



EVALUATION OF PLANTS BASED ON ECOLOGICAL TOLERANCE CRITERIA: A CASE STUDY OF URBAN OPEN GREEN SPACES IN RIZE, TURKIYE

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ABSTRACT: In addition to aggressive urbanization, climate change and ecological challenges also have serious negative effects on urban green areas. Moreover, the selection of inappropriate plants in urban green space landscape projects increases the severity of these negatives. Therefore, inappropriate plant selection is considered a significant threat to the sustainability of urban green spaces. This situation highlights the importance of selecting plants with high ecological tolerance in urban park landscape projects. In this study, all tree, shrub, and ground cover plants identified in 11 urban parks and open green areas in Rize province were evaluated in terms of ecological tolerance criteria (air pollution, drought, wind, temperature, cold, and salinity). A total of 223 plant taxa were examined (77 native, 3 semi-native, 143 exotic), and it was determined that 149 taxa (49 native, 100 exotic) were sensitive to at least one of these criteria, while the remaining 74 taxa (27 native, 47 exotic) had sufficient tolerance to all ecological variables examined. *Prunus serrulata* Lindl. ‘Kanzan’ was identified as the taxon with the weakest ecological tolerance, and the resilience statuses of the other taxa were presented in the assessment table created. As a result, it was found that there are taxa used in Rize urban open green areas that pose risks against ecological factors, and recommendations were made for future landscape planting projects.

Keywords: Ecological tolerance, plant material, Rize.

BİTKİLERİN EKOLOJİK TOLERANS KRİTERLERİNE GÖRE DEĞERLENDİRİLMESİ: RİZE KENTSEL AÇIK YEŞİL ALANLAR ÖRNEĞİ, TÜRKİYE

ÖZET: Kentleşmeden kaynaklanan yeşil alan miktarındaki azalmaya ek olarak iklim değişikliği ve bunun neden olduğu ekolojik değişiklikler de kentsel yeşil alanlar üzerinde ciddi olumsuz etkiler oluşturmaktadır. Ayrıca, kentsel yeşil alan peyzaj projelerinde uygun olmayan bitki seçimleri de bu olumsuzlukların derecesini artırmakta ve yeşil alanların sürdürülebilirliği için önemli bir tehdit olarak görülmektedir. Bu durum yeşil alan bitkilendirme çalışmalarında ekolojik toleransı yüksek bitki seçiminin önemini ortaya koymaktadır. Bu sebeple bu çalışmada Rize ilinde bulunan 11 kent parkı ve açık yeşil alanda tespit edilen tüm ağaç, ağaççık, çalı ve yer örtücü bitkiler ekolojik tolerans kriterleri (hava kirliliği, kuraklık, rüzgar, sıcaklık, soğuk ve tuzluluk) açısından değerlendirilmiştir. Çalışmada 223 bitki taksonu incelenmiş olup (77 doğal, 3 yarı doğal, 143 egzotik) 149 taksonun (49 doğal, 100 egzotik) bu kriterlerden en az birine karşı duyarlı olduğu ve kalan 74 taksonun (27 doğal 47 egzotik) incelenen tüm ekolojik değişkenlere karşı yeterli toleransa sahip olduğu tespit edilmiştir. *Prunus serrulata* Lindl. ‘Kanzan’ ekolojik toleransı en zayıf takson olarak tespit edilmiş ve diğer taksonların dirençlilik durumları oluşturulan değerlendirme tablosunda belirtilmiştir. Sonuç olarak, Rize kentsel açık yeşil alanlarında kullanılan bitki taksonlarından ekolojik faktörlere karşı risk barındıran taksonlar olduğu tespit edilmiş, gelecekte yapılması planlanan bitkilendirme çalışmaları için önerilerde bulunulmuştur.

Anahtar kelimeler: Ekolojik tolerans, bitki materyali, Rize.

INTRODUCTION

Due to rapidly growing cities and increasing urban populations, the pressure on natural and ecological resources is steadily rising, and green spaces in cities are diminishing. In addition to the influences of intense and rapid urbanization, the negative impacts of climate change are also increasing concern in cities. Some of the most mentioned concerns are the increase of the heat island effect, air pollution, and water scarcity (Ekren, 2017; Kösa, 2023; Manoli et al., 2019; Silva et al., 2013; Zencirkıran & Sönmez, 2023). To minimize these consequences, researchers commonly highlight the significance of green infrastructure systems in cities. Past studies discussed that urban parks and other open green spaces are the most common types of green infrastructure and they play important roles in reducing the negative effects of urbanization and climate change (Jones & Somper, 2014). The commonly mentioned benefits of urban open spaces include oxygen production, improving air quality, supporting the water cycle, increasing biodiversity, providing habitats for wildlife, reducing the heat island effect, decreasing dust and noise pollution, enhancing aesthetic quality, and creating recreational areas (Çetinkaya & Uzun, 2014; Doğan & Eroğlu, 2024; Zencirkıran, 2004; Zencirkıran & Sönmez, 2023).

However, the adaptation capability of plants to ecological factors is critical for city parks to maintain a healthy life cycle, perform their functions, and deliver the abovementioned benefits effectively (Oğuztürk et al., 2023; Tanfer, 2019; Zencirkıran & Sönmez, 2023). A plant's capability to adapt to ecological characteristics is called ecological tolerance and refers to its resistance to ecologic variables such as drought, temperature, frost, and salinity (Kösa, 2023). Past research showed that these ecological variables may cause severe damage to plants at the

cellular level and directly affect their development (Bita & Gerats, 2013; Raza et al., 2020). Therefore, it is necessary to understand the ecological tolerance limits of the plants to minimize the risk of being negatively affected by these factors and to create more successful landscape designs (Doğan & Eroğlu, 2021). If they are not selected suitable to local ecological factors, they may require additional chemical fertilizer supplements and excessive water consumption. Studies showed that the excessive use of chemicals and water may negatively influence soil chemistry and cause chemical pollution, water waste, and salinity problems (Acar & Sarı, 2010; Wade et al., 2010; Zencirkıran & Sönmez, 2023). As seen globally, the effects of global warming have become more evident, and the risk of a water crisis is increasing in most parts of Türkiye. Hence, designing with plants that require minimal water consumption and are resistant to heat, frost, drought, and salinity has become essential in landscape projects. Additionally, researchers emphasize that the use of suitable plants for ecological features of the site is a more appropriate approach to reduce landscape maintenance costs, create more successful designs, and minimize the risk of project failures (Çorbacı & Özyavuz, 2024; Çorbacı & Bayramoğlu, 2021; Çorbacı et al., 2020; Oğuztürk & Bayramoğlu, 2020; Yener et al., 2020; Zencirkıran, 2009).

In this regard, research investigating the ecological tolerance of plants is important for choosing the proper taxa in the landscape design process. As a result, several studies have been conducted in different geographical regions of Türkiye to identify the ecological tolerance of plant taxa frequently used in urban parks and other open green areas. For example, Zencirkıran and Seyidoğlu Akdeniz (2017) in the city of Bursa in the Marmara Region, Zencirkıran and Sönmez (2023) in the city of Ankara in the Central Anatolia Region, and Kösa (2023) in the city of Antalya in the Mediterranean Region have examined the ecological tolerance of woody landscape plants used in various urban parks.

This study was conducted to identify the ecological resilience of plants used in urban parks and open green spaces located in the city of Rize in the Black Sea region of Türkiye.

MATERIAL AND METHOD

Different sizes of 11 parks and open green spaces in the city of Rize were chosen as study areas. The list of the plants evaluated in this study consists of the existing plant inventory in these urban areas. All trees, shrubs, bushes, and groundcover plants in the study area were included in the scope of the study. The urban open green spaces examined in the study and the number of taxa in these areas are presented in Table 1.

Table 1. Numbers of Plant Taxa by Urban Open Green Spaces Examined in The Study

No.	Urban Park / Open Green Space	Number of Taxa
1	15 July Democracy Park	35
2	Dogu Park	13
3	28 August Fetih Park	29
4	Isırlık Nature Park	64
5	Castle Park	10
6	Recep Tayyip Erdogan University Zihni Derin Campus	116
7	Sahil Mosque Park	11
8	Sahil Park/Mesut Yılmaz Park	87
9	Tanyel Park	7
10	Tuzcuoğlu Memiş Aga Park	19
11	Ziraat Botanical Park	125

The locations of the urban open and green spaces examined in the study are shown in Figure 1.

