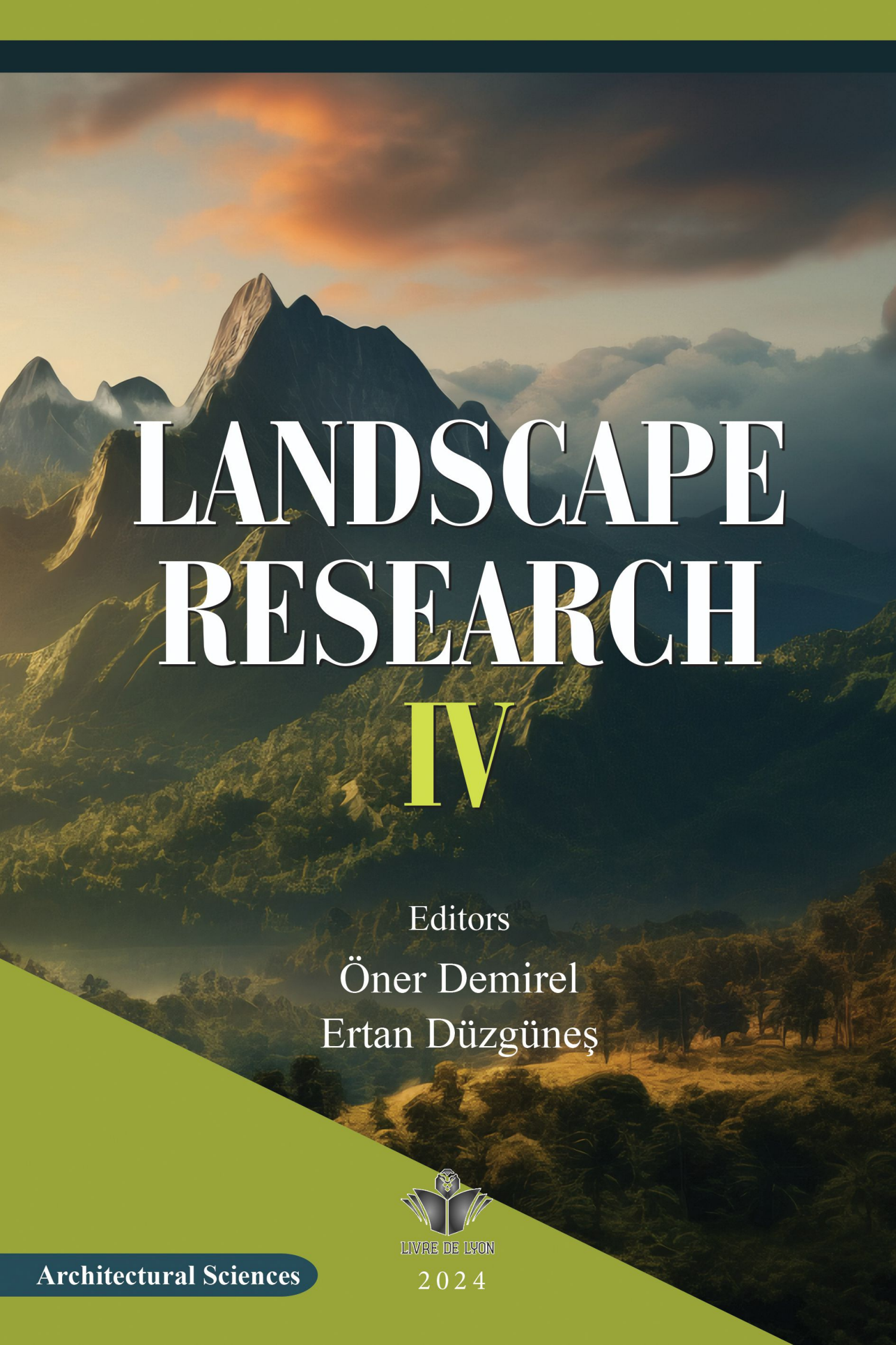


LANDSCAPE RESEARCH

IV

Editors

Öner Demirel

Ertan Düzgüneş

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Architectural Sciences

2024

Landscape Research-IV

Editors
Öner Demirel & Ertan Düzgüneş

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Lyon 2024

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Landscape Research-IV

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PREFACE

DEAR PROFESSORS, COLLEAGUES

Assoc. Prof. Dr. Ertan DÜZGÜNEŞ and I undertook the editing of Landscape Research-IV (English) and Peyzaj Araştırmaları-IV (Turkish) books with your academic contributions and support.

The achievements of the Turkish Journal of Landscape Research (PEYAD), which we have brought to the academic portfolio of landscape architecture and has been continuing for 7 years, have created a driving and encouraging force for us to prepare 6 edited books called 'Landscape Research-I/II/III' and 'Peyzaj Araştırmaları-I/II/III' in 2021, 2022 and 2023. This year, we are happy to realise the fourth edition of both books.

In 2024, 'Landscape Research-IV' in English and 'Peyzaj Araştırmaları-IV' in Turkish will be published as e-books. Our professors who sent their academic studies/book chapters to both books as book chapters sent their book chapters by choosing Landscape Research-IV in English or Peyzaj Araştırmaları-IV in Turkish according to their own wishes. Both books were published by the French publishing house 'Livre de Lyon' and we have shared with you the information conveyed to us by the publishing house (indexes scanned, having contents and competences covering academic applications in the academic sense / compliance with the Application Criteria for Aassociate Professorship and Academic Incentive Applications).

