Original Research

Urban Diversity Impact on Plant Species Due to Environmental Conditions

Asmaa Fahim[1], Qingmei Tan[1]*, Uzair Aslam Bhatti[2],
Saqib Ali Nawaz[3], Arif Hussain Kaleri[3]

[1]College of Economics and Management, Nanjing University of Aeronautics & Astronautics, Nanjing 211106, China
[2]School of Geography, Nanjing Normal University, Nanjing 210014, P.R China
[3]Hainan University, Haikou, Hainan 570208, China

Abstract

Urban parks and road greening are important components of primary gardens, and their plant communities are based on the ecology of different management and operation modes. Urban greening is the link connecting the city segment isolation green space, good road greening can not only achieve the effect of greening, beautification, but also play a role in purifying the air, reducing noise, reducing radiation heat, and protecting the road surface, to people's travel and life to create a safe, pleasant, comfortable, beautiful, and hygienic environment. In this paper, through the Karachi main road and parks greening geo-spatial survey found that it contains 32 tree species, of which 4 species of naked plants, quilt plants 28 species. Road green tree species have a low diameter level and are in their infancy. The tree species of road greening in each district are mainly trees, and the important value of trees is much higher than that of shrubs. The diversity index of green tree species in each district is low, and a few tree species in each district account for more than 50% of all trees. By measuring the light intensity, air temperature, relative humidity and wind speed of different road greening forms, the effects of different road greening forms on small climate, environmental comfort and air flow are analyzed, and the results show that the greening forms of roads with large vertical projection area on the road are the most obvious in reducing light intensity, reducing air temperature, and increasing relative humidity. Trees in the road vertical projection area of large road greening form so that the road environment is in a comfortable situation throughout the day, conducive to human health. Trees in the road above the vertical projection area of the road green form can better reduce the road near the surface temperature, but trees in the road vertical projection area of small road greening.

Keywords: aboveground biomass of trees, types of roads, roadside trees, tree diversity, non-native trees

---

*e-mail: fahim.asmaa@nuaa.edu.cn

Introduction

The road green space is laid out regularly in accordance with the basic principles of road green space design, forming a content urban road green space. An important part of the urban green space system, the road green space system constitutes the city's traffic space, and also has ecological functions such as shading, reducing life, generating oxygen, and retaining dust [1-2]. Road greening is the process of greening roads by using plants such as trees, bamboo shoots, herbs, and climbing [3]. Because of the special urban geographical environment where road green spaces are located, urban road greening is affected differently by man-made roles. The differences in the width and function of roads in their own characteristics have led to the inevitable differences in the composition and configuration of road green plants, and the vast differences in the landscape and ecological pictures of the road lead to the year of greening. The research on urban roads mainly focuses on smart features [4], plant growth characteristics [5], road green coverage rate [6], plant species composition, etc. Karachi is one of the major garden cities and has abundant natural conditions for road greening. Various researches have been conducted on the development of road greening in Karachi. These studies focused on the ecological functions of road greening plants [7-9], overall effects [10], planting patterns [11-12], community structure, etc., and from the outside, the road plants can fix carbon and release carbon. Oxygen, improving the environment, and forming life materials in different seasons are unique. The environment of plants affects the improvement of human settlements. This article investigates the main road greening tree species in the main urban area of Karachi, and analyzes and compares different road greening tree species. It provides a reference for scientifically constructing the awareness of urban path plant community, and realizing the protection and construction of urban organisms [13-15]. The quality of urban road environment greening directly affects the people's living standards [16]. At this stage, people are paying more and more attention to the greening of urban roads, and it has been further improved.

