundance of the total families identified. It is evident that the number of distinct specimens increases as the number of samplings increases, reaching a plateau phase at the 12th sampling. Therefore, subsequent samplings are unlikely to yield a significant increase in newly identified species and twelve samplings were considered sufficient to characterize the diversity of the herbaceous species present.

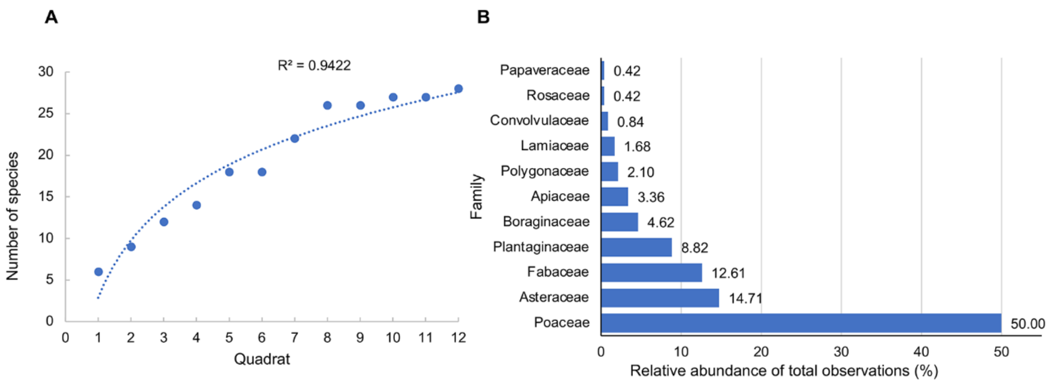

Figure 3 — Accumulation curve of the species in the plots during the floristic survey of *Parque Urbano das Camélias* (A), and abundance of the total families identified (B). Taxa were used up to the maximum level of identification.

3.3. Species richness of *Parque das Camélias*

The floristic survey identified a total of twenty-four plant species, twenty-five genus and eleven families (Table 1, Figures 3 and 4). Approximately ninety species, including *Sanicula europaea*, *Geranium rotundifolium*, and *Digitaria sanguinalis* among others, have the potential to be found in the municipality of Braga and *Parque das Camélias*. This is based on data from the Flora-On database (2023) due to their association with meadows, prairies, and lawns. Species from Poaceae were by far the most abundant in *Parque das Camélias*. Indeed, this family represents 50% of the total observations in the park, followed by Asteraceae with 15%. In turn, Poaceae was the family with most species identified (8), followed by the Fabaceae (4) and the Asteraceae (3). Among the species analysed, Mentha suaveolens stand out as one of the most economically important. It has been used in traditional medicine such as in essential oils on cases of cough, nausea, anorexia, bronchitis, digestion problems, influenza, rheumatism, skin diseases and irritation. It can also act as an analgesic, anti-inflammatory, antifungal, antihypertensive, antioxidant, among others [22], [23].

Table 1 — Taxa identified in the *Parque Urbano das Camélias*.

Family	Genus	Species
Apiaceae	*Daucus*	*D. carota*
	Foeniculum	*F. vulgare*
Asteraceae	*Chamaemelum*	*C. mixtum*
	Coleostephus	*C. myconis*
	Tolpis	*T. barbata*
Boraginaceae	*Echium*	*E. rosulatum*
Convolvulaceae	*Calystegia*	*C. silvatica*
Fabaceae	*Cytisus*	-
	Lotus	*L. castellanus*
	Ornithopus	-
	Trifolium	*T. pratense*
		T. sylvaticum
	Ulex	*U. minor*
Lamiaceae	*Mentha*	*M. suaveolens*
Papaveraceae	*Papaver*	*P. dubium*
Plantaginaceae	*Plantago*	*P. lanceolata*
Poaceae	*Avena*	-
	Briza	*B. maxima*
		B. minor
	Bromus	*B. madritensis*
	Cynosurus	*C. echinatus*
	Dactylis	*D. glomerata*
	Gastridium	*G. ventricosum*
	Hordeum	*H. murinum*
	Lolium	*L. perenne*