Landscape Research-IV book with 24 chapters and Peyzaj Araştırmaları-IV book with 28 chapters have been published. We are proud to have reached these numbers with your contributions and support.

We wish to continue this process we have started in the coming years. Thus, we will ensure the continuity of Landscape Research (English) and Peyzaj Araştırmaları (Turkish) books with successive issues.

We would like to thank the editorial board who contributed to the editorial process, the SEKİZGEN Academic Platform and the Livre de Lyon Publishing House and its officers who followed the process successfully. The biggest thank you deserves to be given to you, our valuable book chapter authors, for sharing your qualified and valuable works with us.

September 2024

Editors
Prof. Dr Öner DEMİREL
Assoc. Prof. Dr Ertan DÜZGÜNEŞ

Prof.Dr.Öner DEMİREL, Landscape Architect, T.C. Kırıkkale University Head of Department of Landscape Architecture, Faculty of Fine Arts



• He was born in Ardahan in 1964. He graduated from Ege University Faculty of Agriculture, Department of Landscape Architecture in 1985. In 1988, he completed his Master's Degree in Landscape Architecture at Ege University Institute of Science and Sciences. and in 1997, he completed his PhD in Landscape Architecture at K.T.U. Science Institute.

• Between 1987 and 1992, he worked at the T.C Ministry of Forestry. Between 1992 and 2017, he served as an academician at Karadeniz Technical University. He was appointed Assistant Professor in 1998, Associate Professor in 2000 and Professor in 2007.

• Between 1990-91, he received the CIHEAM Scholarship, Montpellier (France) and from 1991-92 he received the CIHEAM Scholarship and the Saragosa (Spain) Scholarship. He was granted three Belgian Government scholarships in 1994, 1996 and 2000. Ağustos Between 2001 and June 2002, he conducted research at Arizona State University. Between August 2011 and February 2012, he conducted research at Northern Arizona University with the support of the Research Abroad Project. In 2015, he was granted a 1-year TUBITAK Postdoctoral Research Fellowship (Purdue University/USA).

• In addition to environmental and nature protection organizations, he also served voluntarily in non-governmental organizations and served as of various non-governmental organizations president ***(President of Belediyespor Tennis Club, TEMA Provincial Representative, TMMOB Trabzon Chamber of Landscape Architects Provincial Representative, Head of Mountain Protection Platform)***.

• In addition to the research projects supported by Corporate organizations, TUBITAK, Universities and various research Institutions, which he has managed and completed with wide participation at home and abroad as director and researcher, there are books and book chapters that he has edited and he also serves on the editorial board in scientific journals published at home and

abroad. He has served on the scientific committees of international and national conferences, congresses and symposiums, and has published articles in indexed journals and numerous papers presented abroad and at home.

- Öner Demirel has been serving as head of the Department of Landscape Architecture at The Faculty of Fine Arts, Kırıkkale University since January 2018. He speaks fluent English and French and is married with two children.

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CHAPTER XXI

OPPORTUNITIES FOR THE USE OF NATIVE MACROPHYTES IN DESIGNED LANDSCAPES*

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1. Introduction

As the use of biologically filtered water treatment practices such as biological ponds, natural swimming pools, rain gardens and bioretention swales have increased in landscape architectural practices, the search for ecologically suitable, environmentally sound and aesthetically pleasing aquatic species to be used in these practices is ongoing. In particular, there is a need to identify and propagate native aquatic macrophytes for use in such practices.

Using native species in landscape designs not only contributes to environmental sustainability but also adds aesthetic value to urban sites and marginal areas (Scarici et al., 2018). Aquatic macrophytes found in the native

* This study reports the results of the "Peyzaj değeri olan bazı su üstü köklü makrofitlerin kültürel çoğaltma olanaklarının araştırılması" titled Master's Thesis conducted in the Program of Landscape Architecture, School of Graduate Studies, Çanakkale Onsekiz Mart University. The research was supported by the Çanakkale Onsekiz Mart University Scientific Research Projects Coordination Unit (Project No: FYL-2022-4168).

vegetation are particularly needed in landscape architectural practices such as wetland restoration, rain gardens, biological ponds, and pools to utilize the plants' ability to purify water.

When we look at landscape architectural practices involving aquatic plants, it is evident that the water-purifying capabilities of these plants are often overlooked. Instead, the aesthetic value and ease of provision are prioritized in the selection of aquatic plants. This is mainly because there are some challenges regarding the propagation and cultivation of these plants in practice. This study, therefore, aims to contribute to the scientific literature by exploring the potential use of aquatic macrophytes outside their natural habitats and to promote the use of these species in designed landscapes for both aesthetic and functional purposes.

2. Macrophytes

Aquatic macrophytes, which may also be referred to as hydrophytes or aquatic plants, are defined as macroscopic plants whose life span may completely or periodically take place in an aquatic environment (Lesiv et al., 2020). Macrophytes, are generally refered to plants that can be identified at the species level with the naked eye. This definition, however, is not entirely precise, as in some cases, tools such as microscopes or magnifying glasses may be required for identification. Taxonomically, the definition of macrophytes includes macroalgae, bryophytes (mosses, liverworts and hornworts), pteridophytes (ferns and fern allies), spermatophytes (seed-bearing plants) and some vascular plants (Bornette and Puijalon, 2009; Büke, 2019).