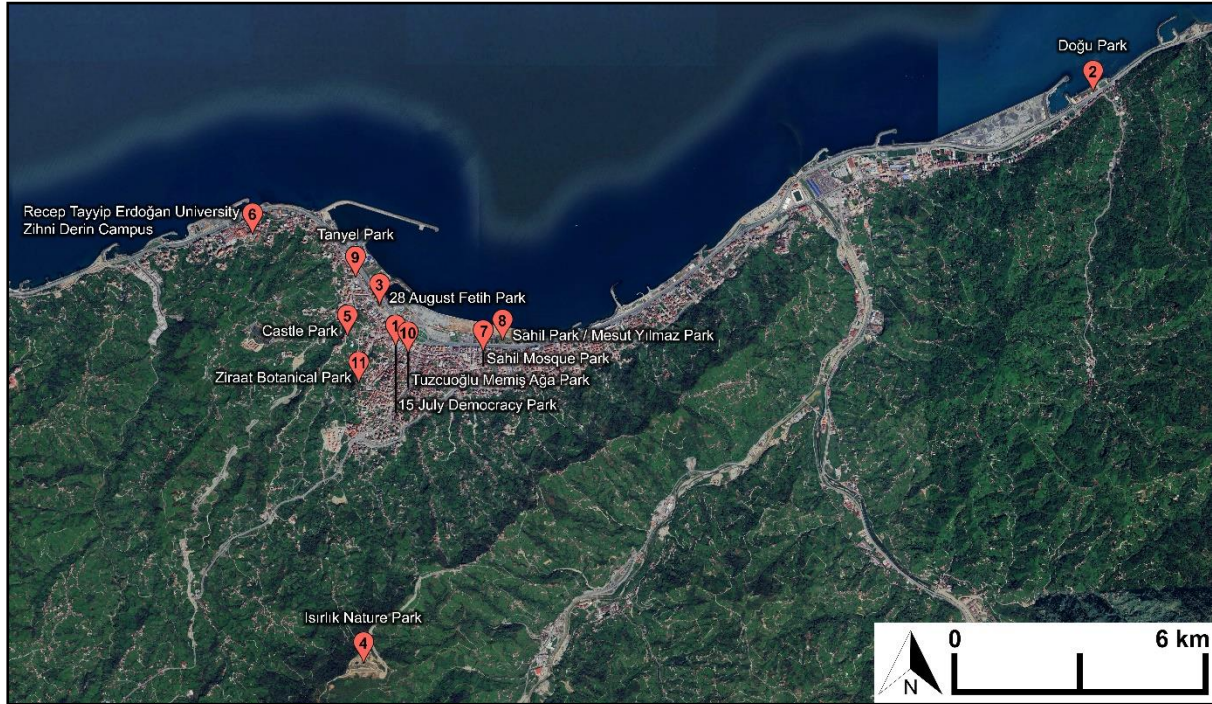


Figure 1. Location of The Study Areas (URL-1, 2024)

The climate characteristics of Rize province are cool in summer, mild in winter, and rainy in every season. According to measurements taken between 1928 and 2023, the annual average temperature is 14.5 °C, the annual average number of rainy days is 172.8, and the average total annual precipitation is 2300.0 mm (MGM, 2024). Due to its subtropical climate features, Rize can utilize not only natural plants but also many exotic ornamental plants in its urban areas. Therefore, floristic diversity is notable in urban green spaces. However, one of the main issues is that 64% of the plant taxa used in Rize's city parks are exotic/foreign species, while only 36% are native plant taxa (Çorbacı & Ekren, 2021). Rize is one of the richest provinces in terms of plant diversity in Türkiye. However, the low use of native taxa in the city parks poses a problem for ecological sustainability.

The plant taxa included in this study were identified during another study conducted by Çorbacı et al. (2019; 2020) and Çorbacı and Ekren (2021) in the urban open green spaces of Rize. The resilience of these taxa to air pollution, drought, wind, heat, cold, and salinity has been investigated using the following references (Akkemik, 2018; Appleton, 1999; AUB, 2024; Bainbridge, 2015; Bharti et al., 2018; Chen et al., 2017; Çorbacı & Ekren, 2022; Ebben Nurseries, 2024; Ganesan & Arul Pragasan, 2017; Horaginamani et al., 2012; Kösa, 2023; Mamikoğlu, 2012; NCSUE, 2024; OSU, 2024; Penick, 2016; PFAF, 2024; Rockledge Gardens, 2024; URL-2, 2024; USDA, 2024; Williams, 2013; Zencirkıran & Seyidoğlu Akdeniz, 2017; Zencirkıran & Sönmez, 2023).

Zencirkıran and Seyidoğlu Akdeniz (2017) classified the resilience of the taxa to air pollution, drought, wind, and salinity into four levels: Intolerant, Slightly Tolerant, Moderately Tolerant, and Tolerant. The same classification was used in this study. Additionally, plants' tolerance to heat and cold was examined using the "Plant Hardiness Zone Map" prepared by the United

States Department of Agriculture (USDA) and the “AHS Heat Zone Map” developed by the American Horticultural Society (AHS) (USDA, 2023; AHS, 2024). These maps were created for the United States but have been adapted to other countries based on their climatic conditions. For the study area of Rize, the “Plant Hardiness Map” and the “Plant Heat Tolerance Map” were adapted to Türkiye by the General Directorate of Meteorology of the Republic of Türkiye (MGM, 2022).

According to the maps, there are 13 plant hardiness zones, and each zone is defined by intervals of 10°F (5.6°C). Also, each zone is divided into two sub-zones, labeled "a" and "b," separated by 5°F (2.8°C). In the plant hardiness map, Zone 1a represents the coldest temperature range (-55 to -60°F or -48.3 to -51.1°C), while Zone 13b, corresponds to the warmest zone with temperatures between 65 and 70°F (18.3°C - 21.1°C). According to the General Directorate of Meteorology, the study area is located in Zone 9b (Figure 2).

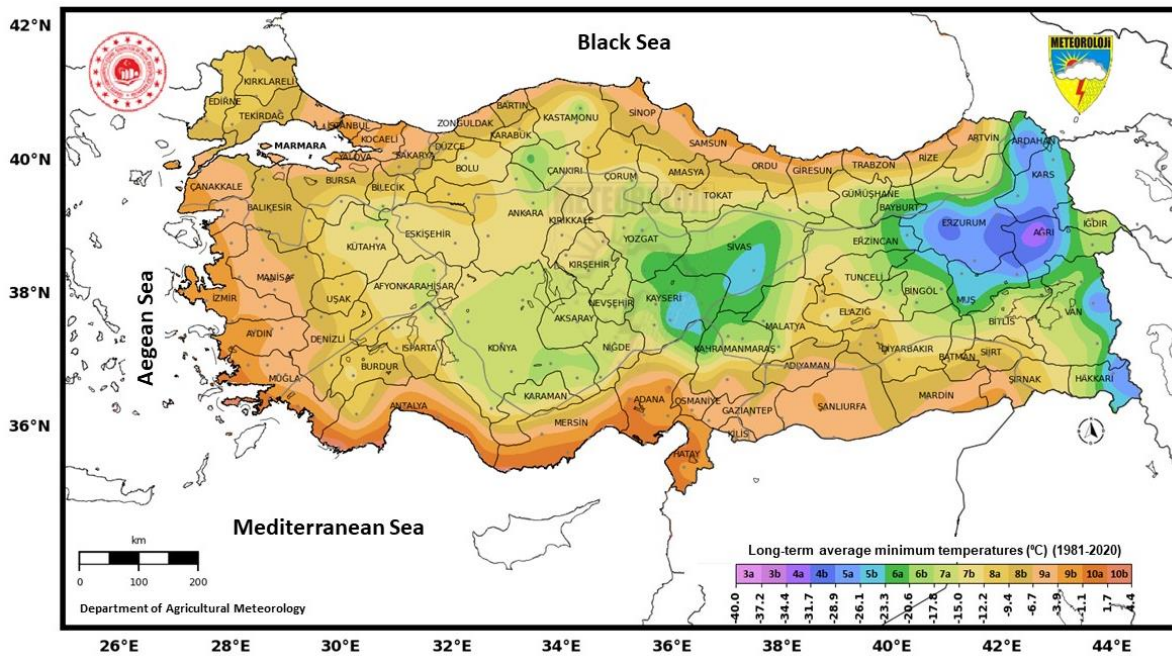


Figure 2. Plant Hardiness Map (MGM, 2022)

The heat tolerance map is created based on the long-term average number of days in which the maximum air temperature exceeds 30°C. The map consists of 12 different zones. Zone 1 represents cold areas where the annual average number of days above 30°C is less than 1, while Zone 12 represents the warmest areas with more than 210 annual average days above 30°C. The General Directorate of Meteorology locates the study area in Zone 3 (Figure 3).

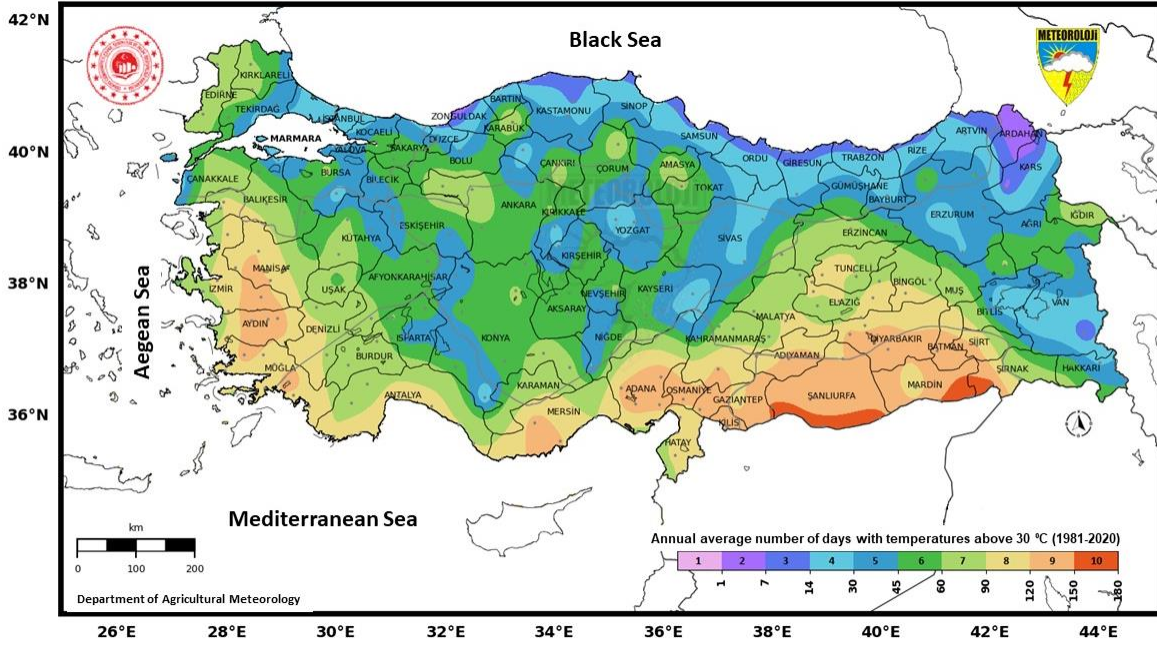


Figure 3. Plant Heat Tolerance Map (MGM, 2022)

In the final phase of the study, the classifications of the identified taxa regarding their resilience to air pollution, drought, wind, heat, cold, and salinity were illustrated with graphs, and evaluations were conducted based on these findings.