1. Problems in road greening in small and medium-sized cities

a. Road construction is out of touch with greening construction, lack of unified planning and design

Under normal circumstances, greening projects are started after road construction is completed. Road construction often lacks consideration of future road greening projects, which leads to inconsistent and inconsistent road construction and road greening, which brings a lot of greening work. The inconvenience increases the engineering difficulty and cost of the greening project [17]. For example, the road planning did not leave enough green area for the green belt. When the greening construction is completed, the expected greening effect cannot be achieved, which is neither beautiful nor practical.

b. The artistic and regional nature of the garden plant landscape is not obvious enough

Currently, there are many problems in the road greening construction in downtown Karachi. First, the greening form is simple and the landscape style is monotonous. The road tree pond is basically filled with hard materials and the green area is small. At the same time, the design of the street green belt is generally a single green landscape, such as Shahraifaisal, Guru mandar road etc. The landscape composition within the scope is simple, the plant species are monotonous, lacking a sense of hierarchy and artistic beauty. The second is because the urban road garden plant landscape is the embodiment of a city's style and features, and it should fully reflect the historical culture and unique environmental geomorphology of the landscape location. However, the road greening design of Karachi City lacks consideration of its own cultural connotation and local environment and geomorphology.

c. Lack of traffic safety considerations in road greening design

According to the relevant standards and norms of urban road greening, it can be found that the focus of road greening design includes that the layout of greening landscape should be reasonable, and the driver's vision should not be blocked; the greening design should be scientific, so as not to affect the smoothness of the road [18-19]. However, some designers lack practical experience and experience. They only pay attention to landscape greening when designing greening, and do not consider road safety. There are loopholes or mistakes in the road greening plan designed, which will leave potential safety hazards for future road operations.

d. Investment in maintenance management in the later stage, and insufficient consolidation of greening achievements

Due to the limited cost of road maintenance, road greening work lacks advanced maintenance equipment and professional staff, the road greening effect is very poor, the survival rate of vegetation is not high, lack of vitality, and branches and leaves wither occur from time to time [20]. Government departments should pay attention to greening and maintenance work, so that greening construction should be synchronized with maintenance, and fully reflect the effect of road greening.

2. Solutions for road greening

a. Make a systematic plan before construction

When designing a road greening plan, it is necessary to comprehensively consider the distribution of pipelines in the area where the road is located, design a reasonable greening landscape layout plan, and give full play to the effect of road greening [21]. For example, the root system of plants planted in areas with pipelines in the green belt is not easy to be too deep; in order to ensure the evergreen landscape of the green landscape, you can choose evergreen trees of the

conifers and cypresses as landscape trees; pay attention to the spacing of the trees, so as not to be too dense to affect plant growth; properly trim the branches and leaves of trees so as not to affect the safety of traffic and the routes in the area; in the green belt around the island, vegetation with too tall plants should not be used to avoid affecting the sight of passing drivers and avoid traffic accidents [22].

b. Design concepts that highlight individuality, characteristics, and diversity

Road landscape is the embodiment of urban style. Karachi road greening landscape design should fully excavate the well-known historical figures, historical events or folk culture of Karachi City, and design a batch of landscape designs with traditional culture as the main theme, highlighting the cultural heritage of Karachi. The road greening landscape is a full response to the characteristics and individuality of the city. Therefore, when choosing green vegetation, local vegetation should be the mainstay, and local trees, shrubs, flowers and grasses should be used to create a green landscape with rich content, bright colors, distinct layers and strong local characteristics.

c. Choose plants reasonably, pay attention to the matching of layers and colors

The purpose of road greening design is to create a composite natural landscape, which not only pays attention to the color matching and hierarchical design in the green landscape, but also pays attention to the combination of landscape plant functions, and gives full play to the ecological functions of green plants such as dust reduction, clean air, cooling and noise reduction [23]. Using artistic skills as the basis of landscape matching, fully combining the respective characteristics of different trees, shrubs, flowers and grasses, design a green landscape that can highlight the characteristics of plant colors, lines or shapes, and create urban road greening designs that conform to the trend of the times[24]. It presents unique artistic beauty throughout the year.

d. Increasing the cost standard of plant maintenance in the later stage, and consolidating the achievements of road greening.