Macrophytes have adaptive mechanisms, which allow them to inhabit a variety of aquatic habitats such as wetland, swamps and marine environments. Aquatic macrophytes include both deep water and shallow water species. While some species are completely aquatic, others can adopt to changes in water levels and grow in periodically inundated environments (Lesiv et al., 2020).

Aquatic macrophytes can be classified according to their interaction with the aquatic environment depending on whether they are emerged, submerged or floating, and whether they are free of or attached to the sediment (Kochi et al., 2020) (Figure 1). Bakır (2015) define aquatic macrophytes under the following three headings.

1. **Submerged macrophytes**: These plants live underwater, with roots anchored to the bottom. Their leaves and stems remain submerged. Some live entirely underwater, while others have leaves that extend towards the surface.

2. **Emergent macrophytes:** These plants are rooted below the water surface, but their leaves and flowers are found at or just above the water surface. They live partially or completely free of the water's surface depending on periodical changes in water levels.

3. **Floating macrophytes:** These plants float entirely on the water's surface. Their leaves are usually large and round, visible above the water. Floating macrophytes can be further divided as attached or free floating macrophytes. With floating attached macrophytes, while a significant portion of the plant floats on the surface, the roots are anchored to the bottom

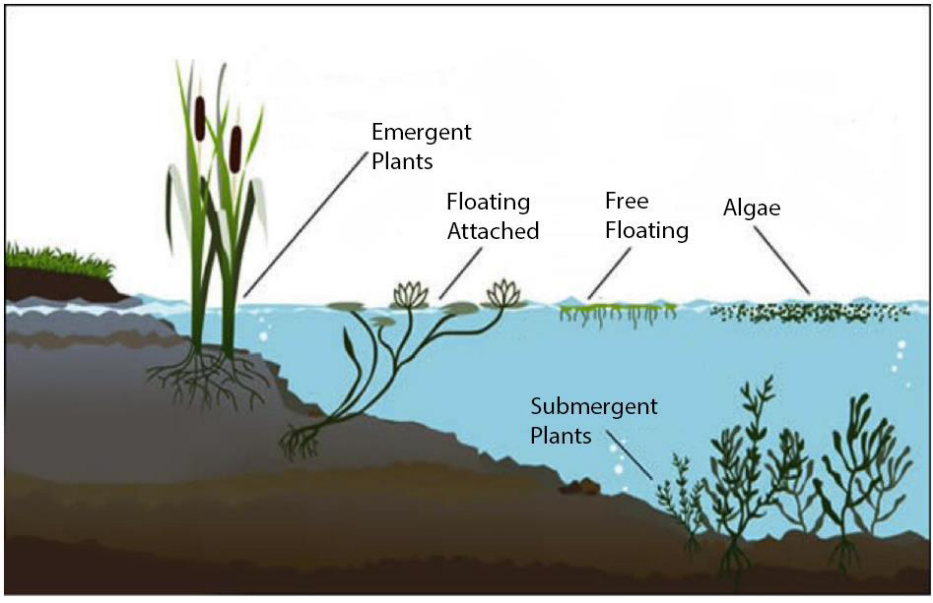


Figure 1. Classification of aquatic macrophytes according to their interaction with the aquatic environment (Bütünoğlu, 2018; Gün and Ak, 2022)

Although it may differ across different taxonomic groups, must aquatic species can reproduce vegetatively (Bornette and Puijalon, 2009). Clonal propagation is considered another main mechanism for macrophyte reproduction. While sexual reproduction is considered a less productive strategy, the main means for pollination or the fruit and seed dispersal of angiosperms is described as hydrochory (dispersal by water), zoochory (dispersal by animals) and anemochory (dispersal by wind) (Lesiv et al., 2020).

3. Ecosystem Services Provided by Macrophytes

Macrophytes function as key elements of freshwater ecosystems, by changing the physical and chemical environment, assisting nutrient cycling, providing habitat for biodiversity, in addition to providing cultural benefits to people (Bornette and Puijalon, 2009; Thomaz, 2023). Aquatic macrophytes, furthermore, provide both habitat and food for fish and invertebrate communities, stabilize substrates and modify stream flow (Suren, 2009).

A review carried out by Thomaz (2023), identified 26 types of ecosystem services provided by freshwater macrophytes. These services were classified under four categories (supporting, regulating, provisioning and regulating services) developed by the Millenium Ecosystem Assessment Report of 2003 and 2005 (Thomaz, 2023). Among these services those that were more strongly affected by macrophytes were *nutrient cycling* and *provisioning of habitat* (supporting services - indirect/long-term benefits), *water purification and waste treatment* (regulating services) and *food* (provisioning services).

From a landscape architectural perspective, the cultural services that aquatic macrophytes provide such as local knowledge system, educational value, inspiration, aesthetic value, as well as recreation and ecotourism are also thought to be important.

4. Nutrient Removal of Macrophytes

Contamination of water resources resulting from rapid population growth, intense industrial and agricultural activities increase the demand for clean water, necessitating more cautious measures against the pollution of currently used water resources. Harmful substances found in wastewater reduce the amount of oxygen available in water, negatively affecting the ecological balance and decreasing the quality of surface waters. Additionally, nitrogen and phosphorus compounds in wastewater cause algal blooms, oxygen depletion and fish deaths (Coşkun et al., 2018).