Polygonaceae	*Rumex*	*R. obtusifolius*
Rosaceae	*Rosa*	*R. canina*

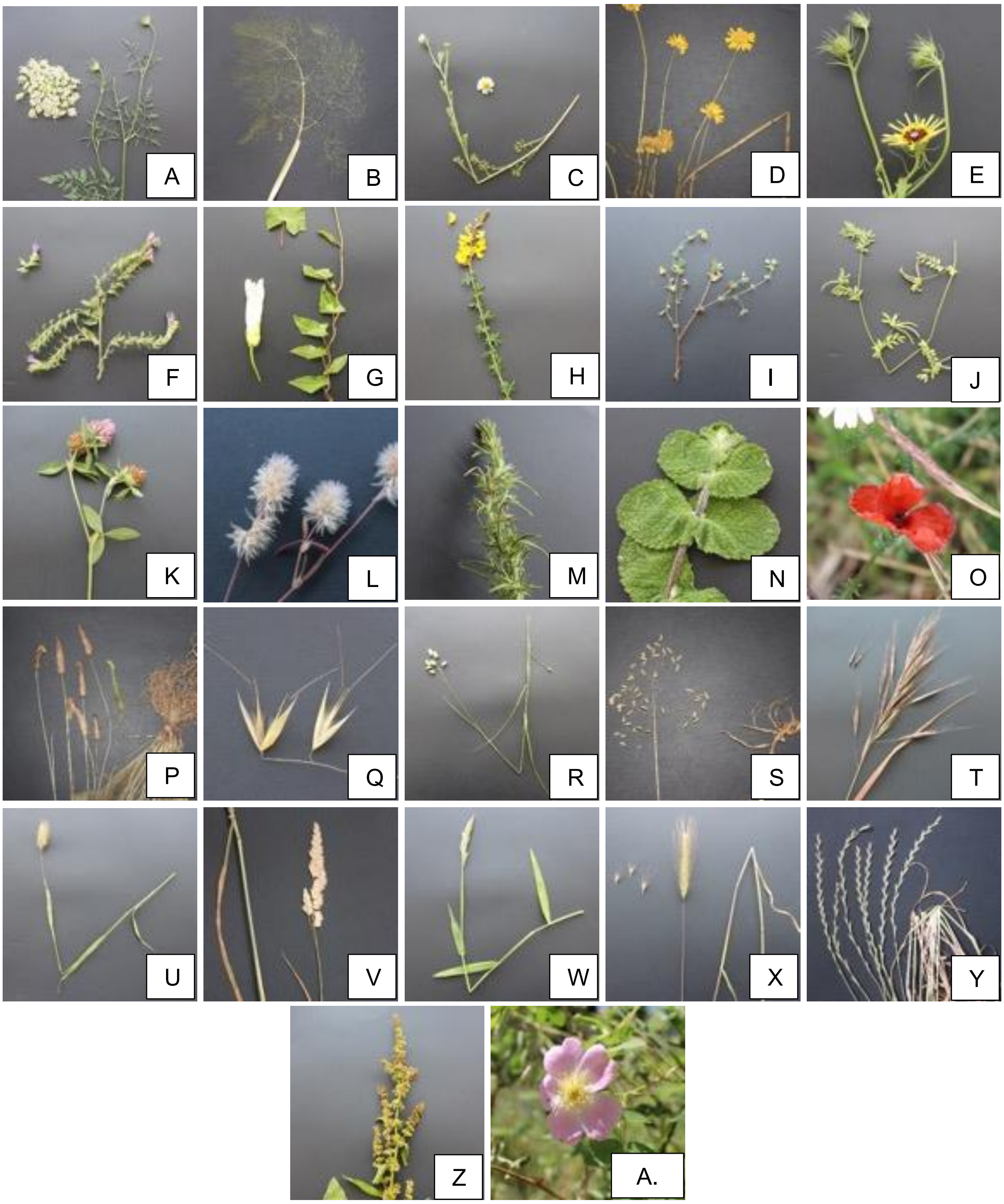

Figure 4 — Species identified in Parque Urbano das Camélias. A, *Daucus carota*; B, *Foeniculum vulgare*; C, *Chamaemelum mixtum*; D, *Coleostephus myconis*; E, *Tolpis barbata*; F, *Echium rosulatum*; G, *Calystegia silvatica*; H, *Cytisus spp.*; I, *Lotus castellanus*; J, *Ornithopus spp.*; K, *Trifolium pratense*; L, *Trifolium sylvaticum*; M, *Ulex minor*; N, *Mentha suaveolens*; O, *Papaver dubium*; P, *Plantago lanceolata*; Q, *Avena spp.*; R, *Briza maxima*; S, *Briza minor*; T, *Bromus madritensis*; U, *Cynosurus echinatus*; V, *Dactylis glomerata*; W, *Gastridium ventricosum*; X, *Hordeum murinum*; Y, *Lolium perenne*; Z, *Rumex obtusifolius*; A, *Rosa canina*.