Plant growth is inseparable from careful maintenance and irrigation. Therefore, the relevant urban greening management departments should appropriately increase the capital investment for road greening maintenance to ensure the quality of road greening work and effectively improve the spiritual outlook of the city. With the continuous improvement of people's living standards, people have higher requirements for the environment. As an important part of urban infrastructure construction, the construction of urban roads has also received much attention. This study focuses on the analysis of the biodiversity patterns along the roadside and highlights the changes in the diversity patterns of plants. Therefore, this article investigates the composition and configuration of plant species along the main streets of the metropolitan city Karachi in Pakistan, which will help in improving the quality of the diversity patterns and ecological impact of the city.

Material and Methods

Study Area

We selected the metropolitan city Karachi, which is the most populous city in Pakistan and the sixth-largest city in the world [25]. The reasons for selecting this city are the continuous development of roads and the implementation of new projects for underpasses under bridges. This study highlights the significance of diversity patterns for the government for planning the roadside tree species. Karachi is located at 24°45'N to 25°37'N and 66°42'E to 67°34'E along the coast of the Arabian Sea (Fig. 1) and it is eight meters above sea level [26]. The difference in precipitation between the driest month and the wettest month is 52 mm|2 inch. The variation in temperatures throughout the year is 10.7°C|19.3°F. The warmest month of the year is June, with an average temperature of 30.2°C|86.3°F. The lowest average temperatures in the year occur in January, when it is around 19.5°C|67.0°F. The driest month is April, with 0 mm|0.0 inch of rainfall. The greatest amount of precipitation occurs in July, with an average of 52 mm|2.0 inch (Fig. 2).

Data Collection

To examine the diversity pattern along the roads, categories of roads are divided into wide (24 m or wider), medium (12 m to 24 m wide) and narrow (less than 12 m wide) roads. The large roads of Karachi are known as the main roads and are bigger in scale than other road types. The linking roads between these large roads are medium roads.

Data Analysis

Species Diversity Data

To identify the species diversity in the plant population, the plant species diversity index was used as the most simple and succinct attribute, and the stability index was used to assess ecosystem stability [27-28]. Biodiversity can be quantified in many ways, and there are two major factors: richness (richness) and uniformity (evenness). We used indices of species diversity from Simpson and Pielou (1966). The computational formulas are clarified below.

1. Richness of species (S) refers to the number of species of trees in each systemic urban unit.
2. The Simpson Diversity Index (D) corresponds to the possibility that two consecutive samples of a population that belong to the same species derive the corresponding number of individuals:
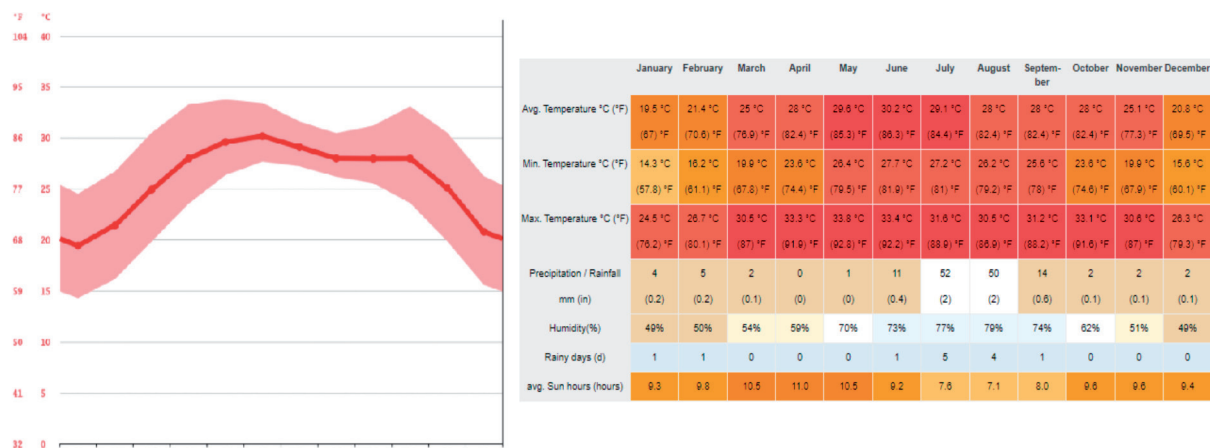
Fig. 1. Location of towns in Karachi.