FINDINGS

The plant taxa identified as being used in the urban open and green spaces of Rize, along with their resilience to air pollution, drought, wind, heat, cold, and salinity, are presented in Table 2. Table 2 is generated from the following references; Akkemik, 2018; Appleton, 1999; AUB, 2024; Bainbridge, 2015; Bharti et al., 2018; Chen et al., 2017; Çorbacı & Ekren, 2022; Ebben Nurseries, 2024; Ganesan & Arul Pragasan, 2017; Horaginamani et al., 2012; Kösa, 2023; Mamıkoğlu, 2012; NCSUE, 2024; OSU, 2024; Penick, 2016; PFAF, 2024; Rockledge Gardens, 2024; URL-2, 2024; USDA, 2024; Williams, 2013; Zencirkıran & Seyidođlu Akdeniz, 2017; Zencirkıran & Sönmez, 2023.

Table 2. Plant Taxa Identified in The Study Area And Their Ecologic Tolerance.

Family	Name	E/N	Air Pollution	Drought	Wind	Heat (3)	Cold (9b)	Salinity	Map Location
ACANTHACEAE	<i>Acanthus mollis</i> L.	E	Moderately Tolerant	Tolerant	Slightly Tolerant	7-12	7a-10b	Tolerant	11
ACTINIDIACEAE	<i>Actinidia deliciosa</i> (A Chev) Liang et Ferguson 'Hayward'	E	Moderately Tolerant	Intolerant	Slightly Tolerant	7-9	7a-9b	Slightly Tolerant	6,11
ADOXACEAE	<i>Viburnum fragrans</i> Bunge	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	5a-8b	Moderately Tolerant	6
	<i>Viburnum opulus</i> L.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	4a-8b	Moderately Tolerant	4,8
AIZOACEAE	<i>Aptenia cordifolia</i> (L.f.) Schwantes	E	Moderately Tolerant	Tolerant	Moderately Tolerant	10-12	10a-11b	Moderately Tolerant	1
AMARYLLIDACEAE	<i>Allium sativum</i> L.	N	Tolerant	Slightly Tolerant	Slightly Tolerant	1-9	4a-9b	Moderately Tolerant	6
	<i>Narcissus pseudonarcissus</i> L.	E	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-9	5a-10b	Tolerant	6,11
APOCYNACEAE	<i>Nerium oleander</i> L.	N	Moderately Tolerant	Tolerant	Tolerant	1-12	8a-11b	Tolerant	1,3,4,6,8,11
	<i>Vinca major</i> L.	N	Moderately Tolerant	Moderately Tolerant	Tolerant	7-9	7a-9b	Moderately Tolerant	1,6,8,11
AQUIFOLIACEAE	<i>Ilex aquifolium</i> L.	N	Tolerant	Moderately Tolerant	Intolerant	7-10	6a-8b	Tolerant	4,6
ARACEAE	<i>Zantedeschia aethiopica</i> (L.) K. Spreng	E	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	4-10	7a-10b	Moderately Tolerant	6,11
ARALIACEAE	* <i>Schefflera arboricola</i> Hayata	E	Tolerant	Tolerant	Moderately Tolerant	1-12	9a-11b	Moderately Tolerant	11
ARAUCARIACEAE	* <i>Araucaria angustifolia</i> (Bert.) O. Kuntze	E	Moderately Tolerant	Tolerant	Moderately Tolerant	6-9	6b-9b	Moderately Tolerant	11
ARECACEAE	<i>Chamaerops excelsa</i> Thunb. (syn. <i>Trachycarpus fortunei</i> (Hook.) H.Wendl.)	E	Tolerant	Tolerant	Tolerant	10-12	8a-11b	Moderately Tolerant	10,11
	<i>Phoenix canariensis</i> Hort.	E	Tolerant	Tolerant	Tolerant	10-12	9a-11b	Tolerant	8,11
	<i>Washingtonia filifera</i> (Linden ex André) H.Wendl. ex de Bary	E	Tolerant	Tolerant	Tolerant	8-12	8a-11b	Tolerant	3,8,10
ASPARAGACEAE	<i>Agave americana</i> L.	E	Tolerant	Tolerant	Tolerant	5-12	8a-10b	Tolerant	6,11
	<i>Aspidistra elatior</i> Blume	E	Tolerant	Tolerant	Slightly Tolerant	4-12	7a-11b	Slightly Tolerant	11
	<i>Yucca filamentosa</i> L.	E	Tolerant	Tolerant	Tolerant	5-11	4a-11b	Moderately Tolerant	4,8,11

ASPHODELACEAE	<i>Aloe barbadensis</i> Mill.	E	Tolerant	Tolerant	Moderately Tolerant	10-12	9a-11b	Moderately Tolerant	6,11
	<i>Hemerocallis fulva</i> L.	E	Tolerant	Moderately Tolerant	Slightly Tolerant	2-11	3a-9b	Tolerant	6,11
ASTERACEAE	<i>Argyranthemum frutescens</i> L.	E	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	1-11	9a-11b	Moderately Tolerant	1,4,6
	<i>Santolina chamaecyparissus</i> L.	E	Tolerant	Tolerant	Tolerant	3-9	6a-9b	Tolerant	1,6,10,11
BEGONIACEAE	<i>Begonia x semperflorens-cultorum</i> Hort. 'Scarlet'	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-12	9a-11b	Moderately Tolerant	6,11
BERBERIDACEAE	<i>Berberis julianae</i> C.K.Schneid.	E	Tolerant	Tolerant	Tolerant	3-9	6a-9b	Moderately Tolerant	4
	<i>Berberis thunbergii</i> DC. 'Atropurpurea'	E	Tolerant	Tolerant	Tolerant	3-9	5a-10b	Slightly Tolerant	3,11
	<i>Berberis vulgaris</i> L.	N	Tolerant	Tolerant	Tolerant	3-9	4a-9a	Moderately Tolerant	8
	<i>Mahonia aquifolium</i> (Pursh) Nutt.	E	Tolerant	Moderately Tolerant	Tolerant	3-9	5a-9b	Moderately Tolerant	3
	<i>Nandina domestica</i> Thunb.	E	Tolerant	Tolerant	Moderately Tolerant	3-12	6a-11b	Slightly Tolerant	5,6,8,11
BETULACEAE	<i>Alnus glutinosa</i> (L.) Gaertn.	N	Tolerant	Tolerant	Tolerant	1-7	3a-8b	Moderately Tolerant	6
	<i>Betula pendula</i> Roth	N	Tolerant	Moderately Tolerant	Tolerant	1-9	2a-9a	Moderately Tolerant	6,8
	<i>Carpinus betulus</i> Mill.	N	Tolerant	Tolerant	Tolerant	1-8	5a-8b	Intolerant	4,8
	<i>Corylus avellana</i> L.	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	5a-8b	Moderately Tolerant	4,6
BIGNONIACEAE	<i>Campsis radicans</i> (L.) Seem.	E	Tolerant	Tolerant	Moderately Tolerant	3-9	5a-9b	Moderately Tolerant	3,6,11
	<i>Catalpa bignonioides</i> Walter	E	Tolerant	Moderately Tolerant	Slightly Tolerant	3-9	6a-9b	Slightly Tolerant	4
	<i>Pandorea jasminoides</i> (Lindl.) K.Schum.	E	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	8-12	9a-11b	Slightly Tolerant	6
BUDDLEJACEAE	<i>Buddleja davidii</i> Franch.	E	Tolerant	Moderately Tolerant	Slightly Tolerant	2-9	6b-10a	Moderately Tolerant	11
CACTACEAE	<i>Opuntia ficus indica</i> (L.) Mill.	E	Tolerant	Tolerant	Moderately Tolerant	9-12	8a-11b	Slightly Tolerant	11
CANNACEAE	<i>Canna x generalis</i> L.H. Bailey & E.Z. Bailey	E	Tolerant	Intolerant	Slightly Tolerant	1-12	8a-11b	Slightly Tolerant	1,11
CAPRIFOLIACEAE	<i>Abelia x grandiflora</i> (Andre) Rehd.	E	Tolerant	Tolerant	Slightly Tolerant	6-9	7b-9b	Slightly Tolerant	8,11