3.4. Comparing species composition between understory and open field surveyed zones

The Principal Coordinate Analysis (PCoA) showed a dissimilarity between the species composition of "understory" surveyed zones when compared to open field surveyed zones (Figure 5A). For example, *Foeniculum vulgare*, *Trifolium pratense* or *Briza minor* exhibited a preference for "understory" zones while *Bromus madritensis*, *Ordeum murinum* or *Rumex obtusifolius* exhibited a preference for open field zones. Species as *Tolpis barbata*, *Calystegia silvatica* or *Lolium perenne* showed a similar distribution among both zones (Figure 5A). Open field zones exhibited the presence of ten out of the eleven identified plant families (excluding Papaveraceae), whereas shadowed zones only contained eight (excluding Asteraceae, Boraginaceae, and Lamiaceae) (Figure 5B). Convolvulaceae was nearly absent in sunny zones, in contrast to shadowed ones where it showed a relative abundance of 12%.

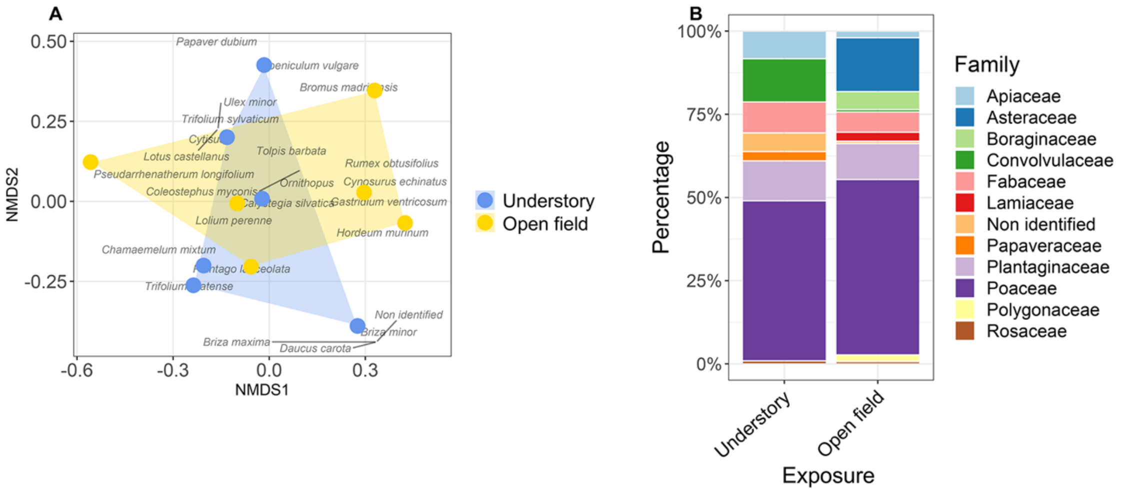

Figure 5 — Principal Coordinate Analysis (PCoa) of the floristic survey (A). Barplots showing the relative abundance of each family by surveyed zone (B).