Recently, environmental pollution and the contamination of water resources have emerged as serious global issues. As a result, various methods are being sought to combat water pollution. In this context, the contributions of macrophytes to water purification are an important topic. Macrophytes play a crucial role in improving water quality and reducing pollution in aquatic environments. In the absence of macrophytes, water quality in aquatic environments can deteriorate. Factors such as turbidity and salinization are

considered reasons for this decline. The high nutrient content of water can lead to excessive growth of macrophytes, which can disrupt the natural functions of the water (Topaldemir, 2021).

Macrophytes are organisms that respond to various pressures, such as nutrients, toxic pollutants, metals, herbicides, turbidity, light, water level changes, and salinity. Due to these characteristics, they are considered good indicators of the current state of water bodies (Topaldemir, 2021).

Macrophytes absorb excess nutrients such as nitrogen and phosphorus in aquatic environments, preventing the proliferation of these substances. These nutrients cause the excessive growth of algae (phytoplankton blooms) and are factors that reduce water quality. Additionally, if the levels of nitrogen and phosphorus in aquatic systems are above recommended levels, they can lead to eutrophication (Hoffman, 2013).

These nutrients are consumed by macrophytes through plant growth, which leads to improved water quality. Additionally, macrophytes compete with algae and bacteria for the existing nitrogen and phosphorus in the aquatic environment, preventing the excessive growth of these organisms (Hoffman, 2013). In other words, aquatic plants absorb excess nutrients, grow, and convert the absorbed substances into energy through photosynthesis.

5. Use of Macrophytes in Designed Landscapes

Since the nutrient removal capacity of macrophytes is utilized in water purification processes, this aspect has gained increasing importance in landscape architecture. In addition to their nutrient removal and water purification capabilities, macrophytes also hold a significant place in landscape architectural practices due to the aesthetic appeal and the natural environments they create. Freshwater landscapes contain various submergent, emergent, and floating-leaved aquatic macrophytes, which create visually appealing environments with their flowers and foliage (Taş and Topaldemir, 2021). Aquatic plants found in nature are needed, particularly in landscape architectural practices such as wetland restoration, rain gardens, swimming and ornamental ponds to harness their water purification capabilities.

Aquatic macrophytes not only provide aesthetic and natural environments but also improve water quality, clean water in artificial wetlands, and provide food, breeding, and shelter for some organisms as they do in natural wetlands, thus expanding the ecological spectrum. The dense plant cover in these areas can also mitigate the effects of negative environmental factors (e.g., wind, storms)

(Gülgün et al., 2010). Significant aquatic plants used in landscape architecture include *Acarus calamus, Arundo donax, Alisma lanceolatum, Alisma plantago-aquatica, Butomus umbellatus, Iris pseudacorus, Menyanthes trifoliata, Myosotis palustris, Sparganium emersum, Elodea canadensis, Myriophyllum spicatum, Nuphar lutea, Nymphaea alba, Salvinia natans, Typha domingensis, Phragmites australis, Fontinalis antipyretica, Pistia stratiotes, Lemna minor, Salix babylonica*, and *Eichhornia crassipes* (Gülgün et al., 2007; Gülgün et al., 2010).

Each plant has different water purification, water improvement, or aesthetic properties, and thus, are used according to their suitability to the purpose. For example, in a design where a windbreak is desired, *Arundo donax*, which can grow tall, can be used. In landscape designs where aesthetics and natural appearance are prioritized, such as rain gardens or ornamental ponds, it is more appropriate to use *Nymphaea alba*, known for its aesthetic effect (Gülgün et al., 2007).

6. Use of Native Plants in Landscape Architecture

Plant selection is of great importance in the design of landscapes. Plants are fundamental elements of landscape designs in terms of functionality, aesthetics, and ecology. The inclusion of native plants in such designs is, therefore, becoming increasingly important. The use of native plants not only expand the range of plants in landscape designs but also add aesthetic and functional features to these designs. Plants that play a significant role in landscape design also help create livable spaces. Utilizing the native vegetation of a region makes the planting design aesthetically and functionally more impressive and effective through the combination of different plant forms (Kılıçaslan and Dönmez, 2016).

Various studies emphasize that Turkey has significant potential in terms of plant diversity. Although there is great diversity in our native vegetation, the use of exotic plants in planting designs is still quite high. The use of exotic species in landscape designs may negatively affect biodiversity. Moreover, some exotic plant species put pressure on other plants and disrupt the ecological balance. Additionally, there are trees, shrubs, and herbs in the native vegetation that can be used in landscape designs, which have minimal requirements. The inclusion of these plants, therefore, in landscape designs becomes increasingly significant (Deniz and Şirin, 2005).