	<i>Lonicera caprifolium</i> L.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	5-9	4a-8b	Tolerant	6,8,11
	<i>Lonicera tatarica</i> L.	E	Tolerant	Moderately Tolerant	Tolerant	5-9	3a-8b	Moderately Tolerant	6
	<i>Symphoricarpos albus</i> (L.) S.F. Blake	E	Tolerant	Tolerant	Tolerant	1-9	3a-8b	Tolerant	10
	<i>Symphoricarpos orbiculatus</i> Moench	E	Tolerant	Tolerant	Tolerant	1-9	2a-7b	Tolerant	4
	<i>Weigela floribunda</i> (Sieb. & Zucc.) K. Koch.	E	Tolerant	Moderately Tolerant	Tolerant	3-8	5a-9b	Slightly Tolerant	3,8
CARYOPHYLLACEAE	<i>Cerastium tomentosum</i> L.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	1-7	3a-7b	Moderately Tolerant	1
CELASTRACEAE	<i>Euonymus alatus</i> (Thunb.) Siebold	E	Tolerant	Tolerant	Tolerant	1-9	4a-9b	Tolerant	6
	<i>Euonymus japonicus</i> Thunb.	E	Tolerant	Tolerant	Tolerant	1-9	4a-10b	Moderately Tolerant	6,8,11
COMPOSITAE	<i>Calendula officinalis</i> L.	N	Tolerant	Moderately Tolerant	Slightly Tolerant	1-6	2a-11b	Moderately Tolerant	1
	<i>Stevia rebaudiana</i> (Bert.)	E	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	8-11	9a-11b	Moderately Tolerant	6,11
	<i>Tagetes erecta</i> L. 'Giant Orange'	E	Moderately Tolerant	Slightly Tolerant	Slightly Tolerant	1-12	2a-11b	Moderately Tolerant	1,6,11
	<i>Tagetes patula</i> L.	E	Moderately Tolerant	Slightly Tolerant	Slightly Tolerant	1-12	2a-11b	Moderately Tolerant	1,6,11
CORNACEAE	<i>Aucuba japonica</i> Thunb.	E	Tolerant	Tolerant	Intolerant	6-11	6a-10b	Moderately Tolerant	6,11
	<i>Cornus florida</i> L.	E	Tolerant	Slightly Tolerant	Tolerant	3-8	6b-9b	Intolerant	6
	<i>Cornus mas</i> L.	N	Moderately Tolerant	Moderately Tolerant	Tolerant	3-8	4a-8b	Intolerant	4,11
	<i>Cornus sanguinea</i> L.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-7	4a-8b	Intolerant	4
CUPRESSACEAE	<i>Chamaecyparis lawsoniana</i> (A. Murray) Parl.	E	Tolerant	Tolerant	Moderately Tolerant	1-8	5a-9b	Moderately Tolerant	3,4,5,6,8,10,11
	<i>Cryptomeria japonica</i> (Thunb. ex L.f.) D.Don	E	Tolerant	Tolerant	Moderately Tolerant	3-9	6a-9b	Moderately Tolerant	3,4,6,8,11
	<i>Cupressocyparis leylandii</i> (A.B.Jacks. & Dallim.) Dallim.	E	Tolerant	Tolerant	Tolerant	3-9	6a-10b	Tolerant	8,11
	<i>Cupressus arizonica</i> Greene	E	Tolerant	Tolerant	Tolerant	2-10	7a-11b	Moderately Tolerant	3,4,6,8,11
	<i>Cupressus macrocarpa</i> Hartw. 'Goldcrest'	E	Tolerant	Tolerant	Tolerant	7-12	7a-11b	Tolerant	2,4,6,8,9,11
	<i>Cupressus sempervirens</i> L.	N	Tolerant	Tolerant	Tolerant	3-9	8a-10b	Moderately Tolerant	1,4,7,8,11
	<i>Juniperus chinensis</i> L. 'Pfitzeriana Glauca'	E	Tolerant	Tolerant	Tolerant	1-9	3a-9b	Tolerant	6,7,8

	<i>Juniperus communis</i> L. ‘Hibernica’	N	Tolerant	Tolerant	Moderately Tolerant	1-6	3a-8b	Tolerant	4,6,7,8
	<i>Juniperus horizontalis</i> Moench	E	Tolerant	Tolerant	Tolerant	1-9	3a-9b	Tolerant	4,8
	<i>Juniperus sabina</i> L.	N	Tolerant	Tolerant	Tolerant	1-7	3a-7b	Tolerant	8
	<i>Juniperus squamata</i> Buch.-Ham ex D. Don ‘Blue Carpet’	E	Tolerant	Tolerant	Tolerant	1-9	4a-8b	Tolerant	6,8
	<i>Juniperus virginiana</i> L.	E	Tolerant	Tolerant	Tolerant	1-9	4a-9b	Tolerant	8
	<i>Libocedrus decurrens</i> ‘Aureovariegata’ (Schwer.) Rehder	E	Tolerant	Tolerant	Tolerant	2-8	5a-8b	Tolerant	11
	<i>Sequoia sempervirens</i> (D. Don) Endl.	E	Tolerant	Tolerant	Tolerant	8-9	7a-9b	Moderately Tolerant	3,4,8,11
	<i>Sequoiadendron giganteum</i> (Lindl.) Buchh.	E	Tolerant	Tolerant	Tolerant	4-9	5a-9b	Slightly Tolerant	11
	<i>Thuja orientalis</i> (L.) Franco	E	Tolerant	Moderately Tolerant	Tolerant	1-7	6a-9a	Slightly Tolerant	6,7,8,11
CYCADACEAE	<i>Cycas revoluta</i> Thunb.	E	Slightly Tolerant	Slightly Tolerant	Slightly Tolerant	6-11	9a-12b	Tolerant	1,6,11
EBENACEAE	<i>Diospyros kaki</i> Thunb.	E	Tolerant	Tolerant	Slightly Tolerant	3-10	8a-11b	Tolerant	3,4,11
ELAEAGNACEAE	<i>Elaeagnus x ebbingei</i> Door.	E	Tolerant	Tolerant	Tolerant	1-12	7a-10a	Tolerant	4
	<i>Elaeagnus umbellata</i> Thunb.	E	Tolerant	Tolerant	Tolerant	1-8	4a-8b	Tolerant	4
	<i>Elaeagnus pungens</i> Thunb. ‘Maculata Aurea’	E	Tolerant	Tolerant	Tolerant	7-9	7a-9b	Tolerant	5
ERICACEAE	<i>Arbutus unedo</i> L.	N	Tolerant	Tolerant	Tolerant	3-9	7b-9b	Moderately Tolerant	1,4
	<i>Rhododendron ponticum</i> L.	N	Tolerant	Intolerant	Moderately Tolerant	10-12	6a-9b	Tolerant	1,6,8,11
	<i>Vaccinium arctostaphylos</i> L.	N	Tolerant	Tolerant	Tolerant	1-7	5a-8b	Tolerant	1
	<i>Vaccinium myrtillus</i> L.	N	Tolerant	Moderately Tolerant	Tolerant	1-7	3a-8b	Moderately Tolerant	4,6
FABACEAE	<i>Acacia dealbata</i> L.	E	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	5-9	9-11	Moderately Tolerant	11
	<i>Albizia julibrissin</i> Durazz.	E	Moderately Tolerant	Tolerant	Tolerant	6-10	7b-10b	Moderately Tolerant	6
	<i>Ceratonia siliqua</i> L.	N	Tolerant	Tolerant	Moderately Tolerant	1-12	9a-11b	Tolerant	6
	<i>Cercis siliquastrum</i> L.	N	Moderately Tolerant	Tolerant	Moderately Tolerant	7-9	6b-9b	Slightly Tolerant	4,6,11
	<i>Robinia pseudoacacia</i> L.	SN	Tolerant	Tolerant	Moderately Tolerant	3-9	5a-9b	Tolerant	4,6,8,11
	<i>Spartium junceum</i> L.	N	Tolerant	Tolerant	Tolerant	8-12	8a-10b	Tolerant	6

	<i>Wisteria sinensis</i> Sweet.	E	Tolerant	Tolerant	Slightly Tolerant	3-9	5a-9b	Slightly Tolerant	2,3,4,6,8,11
FAGACEAE	<i>Castanea sativa</i> Mill.	N	Moderately Tolerant	Tolerant	Tolerant	3-7	6a-11b	Moderately Tolerant	4,11
	<i>Fagus sylvatica</i> L. 'Atropurpurea'	E	Moderately Tolerant	Slightly Tolerant	Slightly Tolerant	3-9	5b-7b	Slightly Tolerant	8
	<i>Quercus robur</i> L.	N	Tolerant	Tolerant	Tolerant	3-8	5a-10a	Tolerant	4
	<i>Quercus rubra</i> L.	E	Tolerant	Tolerant	Tolerant	3-9	5a-8b	Tolerant	6
GERANIACEAE	<i>Geranium sanguineum</i> L.	E	Tolerant	Moderately Tolerant	Slightly Tolerant	1-12	3a-8b	Slightly Tolerant	10
	<i>Pelargonium peltatum</i> Ait.	E	Moderately Tolerant	Tolerant	Slightly Tolerant	1-12	10a-11b	Moderately Tolerant	1,6,11
	<i>Pelargonium zonale</i> L.	E	Moderately Tolerant	Tolerant	Slightly Tolerant	1-12	10a-11b	Moderately Tolerant	1,6,10,11
GINKGOACEAE	<i>Ginkgo biloba</i> L.	E	Tolerant	Tolerant	Moderately Tolerant	3-9	5a-8b	Tolerant	6,11
GROSSULARIACEAE	<i>Ribes orientale</i> Desf.	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-7	4a-8b	Moderately Tolerant	6
HAMAMELIDACEAE	<i>Liquidambar orientalis</i> Mill.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	1-10	8a-9b	Moderately Tolerant	4,10,11
	<i>Liquidambar styraciflua</i> L.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-10	5a-9b	Moderately Tolerant	6,10,11
	<i>Loropetalum chinense</i> (R. Br.) Oliv.	E	Tolerant	Tolerant	Slightly Tolerant	8-9	7a-10b	Slightly Tolerant	1,6,10,11
HEDERACEAE	<i>Hedera helix</i> L.	N	Tolerant	Tolerant	Tolerant	3-10	5a-9b	Moderately Tolerant	6,11
HYDRANGEACEAE	<i>Deutzia gracilis</i> Siebold & Zucc.	E	Tolerant	Tolerant	Moderately Tolerant	1-8	5a-8b	Tolerant	6,11
	<i>Hydrangea macrophylla</i> (Thunb.) Ser.	E	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	3-9	5a-9b	Moderately Tolerant	3,6,8,10,11
	<i>Philadelphus coronarius</i> L.	E	Tolerant	Moderately Tolerant	Tolerant	7-10	4a-8b	Moderately Tolerant	11
HYPERICACEAE	<i>Hypericum perforatum</i> L.	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	3-10	5a-8b	Moderately Tolerant	5
IRIDACEAE	<i>Iris germanica</i> L.	N	Moderately Tolerant	Tolerant	Moderately Tolerant	1-12	3a-9b	Slightly Tolerant	6,11
JUGLANDACEAE	<i>Juglans regia</i> L.	N	Tolerant	Moderately Tolerant	Tolerant	1-7	5b-9b	Tolerant	3,4
LAURACEAE	<i>Cinnamomum camphora</i> (L.) Presl.	E	Tolerant	Moderately Tolerant	Tolerant	8-10	9a-11b	Slightly Tolerant	7