4. DISCUSSION

4.1. Increase efforts are needed to preserve floral diversity in *Parque das Camélias*

To date some municipalities have made efforts to inventory and re-naturalise Urban Parks, however, the available results are still few in number. *Parque das Camélias* underwent a requalification project in 2021, involving modifications to access points and a transformation of its vegetative cover. Invasive species were eliminated and controlled, and the area was re-naturalized with careful consideration of the chosen herbaceous plant species, ensuring they were well-suited to the local environment, taking into account factors such as exposure, slope, altitude, soil type, climate, and incorporating aesthetic and functional parameters. Furthermore, a low maintenance approach was adopted, designed to reduce ongoing costs (*Parque Urbano das Camélias* – Laboratório para EMAAC: *Projecto de Execução*, 2018) [24]. The strategic placement of these plants played a pivotal role in stabilizing the soil, preventing erosion, fostering consolidation and depth, and contributing to the mitigation of urban heat, thus enhancing the overall quality of the environment. Another illustrative example is the project aimed at conducting an inventory and characterization of the flora of the municipality of Lousada, spanning across 9600 hectares [25]. The studies allowed the identification of 358 species, belonging to 248 genera and 86 families inserted in five distinct plant communities: eucalyptus production stands, hardwood forests, riparian vegetation patches, bushes, chasmophytic vegetation, acacia, ruderal vegetation, and agriculture [25]. In a different study within Aveiro's industrial district, an in-depth characterization was carried out on the expansion area belonging to EURO-YSER company, covering approximately 2.3 hectares. It was observed that the green areas on this site have largely arisen through anthropogenic activities, with the majority of spontaneous flora species being ruderal and cosmopolitan in nature [26]. In this industrial area, 30 genera were sampled, of which only 24 species were identified, distributed among 17 families. The predominant families in the study area are the Asteraceae, Poaceae and Fabaceae. Comparing these results with those obtained in the Parque Urbano das Camélias, it is evident that both have an equivalent number of identified species and share similarities in terms of the predominant families. Note that while high levels of urbanisation tend to reduce species richness, moderate levels of urbanisation produce different patterns of species diversity across various taxonomic groups [27]. Although the site under investigation in this study underwent a requalification process that contributed to an increase in biodiversity within the park, our findings underscore the need for further efforts to enhance floristic diversity and to implement strategies aimed at countering mechanisms that threaten the loss of existing diversity.

4.2. Poaceae predominate in the *Parque das Camélias*

The Poaceae family is one of the largest angiosperm families presenting an annual or perennial life cycle [28]. As already said, the results showed that this family predominates in Parque Urbano das Camélias (Figure 5). Most of the grass species identified are annuals, thus they are characterized by having a short and fast life cycle when compared to perennial plants with a longer life cycle [29]. Therefore, it is possible that in the initial sowing phase, the floristic composition was quite diverse, however, the stability of these communities is transitory, so it is expected the dominance by two or three more competitive species in the near future. By managing to thrive, the grasses end up competing for resources and space with the remaining plants, mainly perennials (such as *Mentha suaveolens*, *Echium rosulatum* and *Rosa canina*). This process leads to a reduction in the heterogeneity of local communities [30]. Another reason for the predominance of poaceae relies on the absence of competitors such as herbivores. In a recent study two different ways of herbaceous maintenance were compared: i) by the presence of herbivores (cattle) and ii) by annual thinning, compared to a control situation without any kind of intervention [30]. The results showed that in the sites with herbivory small annual plants predominated, while in the thinning sites perennial species and some small annuals prevailed. The control sites were dominated by tall perennial species.

In effect, it was denoted that the presence of grazing livestock at low density, among the three forms of maintenance, was the one that most contributed to increasing the diversity of the site's plant community since it allows the reduction of plant cover, height and competitive capacity of perennial grasses through consumption and trampling, favouring the development of less competitive species, especially small annuals. However, solutions such as this are not feasible in public places such as urban parks. A meta-analysis of biodiversity benefits for grassland management showed that grazing generally had a more positive effect on the conservation value of semi-natural grasslands compared to mowing, but effect sizes were generally small to moderate for most contrasts. In addition, the effects varied across some grassland characteristics (e.g. for different grassland types), with grazing and mowing having a similar effect or mowing having a more positive effect in certain cases [31]. Therefore, the mowing of the herbaceous vegetation of Parque das Camélias by mechanical means, in order to mimic the key role of herbivores [30], [32], will create space by eliminating dense vegetation and will allow native plants to regenerate naturally. Indeed, at the time of sampling, the vegetation cover near the footpath verges was trimmed by Braga City Council gardeners to clear the passage of visitors, and on subsequent days, the verges appeared more floristic diversity. Furthermore, cutting the ground cover 5 to 10 cm from the ground has been shown to be more effective in controlling poaceae than cutting close to the ground [33]. Additionally, it has been shown that a less flush cut can be more effective the more frequently it is done [33].