The benefits of using native plants in landscape architectural practices are summarized below (Özhatay, 2009):

- **Durability:** When properly placed and planted, native plants are less affected by regional climate changes. They are more durable compared to exotic plants.
- **Environmental Compatibility:** Native plants adapt best to local environmental conditions. They contribute to soil fertility, reduce erosion, and generally require less fertilizer and pesticides. Therefore, the initial establishment and maintenance costs of landscape designs using native plants are usually lower than those using exotic plants.
- **Support for Wildlife:** Native plants provide food and shelter for wildlife. When local habitats are lost due to urbanization, the use of native plants creates critical shelters for wildlife in these areas. Native plants can further be used to maintain and repair wildlife habitats.
- **Ecosystem Health:** The use of native plant species contributes to the restoration of healthy ecosystems. In urban areas, landscape designs using native plants help regain the area's natural landscape character.
- **Aesthetic Contribution:** Landscape designs that use native plants can evoke a sense of belonging to the region. For example, alpine plants present the best views in mountainous areas, tropical forest plants in rainforests, and cacti in their natural habitats.
- **Less invasive capacity:** Some exotic plant species can adapt more rapidly than native species and can become invasive plants that harm natural habitats.

The use of native plants in landscape designs offer a range of advantages in terms of environmental sustainability, ecosystem health, and aesthetics.

7. Objectives of the Study

This study aims to propagate emergent aquatic plants from the natural environment of the Marmara Region in a cultural setting, thereby promoting the use of native plants in landscape designs. Specifically, it aims to investigate the possibilities of culturally propagating native macrophytes for use in rain gardens, natural swimming pools, and biological ponds.

In Turkey, there is a lack of scientific research guiding such practices, and there are also challenges in translating theory into practice. For example,

although scientific studies (Thon and Kircher, 2017; Dold, 2008; Farb, 2020) indicate that species found in their native vegetation should be used in practice, there are difficulties in the propagation and cultivation of these plants. According to Scarici et al. (2018), the preference for using native plants in landscape designs contribute to both environmental sustainability and the aesthetic value of urban settings; however, their use is limited due to insufficient knowledge about their ecological characteristics.

Many national and international research focus on the possibilities of cultivating native plant species. For instance, Smart and Dick (1999) provide a guide for the production of aquatic plants outside their natural habitats, offering detailed recommendations on the environments and conditions needed for these plants. Tedesco and Petry (2013) investigate the cultivation possibilities of some aquatic plants as ornamental plants, using different propagation methods. In line with Turkey's climate conditions, Toscano et al. (2018) and Scarici et al. (2018) conduct studies in Italy on the landscape restoration and general use of wildflowers in the Mediterranean region, experimenting with the propagation and performance of these plants.

In Turkey, there are studies aimed at cultivating some native flowering bulbs (Özhatay, 2009). In addition to these studies, the possibilities of using native grown bulbous plants grown in the lakes region (Kılıçaslan and Dönmez, 2016), the use of native herbaceous plants (Deniz and Şirin, 2005), and the plant species that can be used in natural and artificial wetlands (Gülgün et al., 2010) have been studied under the discipline of landscape architecture. These studies, however, have been limited to reviews. Besides these studies, the distribution of macrophytes in some regions of Turkey (Ulucutsoy, 2006; Büke, 2019; Erduğan et al., 2020) is also a topic studied by other disciplines.

Based on previous studies and landscape practices, it is clear that the possibilities of culturally cultivating native plant species and the water purification capabilities of these plants are not well known in Turkey. One of the objectives of this study, therefore, is to find the optimal conditions for cultivating some macrophyte species with nutrient uptake capacity that naturally grow in Turkey. In this context, the aim of this study is to determine the cultural cultivation conditions of emergent rooted aquatic macrophtyes that grow around Lake Manyas and have the capacity to remove nutrients from the water.

8. Materials and Methods

8.1. Materials

The plant species used in this study were selected from the emergent aquatic plants located in the Manyas Kuş Cenneti National Park and along the shores of Lake Manyas. The primary reason for choosing plants from this site is that the research was conducted in Çanakkale, and the ecological conditions of Lake Manyas are similar to those of the Marmara and Aegean Regions. Another reason for selecting plant species from this area was because of their resilience to environmental stress and changes in water levels.

The master's thesis prepared by Ulucutsoy (2006) identified the summer season macrophytes in the tidal zone of Manyas Kuş Cenneti National Park. The fact that the identified plant species are located in the tidal zone and are exposed to water pollution, showing resistance to environmental stress, is a significant reason for selection of plants from this area.

The climate of the region is influenced by the Mediterranean climate, resulting in winters that are not very cold and generally rainy, and summers that are hot and dry. The average temperature is 15°C. The coldest temperature recorded is -14°C in January, while the hottest temperature recorded is 41°C. The region receives the most rainfall in December and January, while the least rainfall occurs in July and August. The prevailing winds are the northeast and southwest winds and snowfall can be observed in the winter (Alan, 2022; Avan, 2007).

In this study, ten emergent aquatic plants with higher nutrient removal capacity, higher aesthetic value and less invasive capacity were selected for cultivation. The reason for selecting emergent aquatic plants is that these plants have greater species diversity (Thon and Kircher, 2017) and a larger leaf surface area. A larger leaf surface area is important because there is a high correlation between plant biomass and the plant's nitrate removal capacity (Hoffman, 2013).

Another study utilized in the selection of plant species is Bütünoğlu's (2018) specialization thesis, which evaluates the nutrient removal capacities of aquatic plants. From the summer season macrophytes located in the tidal zone of Manyas Lake (Ulucutsoy, 2006), those that had higher nutrient removal capacity (Bütünoğlu, 2018) and higher aesthetic value were further selected for cultivation. Aesthetic features such as plant form, flowering characteristics, and leaf traits were evaluated during the selection process.