Fig. 2. Environmental Factors of Karachi.

$$D = 1 - \sum_{i=1}^{n} Pi^2 \; P_i^{\,2} = \frac{n_i \, (\, n_i - 1 \,)}{N \, (\, N - 1 \,)} \qquad (1)$$

This reflects the probability that two individuals are randomly selected from the same sample, and the two individuals are from the same class. The value of N is between 0 and 1, where 0 means unlimited diversity, and 1 means no diversity; that is, the larger the D value, the lower the diversity.

3. The Pielou evenness index (J) applies to the distribution in a group or society of the number of individuals:

$$J_e' = \frac{H_e'}{H_{emax}'} \qquad (2)$$

The value of Pielou's evenness lies between 0 (no evenness) and 1 (complete evenness).

Results

Along wide roads, where the average aboveground biomass was 4.33 kg/m², much of the aboveground biomass of trees per unit area was found. The lowest tree biomass per unit area was 3.20 kg/m² along narrow roads. The second-lowest tree biomass per unit area was 3.50 kg/m² along medium roads. Conocarpus erectus had the largest number of trees and was followed by Guaiacum officinale. The native species Azadirachta indica had the largest number of trees, followed by Ficus virens. Overall, 32 non-native and 44 native specimens were found. On all path types, non-native species accounted for 79.16% and native species accounted for 20.84% of the tree population. The non-native Conocarpus erectus constituted 61.87% of the total tree population, and it was followed by Guaiacum officinale with 9.02%. The native Azadirachta indica

Table 1. Frequency of roadside tree management variables per year.

Road types	Trimming	Fertilization	Cleaning	Watering
Wide	4.12±3.42	2.23±1.45	120.33±65.12	133.95±112.32
Medium	3.32±2.21	1.88±1.10	98.24±47.48	93.34±67.54
Narrow	1.23±1.01	0.82±0.41	28.53±21.67	32.57±22.65

Table 2. Mean value of PD, MPD and MNTD of three road types in Karachi.

Road types	Non-native PD	Native PD	Non-native MPD	Native MPD	Non-native MNTD	Native MNTD
Wide	1366.51±345.88	549.75±146.86	297.41±34.50	151.77±35.97	145.16±35.68	125.81±44.12
Medium	1086.57±265.88	463.59±122.36	195.57±29.29	134.08±35.59	127.01±28.77	120.40±34.63
Narrow	836.53±165.88	320.87±104.36	184.23±31.99	126.68±32.76	110.45±33.88	109.82±24.69

Note: PD – Faith's phylogenetic diversity; MPD – phylogenetic mean pairwise distance; and MNTD – phylogenetic mean nearest taxon distance

accounted for 8.51% of the entire tree population, and it was followed by Ficus virens with 2.47%. The relative distribution of the non-native species was greater than that of the native species in the field under study. Wide roads and medium roads have optimum maintenance activities (Table 1 and Table 2).

A variety of creatures are precious treasures shared by all mankind. Biodiversity provides abundant food, medicine, fuel and other daily necessities as well as a large number of industrial raw materials for the survival and development of mankind. Biodiversity maintains the ecological balance of nature and provides good environmental conditions for human survival. Biodiversity is an indispensable part of the ecosystem. Biodiversity directly or indirectly brings many benefits to mankind. For example, it provides us with raw materials and also benefits our health. More than 60% of the world's population directly depends on plants to obtain medicinal materials. In the past century, people have transformed natural ecosystems into agricultural land and made use of biodiversity, which has benefited many. Although activities that lead to the loss of biodiversity and changes in ecosystems have benefited many people, the costs that society has to bear as a result are often greater than all benefits.