	<i>Laurus nobilis</i> L.	N	Moderately Tolerant	Tolerant	Slightly Tolerant	1-11	8a-11b	Moderately Tolerant	1,2,4,6,9,11
LABIATAE	<i>Teucrium fruticans</i> L.	E	Tolerant	Tolerant	Tolerant	8-9	8a-10b	Tolerant	11
LAMIACEAE	<i>Lavandula angustifolia</i> Mill.	N	Tolerant	Tolerant	Tolerant	5-8	5a-9b	Moderately Tolerant	1,6,8,11
	<i>Nepeta x faassenii</i> Bergmans ex Stearn	N	Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	3a-8b	Tolerant	1,6
	<i>Rosmarinus officinalis</i> L.	N	Tolerant	Tolerant	Tolerant	6-12	8a-11b	Moderately Tolerant	1,4,6,8,11
	<i>Salvia officinalis</i> L.	E	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-10	4a-10b	Tolerant	1,6
	<i>Salvia splendens</i> L.	E	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-12	10a-11b	Moderately Tolerant	1,6,11
	<i>Thymus serpyllum</i> L.	N	Tolerant	Tolerant	Tolerant	1-9	4a-9b	Tolerant	1
LILIACEAE	<i>Lilium candidum</i> L.	N	Moderately Tolerant	Slightly Tolerant	Slightly Tolerant	6-9	6a-9b	Intolerant	6
	<i>Ophiopogon japonicus</i> (Thunb.)	E	Tolerant	Slightly Tolerant	Moderately Tolerant	1-12	7a-10b	Tolerant	6,8,11
LYTHRACEAE	<i>Lagerstroemia indica</i> L.	E	Moderately Tolerant	Tolerant	Intolerant	5-8	8a-10a	Intolerant	1,2,4,6,8,9,11
MAGNOLIACEAE	<i>Liriodendron tulipifera</i> L.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	2-9	5b-10a	Intolerant	6
	<i>Magnolia grandiflora</i> L.	E	Tolerant	Moderately Tolerant	Tolerant	1-9	6a-10b	Moderately Tolerant	1,2,3,4,5,6,8,10,11
MALVACEAE	<i>Abutilon x hybridum</i> Hort.	E	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	1-10	8a-10b	Slightly Tolerant	10,11
	<i>Hibiscus syriacus</i> L.	E	Tolerant	Tolerant	Intolerant	1-8	5a-11b	Moderately Tolerant	3,4,6,8,11
MELIACEAE	<i>Melia azedarach</i> L.	E	Slightly Tolerant	Tolerant	Tolerant	7-12	7a-10b	Tolerant	4
MORACEAE	<i>Ficus carica</i> L.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	3-8	8a-10b	Tolerant	4,6,8,11
	<i>Morus alba</i> L.	E	Tolerant	Moderately Tolerant	Slightly Tolerant	1-8	5a-9b	Tolerant	8,11
	<i>Morus nigra</i> L. 'Pendula'	E	Tolerant	Moderately Tolerant	Slightly Tolerant	1-8	6b-11b	Tolerant	2,5,6,8,11
MYRTACEAE	<i>Callistemon citrinus</i> (Curtis) Sheels (syn. <i>C. lanceolatus</i> DC)	E	Slightly Tolerant	Slightly Tolerant	Moderately Tolerant	8-12	9a-11b	Moderately Tolerant	8,11
	<i>Eucalyptus camaldulensis</i> Dehn.	E	Tolerant	Slightly Tolerant	Moderately Tolerant	9-12	9a-11b	Slightly Tolerant	4,8

	<i>Feijoa sellowiana</i> Berg.	E	Moderately Tolerant	Tolerant	Moderately Tolerant	9-11	8a-11b	Tolerant	11
NEPHROLEPIDACEAE	<i>Nephrolepis exaltata</i> L.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	8-12	9a-11b	Slightly Tolerant	11
OLEACEAE	<i>Fraxinus excelsior</i> L.	N	Tolerant	Moderately Tolerant	Moderately Tolerant	3-8	4a-9b	Tolerant	2,3,4,8,9,11
	<i>Jasminum fruticans</i> L.	N	Moderately Tolerant	Tolerant	Moderately Tolerant	8-12	7a-10b	Moderately Tolerant	4,6,11
	<i>Ligustrum japonicum</i> Thunb.	E	Tolerant	Tolerant	Moderately Tolerant	7-10	7a-10b	Tolerant	3,4,6,7,10,11
	<i>Olea europaea</i> L.	N	Moderately Tolerant	Moderately Tolerant	Tolerant	8-10	10a-11b	Moderately Tolerant	1,2,3,9,11
	<i>Syringa vulgaris</i> L.	E	Tolerant	Tolerant	Moderately Tolerant	1-8	5a-9b	Tolerant	8,11
	<i>Trachelospermum jasminoides</i> (Lindl.) Lem.	E	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	9-10	8a-10b	Moderately Tolerant	1,6,8,11
PAEONIACEAE	<i>Paeonia suffruticosa</i> Andr.	E	Moderately Tolerant	Slightly Tolerant	Slightly Tolerant	1-8	3a-8b	Slightly Tolerant	1,11
PASSIFLORACEAE	<i>Passiflora edulis</i> Sims	E	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	6-10	9a-11b	Tolerant	11
PAULOWNIACEAE	<i>Paulownia tomentosa</i> Steud.	E	Tolerant	Moderately Tolerant	Slightly Tolerant	4-8	5b-9b	Slightly Tolerant	8
PHYTOLACCACEAE	<i>Phytolacca americana</i> L.	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	4a-8b	Moderately Tolerant	11
PINACEAE	<i>Abies concolor</i> (Gord. & Glen.) Lindl.	E	Tolerant	Moderately Tolerant	Tolerant	1-7	5a-8b	Intolerant	11
	<i>Abies nordmanniana</i> (Stev.) Spach. subsp. <i>nordmanniana</i>	N	Moderately Tolerant	Slightly Tolerant	Tolerant	3-7	5a-9b	Intolerant	3
	<i>Cedrus atlantica</i> (Endl.) Carr. 'Glaucua'	E	Tolerant	Tolerant	Tolerant	6-9	7a-9b	Intolerant	6,11
	<i>Cedrus deodara</i> (Roxb.) G. Don	E	Intolerant	Tolerant	Moderately Tolerant	7-9	7a-11b	Slightly Tolerant	3,4,6,7,8,11
	<i>Cedrus libani</i> A.Rich.	N	Tolerant	Tolerant	Tolerant	3-9	7a-8b	Intolerant	3,4,7
	<i>Picea abies</i> (L.) H.Karst.	E	Slightly Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	3b-8b	Moderately Tolerant	4,6,8,11
	<i>Picea glauca</i> (Moench) Voss	E	Slightly Tolerant	Moderately Tolerant	Tolerant	1-6	4a-7b	Slightly Tolerant	6,11
	<i>Picea glauca</i> (Moench) Voss 'Conica'	E	Intolerant	Moderately Tolerant	Tolerant	1-6	2a-6b	Intolerant	11
<i>Pinus brutia</i> Ten.	N	Tolerant	Tolerant	Moderately Tolerant	1-9	7a-9b	Intolerant	11	

	<i>Pinus griffithii</i> (Hook.f.) Parl.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	5-9	5a-7b	Slightly Tolerant	6
	<i>Pinus mugo</i> Turra	E	Tolerant	Tolerant	Tolerant	1-7	2a-7b	Tolerant	6
	<i>Pinus nigra</i> Lamb.	N	Tolerant	Tolerant	Tolerant	3-8	5b-8b	Tolerant	8
	<i>Pinus pinaster</i> Aiton	E	Tolerant	Tolerant	Tolerant	7-11	7b-10b	Tolerant	3,6,8
	<i>Pinus pinea</i> L.	N	Tolerant	Tolerant	Tolerant	9-11	7b-10b	Tolerant	4,6,8,11
	<i>Pinus radiata</i> D.Don	E	Tolerant	Moderately Tolerant	Tolerant	7-11	7a-10b	Tolerant	6
	<i>Pinus sylvestris</i> L.	N	Tolerant	Moderately Tolerant	Tolerant	1-7	2a-9a	Moderately Tolerant	4,11
PITTOSPORACEAE	<i>Pittosporum tobira</i> Thunb. Ait.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	8-12	8a-11b	Moderately Tolerant	8
PLATANACEAE	<i>Platanus acerifolia</i> Willd.	E	Tolerant	Slightly Tolerant	Moderately Tolerant	3-8	6a-10b	Tolerant	6,8
	<i>Platanus orientalis</i> L.	N	Tolerant	Slightly Tolerant	Moderately Tolerant	3-9	6b-9a	Tolerant	2,4,5,8,10
POLYGONACEAE	<i>Polygonum perfoliatum</i> L.	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	5-9	5a-9b	Moderately Tolerant	6,11
PRIMULACEAE	<i>Primula vulgaris</i> Huds.	N	Slightly Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	4a-8b	Moderately Tolerant	1,6,8
PUNICACEAE	<i>Punica granatum</i> L.	N	Slightly Tolerant	Moderately Tolerant	Moderately Tolerant	1-12	7b-11b	Tolerant	4,6,8
RHAMNACEAE	<i>Hovenia dulcis</i> Thunb.	E	Moderately Tolerant	Moderately Tolerant	Intolerant	5-8	6a-9b	Moderately Tolerant	4
	<i>Ziziphus jujuba</i> Mill.	E	Moderately Tolerant	Tolerant	Tolerant	6-12	8a-11b	Tolerant	6
ROSACEAE	<i>Amygdalus orientalis</i> Miller	N	Moderately Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	5a-9b	Moderately Tolerant	6
	<i>Cotoneaster franchetti</i> Bois.	E	Tolerant	Tolerant	Tolerant	3-7	6a-7b	Tolerant	8
	<i>Crataegus crus-galli</i> Mill.	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-7	4a-7b	Intolerant	6
	<i>Cydonia oblonga</i> Mill.	N	Tolerant	Tolerant	Moderately Tolerant	3-9	5a-9b	Slightly Tolerant	6,8
	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	E	Tolerant	Tolerant	Moderately Tolerant	8-11	7a-11b	Moderately Tolerant	3,4,6,7,8,11
	<i>Kerria japonica</i> (L.) DC	E	Moderately Tolerant	Moderately Tolerant	Intolerant	1-9	5a-9b	Moderately Tolerant	4,11
	<i>Laurocerasus officinalis</i> M.Roem.	N	Tolerant	Slightly Tolerant	Tolerant	3-10	6a-9b	Tolerant	1,2,3,4,5,6,7,8,9,10,11
	<i>Malus floribunda</i> Siebold ex Van Houtte	E	Tolerant	Moderately Tolerant	Moderately Tolerant	1-8	4a-7b	Moderately Tolerant	8