4.3·Perspectives regarding UAV utilization

In this work the UAV was used to survey the terrain from the air, producing an orthomosaic, a digital surface model and a 3d model. These elements enabled the collection of morphological elements of the terrain as well as the determination of vegetation height, especially tree vegetation. It also facilitated positional validation of the sampling points.

Although the use of UAVs in this work was relatively exploratory, this type of platform could play a more important role in this type of survey. Even considering the equipment used, the use of a lower altitude flight, for example 30 m from the ground, and the use of other sensors can allow species to be visually identified and geopositioned [34]–[38]. Given the advantages of having an aerial viewpoint, the use of UAVs can also make it possible to detect floristic associations by recognizing spectral patterns from RGB images. In order to increase the usefulness of UAVs in this work, additional sensors can be used that improve the distant analysis capabilities allowed by these platforms. One example is the use of multispectral cameras that can speed up the automatic detection of species or associations of species, based on their spectral curves associated with the season. It is also possible to use LIDAR sensors which, due to the penetrability of the laser pulses through the vegetation, make it possible to stratify the surface elements of the terrain very efficiently, allowing, for example, the volume and height of plants to be measured or individual trees to be counted. An important advantage that can also be associated with these platforms is that distanced analysis makes it possible to avoid trampling plant species during survey work, which can be very important for particularly vulnerable species or in environments that are relatively inaccessible on foot.

5. CONCLUSION AND PERSPECTIVES

With the present study it was possible to inventory the floristic composition of the *Parque Urbano das Camélias*. It was concluded that with only twelve samplings the sampling effort was sufficient to identify most of the species present. The results denote additional efforts are required to enhance floristic diversity and counteract the loss of diversity in *Parque das Camélias* Furthermore, it was concluded that grasses (Poaceae family) are the most abundant herbaceous species which, in part, limits the establishment of a greater floristic diversity in the park, using the quadrant method (1 x 1 m). In this context, a strategy of controlled mechanical thinning could contribute to the increase of biodiversity in the park, given the impossibility of implementing strategies of natural preservation of biodiversity by herbivores.

Acknowledgements. We would like to express our gratitude to the Municipal Council of Braga for their essential support in facilitating the execution of this project.

Author Contributions. Bárbara Lages, Ana Castro and Renato Henriques: investigation and writing – draft preparation. António Teixeira and Hernâni Gerós: conceptualization and writing – review and editing; All the authors revised and approved the manuscript.

Conflict of Interest. The authors declare no conflict of interests.

REFERENCES

[1] United Nations Department for Economic and Social Affairs, *world population prospects 2022: summary of results*. S.l.: UNITED NATIONS, 2023. [Online]. Available: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf.

[2] M. Hajer and T. Dassen, "*Smart about cities: visualizing the challenge for 21st century urbanism*", Rotterdamnai010 publishers, 2014. [Online]. Available: https://www.researchgate.net/publication/326539234_Smart_about_Cities_-_Visualising_the_Challenge_for_21st_Century_Urbanism.

[3] Z. Nasrollahi, M. Hashemi, S. Bameri, and V. Mohamad Taghvaee, "Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model," *Environ. Dev. Sustain.*, vol. 22, pp. 1105–1122, 2020. doi: https://doi.org/10.1007/s10668-018-0237-5.

[4] S. T. Fakana, *"Causes of Climate Change: Review Article"*, 2020. [Online]. Available: https://www.researchgate.net/profile/Selemon-Fakana/publication/342452772_Causes_of_Climate_Change_Review_Article/links/5ef4ff3092851c52d6fdb650/Causes-of-Climate-Change-Review-Article.pdf.

[5] D. Haase, N. Frantzeskaki, and T. Elmqvist, "Ecosystem Services in Urban Landscapes: Practical Applications and Governance Implications," *AMBIO*, vol. 43, no. 4, pp. 407–412, May 2014, doi: 10.1007/s13280-014-0503-1.

[6] The_worlds_cities_in_2018_data_booklet.pdf'. https://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2018_data_booklet.pdf.

[7] A. Lenzi, "Why urbanisation and health?", Acta *Bio Medica Atenei Parmensis*, vol. 90, no. 2, pp. 181–183, May 2019, doi: 10.23750/abm. v90i2.8354.