The United Nations "Convention on Biological Diversity" stated in a statement said that climate change is expected to become one of the greatest threats to biodiversity. A report issued by the United Nations Climate Group in April 2007 stated that "if the global average temperature rises by more than 1.5 to 2.5 degrees Celsius, then 20% to 30% of the animal and plant species that have been assessed may face greater challenges. The report also shows that in addition, ecosystems will face more unbearable changes. Recent climate changes, such as rising temperatures in certain areas, have already had a significant impact on biodiversity and ecosystems. Climate change affects the distribution of species, the size of the population, the time of reproduction or migration, and the frequency of outbreaks of pests and diseases. It is estimated that by 2050, climate change will cause the extinction of many species living in certain areas. By the end of this century, climate change and its effects may Will become the culprit leading to the loss of biodiversity.

The effects of the natural ecology and environment along the roadside construction also have a negative impact [29]. The damage to the radiation and surface soil along the line is one of the most significant and intuitive effects [30]. The initial stage of roadside construction will completely clear the resettlement and topsoil within the land occupation boundary. This is the most important stage of resettlement and topsoil destruction, which will cause a large amount of biomass loss and soil erosion along the line. The large area of exposed ground formed by the excavation of highway construction is not a difficulty in the reconstruction and restoration of roadside construction and will adversely affect the stability of the regional ecosystem in the future [31-32]. The local plants with parasites distributed along the highway are characterized by good landscape integration, which is of great significance for maintaining the stability of the regional ecosystem. The topsoil along the road is also a type of scarce, non-renewable, and important ecological soil surface in nature [33-35]. The basic resources of value, including the cultivated layer of cultivated land; the surface layer and humus layer of garden land, woodland, and grassland; and the content of organic matter, microorganisms, and local seeds, are most beneficial to the rapid restoration of soil fertility and plant growth [36-37]. Radiation and topsoil along the highway are an important part of the regional ecosystem. Therefore, studying the characteristics of plant species' diversity patterns and soil environmental quality along the highway is of great significance for

roadside environmental protection and green highway construction.

Conclusion

Green plants are an important component of urban roads, and their differences in species composition, growth characteristics, and configuration forms have a profound impact on the landscape value and ecological value of urban roads. The frequency of road greening tree species in Karachi is similar to that of other urban road greening tree species in the northern subtropical region. In terms of diversity index, the diversity index of the greening tree species of the roads in the main urban area of Karachi is different. This is due to the different road widths, the commercial districts where the roads are located, or the establishment of auxiliary roads due to traffic requirements and other objective reasons. The number of belt settings is different. For example, elevated greening has limited plant growth conditions due to its special layout, and the diversity of fixed elevated greening plants will be different from other regions due to the limited selection of tree species. In addition, the species diversity of the shrub layer is higher than that of the tree layer due to the road greening configuration mode and the natural morphology of trees and shrubs. For traffic convenience and smoothness, trees are mostly used for street trees. In addition, the tree canopy is large, and the growth space left between trees is much larger than that of shrubs. Therefore, the species diversity of the shrub layer is higher than that of the tree layer in the road greening design. In the composition of road greening tree species in the main urban area of Karachi, shrub species are more abundant than other species, and there are species similarities between roads; in terms of diversity index, there are many greening tree species between different roads.

Conflict of Interest

The authors declare no conflict of interest.

References

1. BELMEZITI A., CHERQUI F., KAUFMANN B. Improving the multi-functionality of urban green spaces: Relations between components of green spaces and urban services. Sustainable cities and society, **43**, 1, **2018**.

2. HONG W., GUO R., SU M., TANG H., CHEN L., HU W. Sensitivity evaluation and land-use control of urban ecological corridors: a case study of Shenzhen, China. Land Use Policy, **62**, 316, **2017**.