	<i>Mespilus germanica</i> L.	N	Tolerant	Tolerant	Tolerant	1-8	5b-9b	Moderately Tolerant	6
	<i>Prunus armeniaca</i> L.	E	Tolerant	Moderately Tolerant	Intolerant	1-9	6a-7b	Intolerant	6
	<i>Prunus avium</i> L.	N	Tolerant	Moderately Tolerant	Slightly Tolerant	1-8	4a-9b	Intolerant	4,8,11
	<i>Prunus cerasus</i> L.	E	Slightly Tolerant	Moderately Tolerant	Slightly Tolerant	1-8	5b-8b	Moderately Tolerant	6
	<i>Prunus domestica</i> L.	N	Tolerant	Moderately Tolerant	Slightly Tolerant	3-8	6a-8b	Moderately Tolerant	6,8,11
	<i>Prunus persica</i> (L.) Batsch	E	Tolerant	Moderately Tolerant	Slightly Tolerant	1-9	6a-8b	Intolerant	8
	<i>Prunus serrulata</i> Lindl. 'Kanzan'	E	Tolerant	Moderately Tolerant	Intolerant	6-8	6a-8b	Intolerant	2,6,8
	<i>Pyracantha coccinea</i> M.Roem.	N	Tolerant	Tolerant	Tolerant	3-9	5a-9b	Moderately Tolerant	3,8
	<i>Pyrus communis</i> L.	N	Tolerant	Tolerant	Moderately Tolerant	1-9	5a-9b	Intolerant	4,6,8
	<i>Rubus fruticosus</i> L.	N	Moderately Tolerant	Moderately Tolerant	Tolerant	3-8	5a-9b	Intolerant	8
	<i>Rubus idaeus</i> L.	N	Moderately Tolerant	Moderately Tolerant	Tolerant	3-8	4a-8b	Intolerant	8
	<i>Sorbus aucuparia</i> L.	N	Tolerant	Tolerant	Moderately Tolerant	1-7	4a-9b	Moderately Tolerant	6
RUBIACEAE	<i>Gardenia jasminoides</i> J.Ellis	E	Tolerant	Tolerant	Moderately Tolerant	7-12	7a-11b	Slightly Tolerant	1,4,6,8,11
RUSCACEAE	<i>Ruscus colchicus</i> Yeo	N	Tolerant	Tolerant	Moderately Tolerant	7-9	7a-9b	Tolerant	11
RUTACEAE	<i>Citrus aurantium</i> L.	E	Tolerant	Tolerant	Tolerant	8-12	8a-11b	Slightly Tolerant	11
	<i>Citrus bergamia</i> Risso	E	Tolerant	Tolerant	Tolerant	8-12	9a-11b	Slightly Tolerant	11
	<i>Citrus japonica</i> var. <i>Margarita</i> (Lour.) Guillaumin	E	Tolerant	Moderately Tolerant	Moderately Tolerant	8-12	8a-11b	Moderately Tolerant	1,6,8,11
	<i>Citrus limon</i> L. Bum.	E	Tolerant	Tolerant	Moderately Tolerant	8-12	9a-11b	Slightly Tolerant	1,2,6,8,11
	<i>Citrus reticulata</i> L.	E	Tolerant	Tolerant	Moderately Tolerant	8-12	9a-11b	Moderately Tolerant	1,2,6,11
	<i>Citrus sinensis</i> L.	E	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	8-12	9a-10b	Moderately Tolerant	1,2,6,11

SALICACEAE	<i>Populus alba</i> L.	N	Tolerant	Slightly Tolerant	Tolerant	1-9	3a-9b	Tolerant	8
	<i>Populus nigra</i> L.	N	Tolerant	Slightly Tolerant	Tolerant	1-9	4a-8b	Tolerant	8,11
	<i>Salix babylonica</i> L.	E	Tolerant	Intolerant	Tolerant	1-9	5b-9b	Moderately Tolerant	2,3,4,5,6,8
	<i>Salix caprea</i> L.	N	Tolerant	Intolerant	Tolerant	6-8	4a-9b	Slightly Tolerant	4,6
	<i>Salix caprea</i> L. 'Pendula'	N	Tolerant	Intolerant	Tolerant	6-8	4a-9b	Slightly Tolerant	8
	<i>Salix nigra</i> Marshall	E	Moderately Tolerant	Intolerant	Moderately Tolerant	1-9	4a-9b	Slightly Tolerant	8
SAPINDACEAE	<i>Acer negundo</i> L.	E	Tolerant	Moderately Tolerant	Intolerant	3-8	4a-8b	Intolerant	4,5,8
	<i>Acer palmatum</i> Thunb. 'Atropurpureum'	E	Moderately Tolerant	Moderately Tolerant	Intolerant	2-8	6a-9b	Moderately Tolerant	6,11
	<i>Aesculus hippocastanum</i> L.	E	Moderately Tolerant	Tolerant	Moderately Tolerant	1-8	4a-9b	Moderately Tolerant	4,8,9
	<i>Koelreuteria paniculata</i> Laxm.	E	Tolerant	Tolerant	Slightly Tolerant	1-9	6b-9b	Moderately Tolerant	4
SAXIFRAGACEAE	<i>Saxifraga rotundifolia</i> L.	D	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	3-9	5a-8b	Moderately Tolerant	11
SCROPHULARIACEAE	<i>Hebe x franciscana</i> (Eastw.) Souster	E	Tolerant	Moderately Tolerant	Tolerant	7-12	7a-10b	Tolerant	11
SIMORIBACEAE	<i>Ailanthus altissima</i> (Mill.) Swingle	SN	Tolerant	Tolerant	Slightly Tolerant	1-8	6a-8b	Moderately Tolerant	6,8,11
SOLANACEAE	<i>Cestrum elegans</i> (Brongn.) Schtdl.	E	Moderately Tolerant	Tolerant	Moderately Tolerant	9-12	8a-11b	Moderately Tolerant	11
	<i>Cestrum nocturnum</i> L.	E	Slightly Tolerant	Moderately Tolerant	Slightly Tolerant	9-12	9a-11b	Slightly Tolerant	11
	<i>Datura stramonium</i> L.	E	Tolerant	Tolerant	Moderately Tolerant	1-12	6a-9b	Tolerant	10
	<i>Lycium barbarum</i> L.	E	Tolerant	Tolerant	Slightly Tolerant	5-9	6a-9b	Tolerant	6
	<i>Solanum nigrum</i> L.	N	Tolerant	Tolerant	Moderately Tolerant	8-12	10a-11b	Tolerant	11
TAMARICACEAE	<i>Tamarix tetrandra</i> Pallas	N	Tolerant	Tolerant	Tolerant	1-9	6a-11b	Tolerant	11
TAXACEAE	<i>Taxus baccata</i> L.	N	Tolerant	Tolerant	Moderately Tolerant	1-7	6a-9a	Intolerant	4,6
THEACEAE	<i>Camellia japonica</i> L.	E	Moderately Tolerant	Tolerant	Slightly Tolerant	1-9	7a-10b	Slightly Tolerant	11

	<i>Camellia sinensis</i> L.	SN	Moderately Tolerant	Slightly Tolerant	Tolerant	3-8	7a-9b	Moderately Tolerant	1,6,8,10,11
THYMELAEACEAE	<i>Daphne odora</i> Thunb.	N	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	3-8	4a-7b	Moderately Tolerant	1,6,11
TILIACEAE	<i>Tilia rubra</i> DC.	N	Tolerant	Moderately Tolerant	Tolerant	3-8	4a-7b	Moderately Tolerant	3,8
	<i>Tilia tomentosa</i> Moench	N	Tolerant	Tolerant	Tolerant	1-9	6a-10a	Moderately Tolerant	1,4,8
VERBENACEAE	<i>Clerodendrum bungei</i> Steud.	E	Moderately Tolerant	Tolerant	Moderately Tolerant	8-11	7a-10b	Slightly Tolerant	11
	<i>Lantana camara</i> L.	E	Tolerant	Tolerant	Moderately Tolerant	1-12	7a-11b	Moderately Tolerant	1,8,11
VIOLACEAE	<i>Viola odorata</i> Linn.	N	Moderately Tolerant	Slightly Tolerant	Moderately Tolerant	6-8	4a-9b	Moderately Tolerant	6,11
VITACEAE	<i>Parthenocissus quinquefolia</i> L.	E	Tolerant	Moderately Tolerant	Tolerant	1-9	3a-11b	Tolerant	6,11
	<i>Vitis vinifera</i> L.	N	Moderately Tolerant	Moderately Tolerant	Slightly Tolerant	6-9	6a-10b	Tolerant	3,6,7,8,10,11

Notes: E: Exotic, N: Native, SN: Semi-Native

*: Despite being indoor plants, these taxa have been used outdoors under the climatic conditions of Rize City, and they have been able to sustain their existence outdoors due to the effects of climate change.