[8] A.-M. Branea, A. Keller, and S. Badesc, "*CROSS/HOUSE: Sustainable Housing-Cross-Cultural Society / CEEPUS Network View project Large scale vulnerability assessment of historical area of Timisoara View project*". [Online]. Available: https://www.researchgate.net/publication/309739903.

[9] J. P. Teixeira, *"Smart cities tackling cities turning point. Quality of Space – Quality of Life: Planning for Urban Needs of diverse timeframes".* [Online]. Available: http://www.mariomoutinho.pt/images/PDFs/livror_org/2016-livro_interior_aesop_reduzido.pdf.

[10] P. Dai, S. Zhang, Z. Chen, Y. Gong, and H. Hou, "Perceptions of cultural ecosystem services in urban parks based on social network data," *Sustainability* vol. 11, 5386', 2019. doi: https://doi.org/10.3390/su11195386.

[11] H. Chourabi, T. Nam, S. Walker, J. R. Gil-Garcia, S. Mellouli, K. Nahon, T. A. Pardo, and H. J. Scholl, *"Understanding smart cities: An integrative framework"*, 2012. doi: https://doi.org/10.1109/HICSS.2012.615.

[12] A. Chiesura, "The role of urban parks for the sustainable city," *Landsc Urban Plan*, vol. 68, no. 1, pp. 129–138, May 2004, doi: 10.1016/j.landurbplan.2003.08.003.

[13] J. Breuste, D. Haase, and T. Elmqvist, "Urban landscapes and ecosystem services," *Ecosystem services in agricultural and urban landscapes*, pp. 83–104, 2013. doi: https://doi.org/10.1002/9781118506271.ch6.

[14] A. Aflaki, M. Mirnezhad, A. Ghaffarianhoseini, A. Ghaffarianhoseini, H. Omrany, Z. H. Wang, and H. Akbari, "*Urban heat island mitigation strategies: A state-of-the-art review on Kuala Lumpur, Singapore and Hong Kong".* doi: https://doi.org/10.1016/j.cities.2016.09.003.

[15] A. Mohajerani, J. Bakaric, and T. Jeffrey-Bailey, "The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete," *J. Environ. Manage.*, vol. 197, pp. 522–538, Jul. 2017, doi: 10.1016/j.jenvman.2017.03.095.

[16] K. Ward, S. Lauf, B. Kleinschmit, and W. Endlicher, "Heat waves and urban heat islands in Europe: A review of relevant drivers," *Sci. Total Environ.*, vol. 569–570, pp. 527–539, Nov. 2016, doi: 10.1016/j.scitotenv.2016.06.119.

[17] E. Aguilera *et al.*, "Agroecology for adaptation to climate change and resource depletion in the Mediterranean region. A review," *Agric. Syst.*, vol. 181, p. 102809, May 2020. doi: https://doi.org/10.1016/j.agsy.2020.102809

[18] M. De Vitis, H. Abbandonato, K. W. Dixon, G. Laverack, C. Bonomi, and S. Pedrini, "The European native seed industry: characterization and perspectives in grassland restoration", *Sustainability*, vol. 9, no. 10, p. 1682, 2017. doi: https://doi.org/10.3390/su9101682.

[19] A. Teixeira and H. Gerós, *"Restoration guidelines with native seeds",* 2021. [Online]. Available: https://fleurslocales.eu/wp-content/uploads/2022/05/State-of-the-art-Fleurs-locales-GT1.1_Eng.docx.pdf.

[20] Instituto Nacional de Estatística (2022) Censos 2021. XVI Recenseamento Geral da População. VI Recenseamento Geral da Habitação: Resultados definitivos. Lisboa: INE. [Online]. Available: https://www.ine.pt/xurl/pub/65586079'.

[21] Sistema de Monitorização da Ocupação do Solo [SMOS] (2018). [Online]. Available: https://smos.dgterritorio.gov.pt/coscid/.

[22] Câmara Municipal de Braga (2019) Guia Verde de Braga. Braga, Portugal: Câmara Municipal de Braga. [Online]. Available: https://www.cm-braga.pt/archive/doc/GUIA_VERDE_DE_BRAGA.pdf.

[23] Instituto Português Do Mar e da Atmosfera (IPMA). [Online]. Available: https://www.ipma.pt/bin/file.data/climate-normal/cn_8110_BRAGA_POSTO_AGRARIO.pdf.