The ten selected species are as follows:

- *Alisma plantago-aquatica* (Water Plantain)
- *Butomus umbellatus* (Flowering Rush)
- *Carex* sp. (Sedge)
- *Ipomoea sagittata* (Saltmarsh Morning Glory)
- *Iris* sp. (Iris)
- *Juncus effusus* (Common Rush)
- *Lythrum salicaria* (Purple Loosestrife)
- *Mentha aquatica* (Water Mint)
- *Sparganium erectum* (Branched Bur-reed)
- *Typha latifolia* (Broadleaf Cattail)

8.2. Methods

In order to identify the locations of the selected plants for the research and to understand their ecological requirements (light, temperature, sunlight, and humidity), the plants were observed in their natural habitat around Lake Manyas on September 16, 2022 (Figure 2). Samples for propagation were collected on October 24, 2022. Ten cuttings were taken from each plant, and additionally, offspring samples were collected from *Iris* sp., *Mentha aquatica*, *Sparganium erectum, Alisma plantago-aquatica, Juncus effusus*, and *Typha latifolia*.



Figure 2. On-site observation of the plants subject to experiment

The collected plant samples were transferred to rooting trays under controlled conditions (25°C, 14 hours of light, 10 hours of darkness, 50-60% relative humidity) in the experimental laboratory of the Faculty of Agriculture at Çanakkale Onsekiz Mart University on October 24-25, 2022 (Figure 3). On October 31, 2022, a fertilizer solution of 10 N, 10 P, 10 K was diluted with water at a ratio of 30ml/1000ml and 20 cc were applied per plant. On December 8, 2022, after transplanting the plants to an outdoor environment, the same liquid fertilizer was applied again at the same ratio.



Figure 3. Rooting trays under climate-controlled conditions

Three samples from the rooted plants were transplanted on November 29, 2022, into 9.3-liter pots filled with a mixture of 50% perlite and 50% peat. These potted plants were then moved to an outdoor setting, and the pots were placed in 100x150 cm elevated plant growing trays filled with water (Figure 4). To protect the plant growing trays from wind, they were kept in the inner courtyard of the Faculty of Fine Arts at Çanakkale Onsekiz Mart University. After transplantation, a temperature and humidity data logger was installed to collect climate data in the area where the plants were located.



Figure 4. The elevated plant growth trays and pots used in the experiment

On November 29, 2022, the first morphological measurements for the experiment were conducted. These measurements included leaf length and width, shoot length and number, shoot and leaf counts, and the flowering period. Subsequent measurements were taken at two-week intervals. However, due to extreme weather conditions, some measurements were conducted every three weeks. A total of 14 measurements were taken, and the measurements for some species were completed with the onset of flowering.

The plant growing containers, which housed the experimental pots, were initially filled with water at the beginning of the experiment. On the dates when measurements were taken, the water level in the containers was replenished as needed. Particularly after temperatures began to rise in the spring, watering was primarily done from the top of the pots, and subsequently, the containers were refilled.

9. Findings

Among ten macrophyte species collected from Manyas Lake and transplanted into a rooting environment, only six species survived. Specifically, the rooting of reed plants propagated through leaf cuttings such as *Butomus umbellatus, Carex* sp., *Juncus effuses,* and *Typha latifolia* were unsuccessful in the climate-controlled laboratory. The seedlings of the six species that successfully rooted were transplanted to outdoor pots. Among these, *Mentha aquatica* was able to propagate both through cuttings and offsets. For all the plants except *Iris* sp., three samples each were transferred to pots. Since only two samples of *Iris* sp. survived, they were the only ones transplanted outdoors. The first flowering occurred on May 3, 2023. The data were processed in MS Excel, and the arithmetic means of the morphological measurements for each plant species were calculated. The obtained results were analyzed along with the climate data.

The table below shows the average minimum and maximum temperatures, and relative humidity percentages of the outdoor experimental environment (Table 1). While the lowest temperature was recorded in February, the highest temperature was recorded in June. The relative humidity in the experimental environment is generally high (42.3-77.5%). Due to the enclosed nature of the environment where the experiment is conducted, it received a lot of sunlight, and the temperature values measured here are 1-2°C higher than those recorded by the General Directorate of Meteorology for the Center Province of Çanakkale (Table 2).

Table 1: Climate data from the experiment site

Months	Average Temperature (°C)	Minimum Temperature **(°C)**	Maximum Temperature **(°C)**	Relative Humidity (%)
Dec ‘22	12.6	3.2	23.9	77.5
Jan ‘23	10.9	5.5	21.8	75.4
Feb ‘23	9.6	-1.0	25.7	62.9
Mar ‘23	12.5	5.6	33.1	69.8
Apr ‘23	15.6	9.1	33.0	67.0
May ‘23	19.2	10.7	33.5	64.1
Jun ‘23	25.1	16.5	40.6	55.6
Jul ‘23	30.9	21.5	48.0	42.3

With the experimentation of *Alisma plantago-aquatica*, there has been some uncertainty in species identification as the plant developed. The data obtained from this species, therefore, are not presented here.