A total of 223 different plant taxa were identified in the study areas. Among these, 80 are native (77 native and 3 semi-native), while 143 exhibit exotic characteristics. The three most abundant families in the study areas are as follows: Rosaceae (20 species), Cupressaceae (16 species), and Pinaceae (16 species). When evaluating the resilience of the plants in the study areas to air pollution, it was found that out of the 223 plant taxa, 2 are classified as intolerant, 9 as slightly tolerant, 59 as moderately tolerant, and 153 as tolerant (Figure 4).

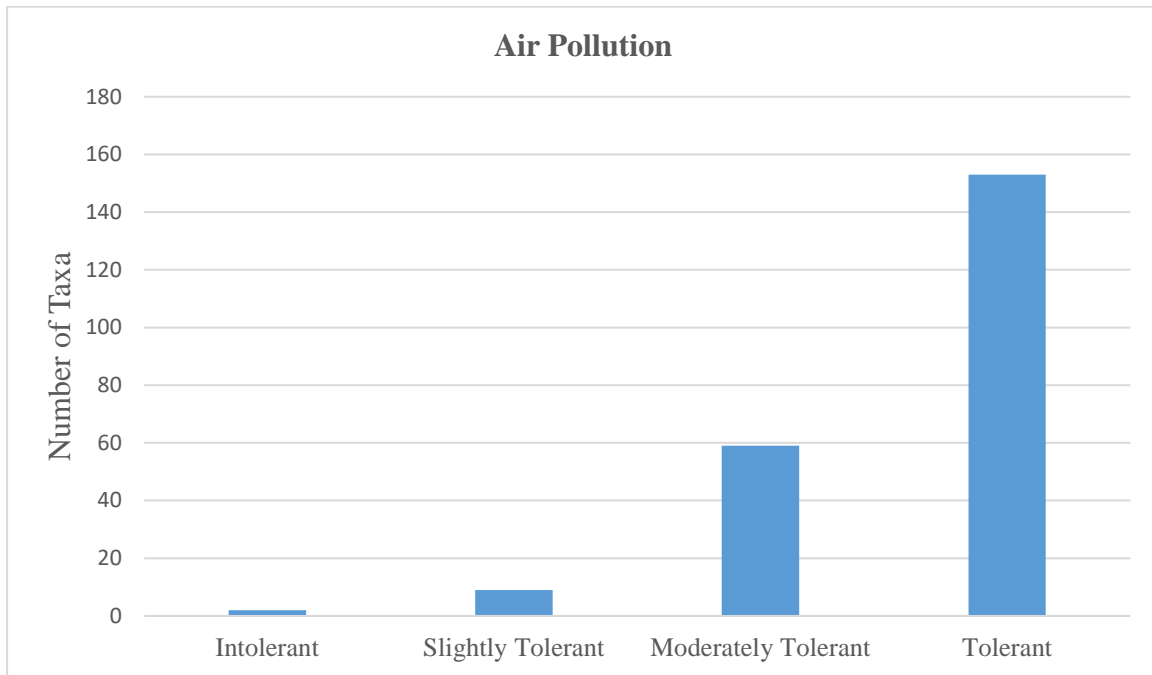


Figure 4. Resilience of the Identified Taxa to Air Pollution

In addition, out of the 223 plants, 10 are classified as intolerant, 41 as slightly tolerant, 82 as moderately tolerant, and 90 as tolerant to wind as shown in Figure 5.

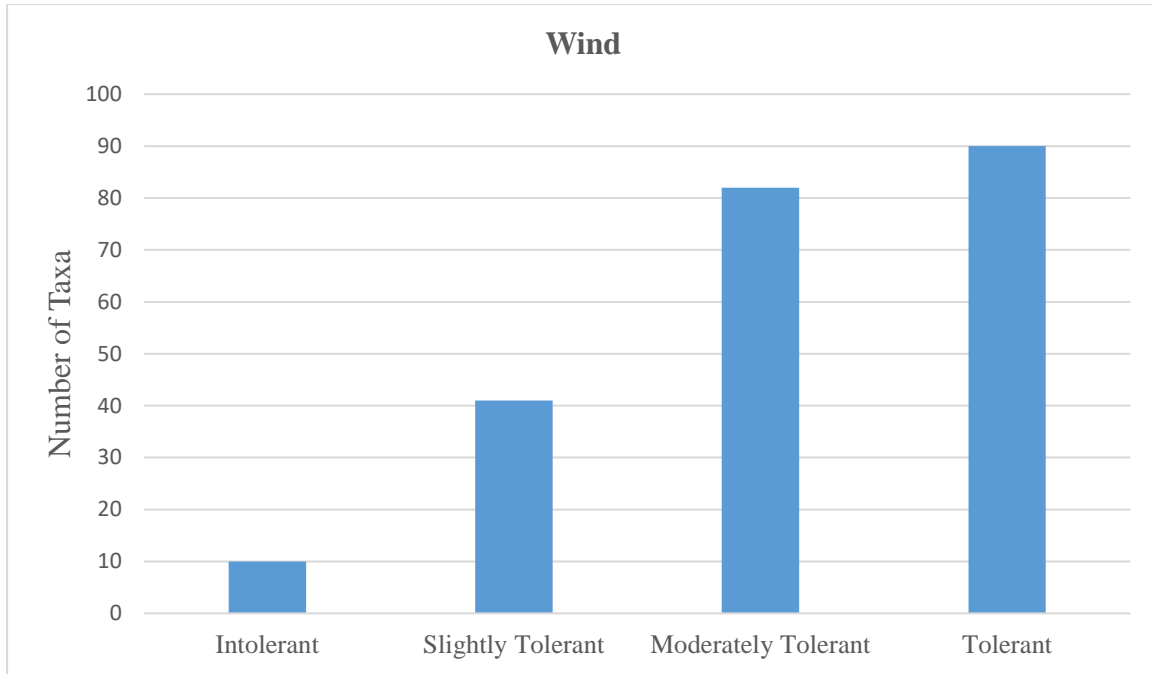


Figure 5. Resilience of The Identified Taxa to Wind

In terms of the drought resilience of the identified plants, it was found that out of the 223 plant taxa, 7 are classified as intolerant, 24 as slightly tolerant, 81 as moderately tolerant, and 111 as tolerant (Figure 6).

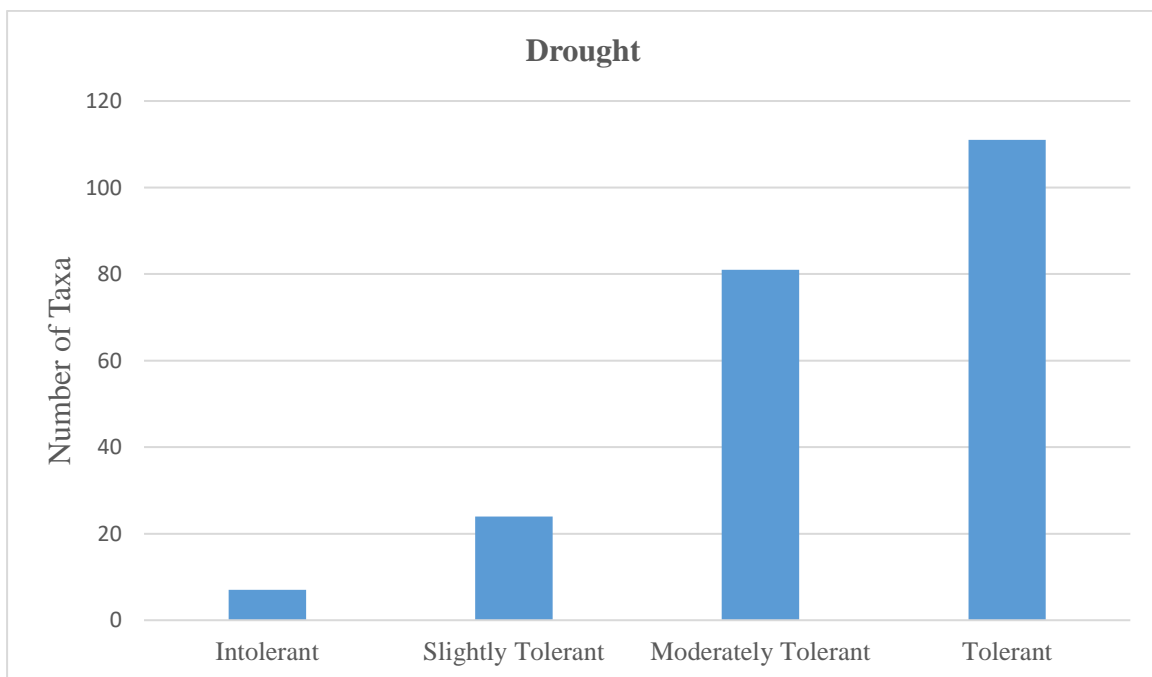


Figure 6. Resilience of The Identified Taxa to Drought

Lastly, as evaluating the salt resilience of the taxa, it was determined that out of the 223 plants, 23 are classified as intolerant, 38 as slightly tolerant, 90 as moderately tolerant, and 72 as tolerant (Figure 7).