[24] Instituto Português Do Mar e da Atmosfera (IPMA) (2022). Normal Climatológica-Braga / Posto agrário. In Instituto Português do Mar e da Atmosfera [IPMA]. [Online]. Available: https://www.ipma.pt/pt/index.html.

[25] M. Božović, A. Pirolli, and R. Ragno, "Mentha suaveolens Ehrh. (Lamiaceae) Essential Oil and Its Main Constituent Piperitenone Oxide: Biological Activities and Chemistry," *Molecules*, vol. 20, no. 5, pp. 8605–8633, May 2015, doi: 10.3390/molecules20058605.

[26] E.-S. A. El-Kashoury, H. I. El-Askary, Z. A. Kandil, and M. A. Salem, "Botanical and genetic characterization of Mentha suaveolens Ehrh. cultivated in Egypt," *Pharmacogn. J*, vol. 5, no. 5, pp. 228–237, 2013. doi: https://doi.org/10.1016/j.phcgj.2013.10.002.

[27] Parque Urbano das Camélias - Laboratório para a EMAAC: Projecto de Execução. (2018). Relatório Interno. Braga, Portugal.

[28] R. Marques, I. Silva, D. Alves, & R. Pinho, Lucanus - Município de Lousada. Lucanus Revista de Ambiente e Sociedade, 78–108. [Online]. Available: http://www.lucanus.cm-lousada.pt/wp-content/uploads/2017/11/2017_Lucanus_VolumeI.pdf.

[29] EURO-YSER, P. Q. S. A. (2010) Estudo de Impacte Ambiental. [Online]. Available: https://siaia.apambiente.pt/AIADOC/AIA2410/RNT2410.pdf.

[30] C. C. Rega-Brodsky, "Urban biodiversity: State of the science and future directions," *Urban. Ecosyst.*, vol. 25, no. 4, pp. 1083–1096, Aug. 2022, doi: 10.1007/s11252-022-01207-w.

[31] M. Faria, Botânica: Curso Geral dos Liceus', 1974.

[32] F. Tan and S. M. Swain, "Genetics of flower initiation and development in annual and perennial plants, "*Physiol. Plant.*, vol. 128, no. 1, pp. 8–17, Sep. 2006, doi: 10.1111/j.1399-3054.2006.00724.x.

[33] C. Moinardeau, F. Mesléard, H. Ramone, and T. Dutoit, "Short-term effects on diversity and biomass on grasslands from artificial dykes under grazing and mowing treatments, "*Environ. Conserv.*, vol. 46, no. 2, pp. 132–139, 2019. doi: https://doi.org/10.1017/S0376892918000346.

[34] M. Tälle, B. Deák, P. Poschlod, O. Valkó, L. Westerberg, and P. Milberg, "Grazing vs. mowing: A meta-analysis of biodiversity benefits for grassland management," *Agric. Ecosys.t Environ.*, vol. 222, pp. 200–212, Apr. 2016, doi: 10.1016/j.agee.2016.02.008.

[35] R. Carmona, "Banco de sementes e estabelecimento de plantas daninhas em agroecossistemas," *Planta daninha*, vol. 13, no. 1, pp. 3–9, 1995, doi: 10.1590/S0100-83581995000100001.

[36] H. Inagaki *et al.*, "Effect of Mowing Height on Dominance of Annual Poaceae Plants," *J. Ecol. Eng.*, vol. 21, no. 1, pp. 8–13, Jan. 2020, doi: 10.12911/22998993/113627.

[37] P. Mishra, & A. N. Singh, "A review on plant species identification and monitoring using unmanned aerial vehicle (UAV) imagery," *Comput. Electron. Agric.,* 2020.

[38] G. Yang *et al.*, "Unmanned Aerial Vehicle Remote Sensing for Field-Based Crop Phenotyping: Current Status and Perspectives," *Front. Plant Sci.*, vol. 8, p. 1111, Jun. 2017, doi: 10.3389/fpls.2017.01111.

[39] J. Torres-Sánchez, F. López-Granados, and J. M. Peña, "An automatic object-based method for optimal thresholding in UAV images: Application for vegetation detection in herbaceous crops, "*Comput. Electron. Agric.*, vol. 114, pp. 43–52, Jun. 2015, doi: 10.1016/j.compag.2015.03.019.