Table 2: Climate data for the Center Province of Çanakkale

Months	Average Temp. (°C)	Minimum Temp. (°C)	Maximum Temp. (°C)	Relative Humidity (%)	Average rainfall (mm)
Dec ‘22	11.5	2.0	19.9	81.9	43.2
Jan ‘23	9.9	1.8	18.7	78.6	51.2
Feb ‘23	7.5	-2.5	18.9	70.2	6.5
Mar ‘23	10.5	1.3	20.3	78.2	114.6
Apr ‘23	13.2	4.5	20.7	79.3	45.1
May ‘23	17.5	8.4	29.5	71.2	33.0
Jun ‘23	23.3	14.8	33.5	63.2	40.2
Jul ‘23	27.9	17.3	39.2	52.8	0.7

Kaynak: TSMS (2023)

The data for the remaining species are provided below. The following graphs show the leaf length, width, number, shoot length, and number for different plant species grown outdoors from end of November to end of June. Each plant’s measurements are based on 2 or 3 samples, the data presented in the graphs are average values obtained from the cultivated plants.

During the initial placement into outdoor pots, *Lythrum salicaria* showed development but began to dry out due to cold weather conditions as winter approached. After producing a few shoots in the initial measurements, all shoots and leaves had dried up by February. Even after the weather warmed up, no revival was observed in the plant. By the end of June, the plant continued in this state, and unfortunately, none of the three plants survived (Figure 5).

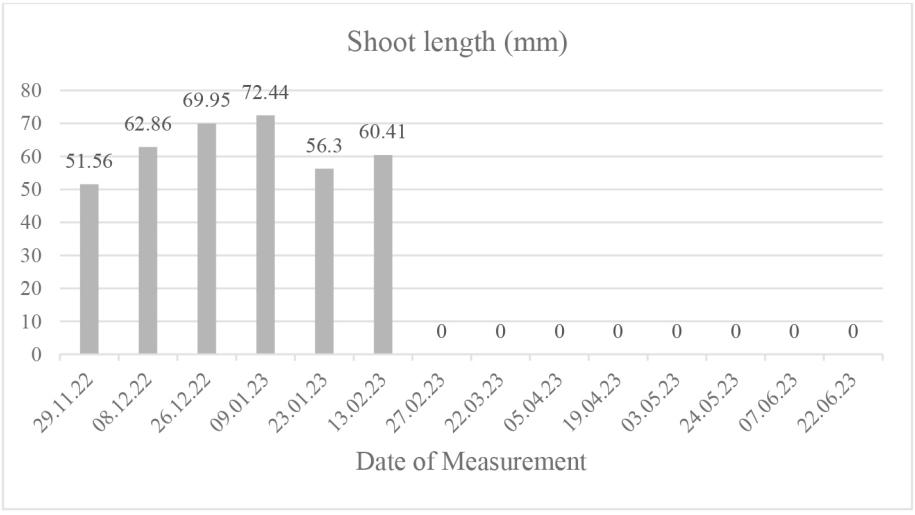


Figure 5. Average shoot length of the propagated *Lythrum salicaria*

Mentha aquatica was propagated using both stem cuttings and plant offsets. Despite both methods being grown under the same conditions, the plants propagated from stem cuttings showed slightly better leaf development (see Figures 6 and 7). Plants grown using both methods survived without any issues until June. The reason the leaf graphs only go up to the 8th measurement is that some of the leaves became deformed due to the shoots growing too long and entering the water in the plant basin.

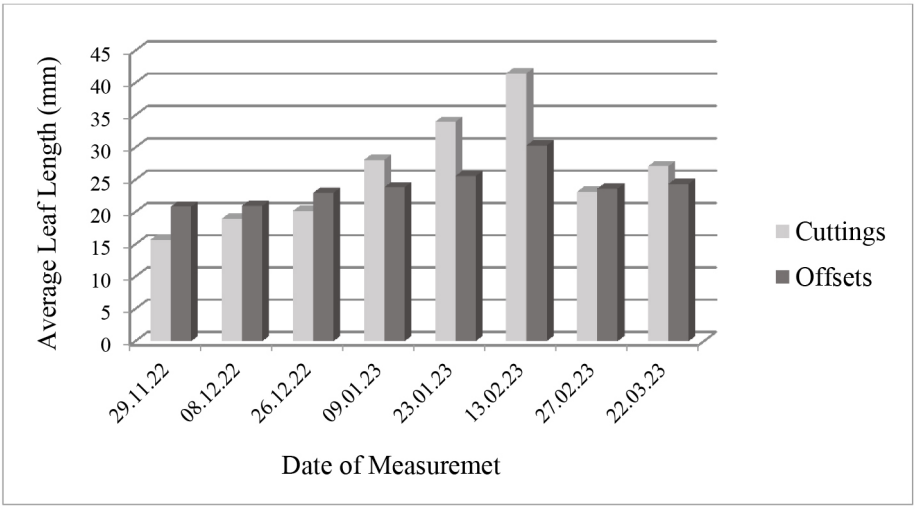


Figure 6. Average length of leaves for the *Mentha aquatica* species propagated from cuttings and offsets