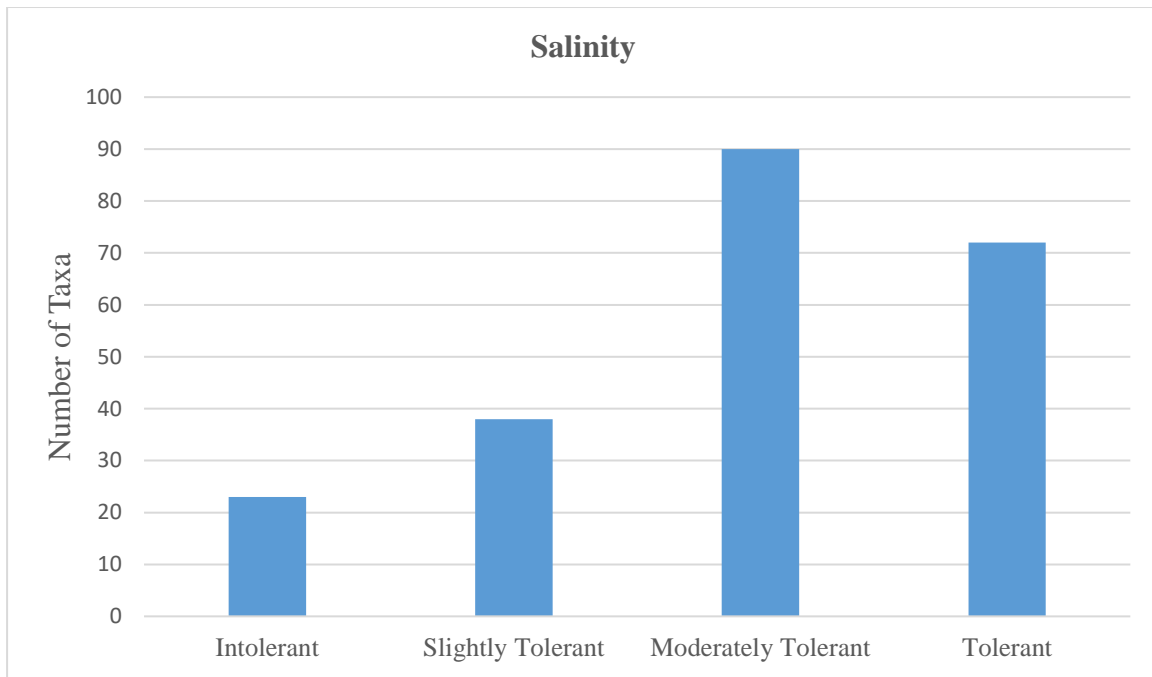


Figure 7. Resilience of The Identified Taxa to Salinity

The cold and heat resilience of the plants was examined to assess their suitability for Rize. Among the 223 plant taxa evaluated for cold resilience, it was determined that 164 are suitable for Rize, which is located in the 9b region of the plant cold hardiness map, while 59 are not suitable. Additionally, in the assessment of heat resilience, out of the 223 plant taxa, 145 were found to be suitable for Rize, which is located in the 3rd region of the plant heat hardiness map, while 78 were deemed unsuitable (Figure 8).

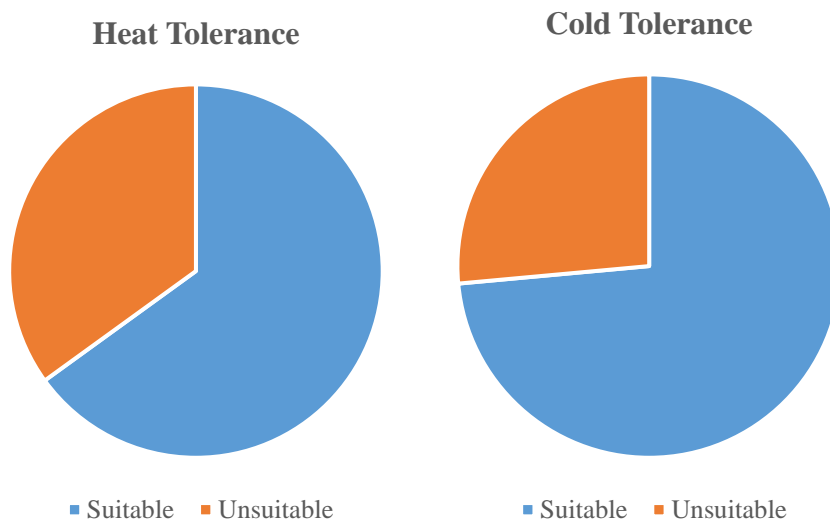


Figure 8. The Resilience of the Identified Taxa to Cold and Heat

CONCLUSION AND RECOMMENDATIONS

In this study, the ecological tolerances of 223 plant taxa used in Rize urban parks were evaluated to variables such as air pollution, drought, wind, temperature, cold, and salinity. It

was found that 149 taxa (49 native and 100 exotic) were sensitive to at least one of these ecological factors (indicated in bold in the table), marking them as taxa that require careful consideration when used in planting projects in this region. The remaining 74 taxa (27 native, 47 exotic) were found to have sufficient resilience to all of these ecological factors. Given these ratios, it is expected that the planting implementations in urban parks in the region may have lower tolerance to certain ecological factors.

Based on the ecological factors examined, *Prunus serrulata* Lindl. ‘Kanzan’ was identified as the taxon with the lowest ecological tolerance, as it showed low tolerance to four out of the six factors (wind, heat, cold, and salinity). Therefore, its use in planting designs in the region is considered risky, and close attention is recommended if planted.

Additionally, Exotic taxa *Acer negundo* L. (wind, cold, salinity), *Prunus armeniaca* L. (wind, cold, salinity), *Lagerstroemia indica* L. (wind, heat, salinity), and *Picea glauca* (Moench) Voss ‘Conica’ showed sensitivity to three ecological factors (air pollution, cold, salinity). *Ilex aquifolium* L. was the only native taxa sensitive to three factors (wind, heat, and cold). This result implies that selecting a plant solely because it is a native taxon may not always be the correct decision, because it may have a similar risk level to exotic species in terms of ecological tolerance. Plants that are sensitive to three of the six factors are not recommended as primary choices for landscaping projects in the study area. However, it is also not accurate to classify these species as completely unsuitable for the region. Designers should make their final decision based on the conditions of the specific location aimed to be planted.

For example, because it was found that *Acer negundo* L. and *Prunus armeniaca* L. have a low tolerance to wind and salinity, their use in the study area is not directly recommended. However, these species can adapt to the region’s ecological conditions when used in areas protected from direct sea salt spray, without significant soil salinity risks, and with adequate wind protection. Similarly, high resilience to all ecological tolerance criteria does not necessarily mean that it is the most suitable taxa for the region. Another example, although the exotic taxon *Buddleja davidii* Franch. meets all ecological tolerance criteria, designers should be careful for their use in landscape projects because of its invasive characteristics. Therefore, in addition to the ecological tolerance criteria, it is also important to consider the potential negative impacts (e.g. being invasive or toxic) a plant might have on its environment. These factors should also be carefully assessed before making final decisions on plant selection.

Moreover, it was found that 24 plant taxa are sensitive to two ecological factors, while 119 taxa show sensitivity to only one ecological factor. Although these species have relatively high ecological tolerance, it is still recommended to be careful for their use in landscaping projects in this region. This emphasizes the importance of this study and future ecological tolerance assessment studies in plant selection processes.

In this study, 79 taxa demonstrated sufficient resistance to all the ecological factors and posed no risk to use in the study area. However, to support ecological sustainability in the region, it is recommended to prioritize the use of native taxa such as *Amygdalus orientalis* Miller, *Arbutus unedo* L., *Calendula officinalis* L., *Castanea sativa* Mill., *Ceratonia siliqua* L., *Cupressus sempervirens* L., *Ficus carica* L., *Iris germanica* L., *Juglans regia* L., *Laurocerasus officinalis* M.Roem., *Laurus nobilis* L., *Punica granatum* L., *Pyracantha coccinea* M.Roem., *Quercus robur* L., *Sorbus aucuparia* L., *Thymus serpyllum* L., and *Tilia tomentosa* Moench in landscaping projects.

Considering the changing environmental conditions is another important issue that needs attention during the design process. For example, annual average rainfall, extreme day-night temperatures, and wind characteristics may change over the years due to the increasing and changing effects of global warming. For this reason, choosing plants with borderline tolerance levels may be risky in the long run. Hence, designers should prefer plants with higher ecological resistance in their designs for the development of landscape projects more tolerant to the changing environmental conditions.

Designers may prioritize the aesthetic quality of plants over their ecological characteristics. This would lead to the widespread use of exotic taxa which may not easily adapt to the local environment and result in increasing water consumption and the use of chemical nutrients (Korkut et al., 2017). The dependence on excessive water and chemical use presents significant risks to the sustainability of cities and natural resources (Zencirkiran & Seyidođlu Akdeniz, 2017). However, this approach also should not create the perception that species with high ecological tolerance lack aesthetic value or aesthetic quality should be ignored due to ecological concerns. On the contrary, landscape projects must meet the aesthetic expectations of their users to be considered successful and to ensure their long-term sustainability (Kordon & Miller, 2023; Kordon et al., 2022). Therefore, in addition to the ecological tolerance research, the number of studies evaluating the aesthetic quality of frequently used plants should be increased. Such research can help designers in the selection of plants with higher ecological resistance and better aesthetic qualities. This surely contributes to the creation of more successful landscape projects. Future studies that address both ecological tolerance and aesthetic value are expected to provide a more holistic examination of the sustainability of urban green spaces and serve as a guide for planting design.

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All authors contributed equally to the article. There is no conflict of interest.

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The authors declare no conflict of interest.

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This study does not require any ethics committee approval.

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