3. PEARLMUTTER D., THEOCHARI D., NEHLS T., PINHO P., PIRO P., KOROLOVA A., PUCHER B. Enhancing the circular economy with nature-based solutions in the built urban environment: green building materials, systems and sites. Blue-Green Systems, **2** (1), 46, **2020**.

4. PETER L.L., YANG Y. Urban planning historical review of master plans and the way towards a sustainable city: Dar es Salaam, Tanzania. Frontiers of Architectural Research, **8** (3), 359, **2019**.

5. DRONOVA I. Environmental heterogeneity as a bridge between ecosystem service and visual quality objectives in management, planning and design. Landscape and Urban Planning, **163**, 90, **2017**.

6. CAI Z., TANG Y. Toward a Sustainable City: A Scoping Review of Eco-Cities Development and Practices in China. Chinese Urban Planning and Construction, 179, **2021**.

7. CHEN Y., XU Z., BYRNE J., XU T., WANG S., WU J. Can smaller parks limit green gentrification? Insights from Hangzhou, China. Urban Forestry & Urban Greening, **59**, 127009, **2021**.

8. LI X., NI G., DEWANCKER B. Improving the attractiveness and accessibility of campus green space for developing a sustainable university environment. Environmental Science and Pollution Research, **26** (32), 33399, **2019**.

9. WANG R., ZHAO J., MEITNER M.J., HU Y., XU X. Characteristics of urban green spaces in relation to aesthetic preference and stress recovery. Urban Forestry & Urban Greening, **41**, 6, **2019**.

10. SUN Y., XIE S., ZHAO S. Valuing urban green spaces in mitigating climate change: A city-wide estimate of aboveground carbon stored in urban green spaces of China's Capital. Global change biology, **25** (5), 1717, **2019**.

11. ZHANG Z., LI J., LUO X., LI C., ZHANG L. Urban lake spatial openness and relationship with neighboring land prices: Exploratory geovisual analytics for essential policy insights. Land Use Policy, **92**, 104479, **2020**.

12. LU J., LUO X., YANG N., SHEN Y. Multiple Pathways: The Influence Mechanism of Greenspace Exposure on Mental Health – A Case Study of Hangzhou, China. Land, **10** (4), 339, **2021**.

13. ZONG H., XIONG W., LIU M. L., WANG Q., ZHANG L. Seasonal microclimate effect of Linpan settlements on the surrounding area in Chengdu Plain. Theoretical and Applied Climatology, **141** (3), 1559, **2020**.

14. NIKOLIĆ M., STEVOVIĆ S. Family Asteraceae as a sustainable planning tool in phytoremediation and its relevance in urban areas. Urban Forestry & Urban Greening, **14** (4), 782, **2015**.

15. CURRIE P. K., MUSANGO J. K., MAY N. D. Urban metabolism: A review with reference to Cape Town. Cities, **70**, 91, **2017**.

16. WOLF K. L., LAM S. T., MCKEEN J. K., RICHARDSON G. R., VAN DEN BOSCH M., BARDEKJIAN A. C. Urban trees and human health: A scoping review. International journal of environmental research and public health, **17** (12), 4371, **2020**.

17. BEDINGER M., WALKER G. H., PIECYK M., GREENING P. 21st century trucking: A trajectory for ergonomics and road freight. Applied ergonomics, **53**, 343, **2016**.

18. DONG R., ZHANG Y., ZHAO J. How green are the streets within the sixth ring road of Beijing? An analysis based on tencent street view pictures and the green view index. International journal of environmental research and public health, **15** (7), 1367, **2018**.

19. LI H., LV L., ZUO J., BARTSCH K., WANG L., XIA Q. Determinants of public satisfaction with an Urban Water

environment treatment PPP project in Xuchang, China. Sustainable Cities and Society, **60**, 102244, **2020**.