[40] R. Calderón, J. A. Navas-Cortés, C. Lucena, and P. J. Zarco-Tejada, "High-resolution airborne hyperspectral and thermal imagery for early detection of Verticillium wilt of olive using fluorescence, temperature and narrow-band spectral indices, "*Remote Sens. Environ.*, vol. 139, pp. 231–245, Dec. 2013, doi: 10.1016/j.rse.2013.07.031.

[41] L. Wallace, A. Lucieer, C. Watson, and D. Turner, "Development of a UAV-LiDAR System with Application to Forest Inventory," *Remote Sens*, vol. 4, no. 6, pp. 1519–1543, May 2012, doi: 10.3390/rs4061519.

SUPPLEMENTARY FILES

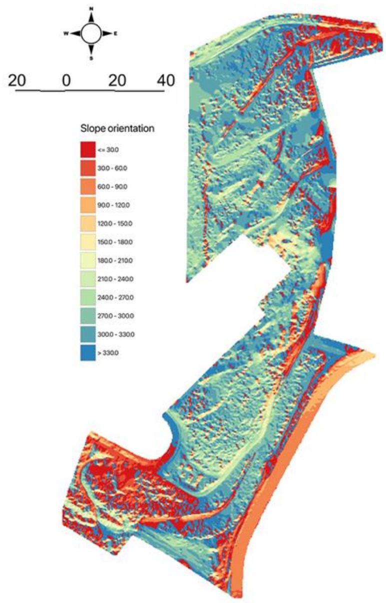

Figure S1 — *Parque Urbano das Camélias* slope orientation analysis.

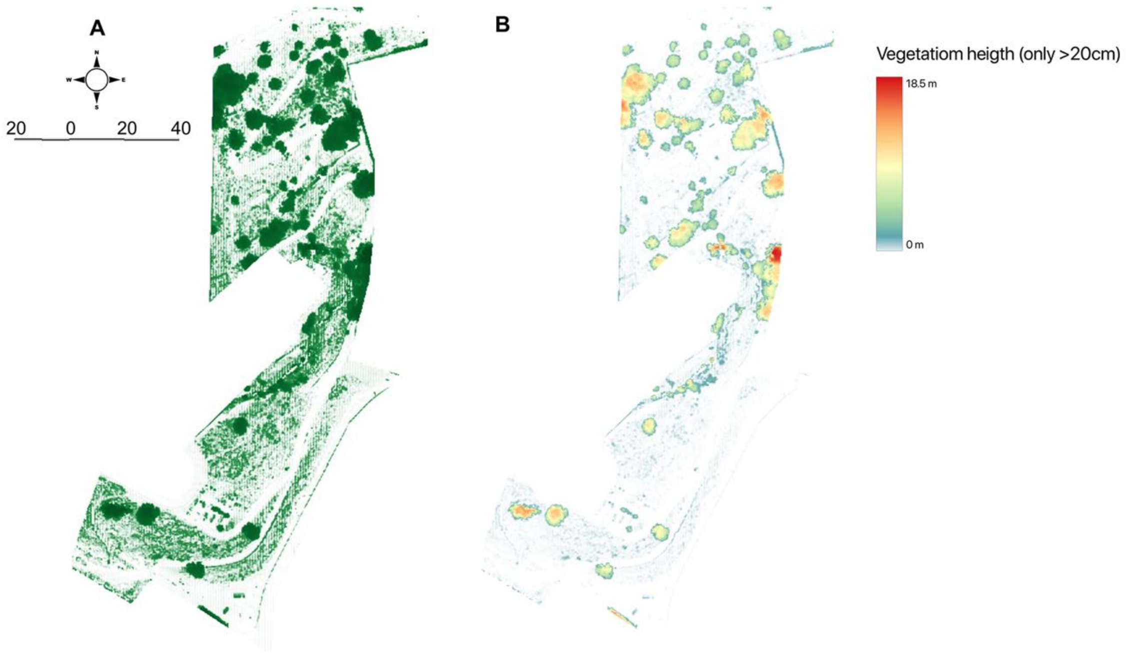

Figure S2 — *Parque Urbano das Camélias vegetation areas (**A**) and vegetation high (**B**) obtained from digital terrain model (DTM) and the digital surface model (DSM) data.*