20. KELFAOUI A., REZZAZ A. M., KHERROUR L. (2021). Revitalization of mountain rural tourism as a tool for sustainable local development in Kabylie (Algeria). The case of Yakouren municipality. GeoJournal of Tourism and Geosites, **34** (1), 112, **2021**.

21. YANG J., ZHENG B. Spatial Structure Planning and Optimization Strategy of Sponge City in Coastal Area. Journal of Coastal Research, **103** (SI), 561, **2020**.

22. ZHANG S., LI Y., MA M., SONG T., SONG R. Storm water management and flood control in sponge city construction of Beijing. Water, **10** (8), 1040, **2018**.

23. ZHU X. Optimization Design of Public Space Structure in Coastal Cities Based on Interactive Design. Journal of Coastal Research, **104** (SI), 751, **2020**.

24. BARRON S., NITOSLAWSKI S., WOLF K. L., WOO A., DESAUTELS E., SHEPPARD S. R. Greening blocks: A conceptual typology of practical design interventions to integrate health and climate resilience co-benefits. International journal of environmental research and public health, **16** (21), 4241, **2019**.

25. MALIK S., ROOSLI R., TARIQ F. Investigation of informal housing challenges and issues: experiences from slum and squatter of Lahore. Journal of Housing and the Built Environment, **35** (1), 143, **2020**.

26. BUTSCH C., CHAKRABORTY S., GOMES S.L., KUMAR S., HERMANS L.M. Changing hydrosocial cycles in Periurban India. Land, **10** (3), 263, **2021**.

27. HUI G., ZHANG G., ZHAO Z., YANG A. Methods of forest structure research: A review. Current Forestry Reports, **5** (3), 142, **2019**.

28. VAN DER WALT L., CILLIERS S.S., DU TOIT M.J., KELLNER K. Conservation of fragmented grasslands as part of the urban green infrastructure: how important are species diversity, functional diversity and landscape functionality?. Urban Ecosystems, **18** (1), 87, **2015**.

29. STREETER M.T., SCHILLING K.E. Assessing and mitigating the effects of agricultural soil erosion on roadside ditches. Journal of Soils and Sediments, **20** (1), 524, **2020**.

30. DENG J., PICKLES B.J., SMITH S.T., SHAO L. Infrared radiative performance of urban trees: spatial distribution and interspecific comparison among ten species in the UK by *in-situ* spectroscopy. Building and Environment, **172**, 106682, **2020**.

31. VEPAKOMMA U., KNEESHAW D.D., DE GRANDPRÉ L. Influence of natural and anthropogenic linear canopy openings on forest structural patterns investigated using lidar. Forests, **9** (9), 540, **2018**.

32. WILLIAMS A.T., RANGEL-BUITRAGO N. Marine litter: Solutions for a major environmental problem. Journal of coastal research, **35** (3), 648, **2019**.

33. CAMPOY J.G., ACOSTA A.T., AFFRE L., BARREIRO R., BRUNDU G., BUISSON E., FAGÚNDEZ J. Monographs of invasive plants in Europe: Carpobrotus. Botany Letters, **165** (3-4), 440, **2018**.

34. ZHAO L., HOU R. Human causes of soil loss in rural karst environments: a case study of Guizhou, China. Scientific reports, **9** (1), 1, **2019**.

35. BUTENKO K.O., GONGALSKY K.B., KOROBUSHKIN D.I., EKSCHMITT K., ZAITSEV A.S. Forest fires alter the trophic structure of soil nematode communities. Soil Biology and Biochemistry, **109**, 107, **2017**.

36. CREWS T.E., RUMSEY B.E. What agriculture can learn from native ecosystems in building soil organic matter: A review. Sustainability, **9** (4), 578, **2017**.

37. SWARUP A., MANNA M.C., SINGH G.B. Impact of land use and management practices on organic carbon dynamics in soils of India. Global climate change and tropical ecosystems, 261, **2019**.