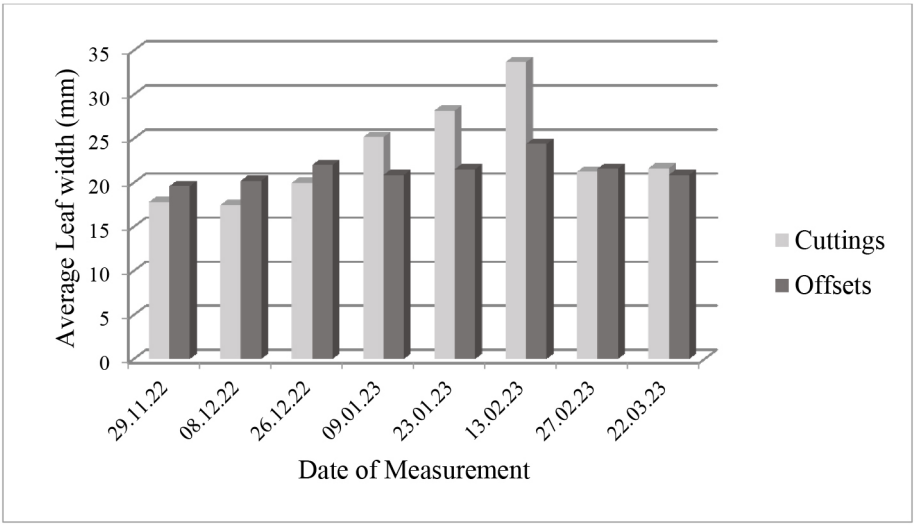


Figure 7. Average width of leaves for the *Mentha aquatica* species propagated from cuttings and offsets

After the plants were transferred to pots, the shoots began to elongate rapidly during the summer months. When comparing different propagation methods, the plants exhibited similar development in terms of the number of shoots (Figure 8), while the *Mentha aquatica* species grown from cuttings showed better growth in terms of shoot length (Figure 9). Both types of plants developed well in a pot and grew in a more upright form compared to their natural habitat.

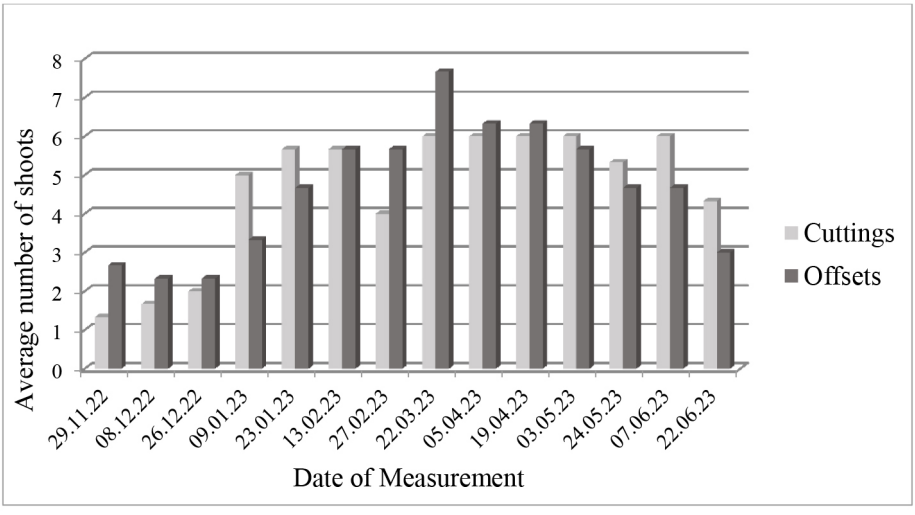


Figure 8. Number of shoots obtained from the *Mentha aquatica* species propagated from cuttings and offsets

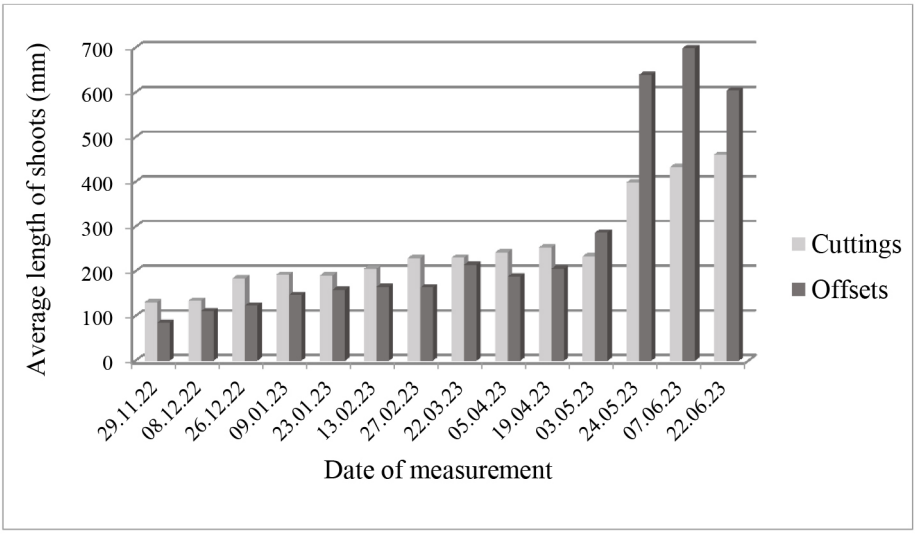


Figure 9. Length of shoots obtained from the *Mentha aquatica* species propagated from cuttings and offsets

The *Iris sp.* species propagated from bulbs initially rooted successfully in the climate-controlled laboratory. A few weeks after being transferred to pots, they entered dormancy due to the cold weather. Once the weather warmed up, they resumed growth and started producing new shoots. A total of 2 plants were cultivated, and the data for plant height and number of leaves are shown in Figures 10 and 11.

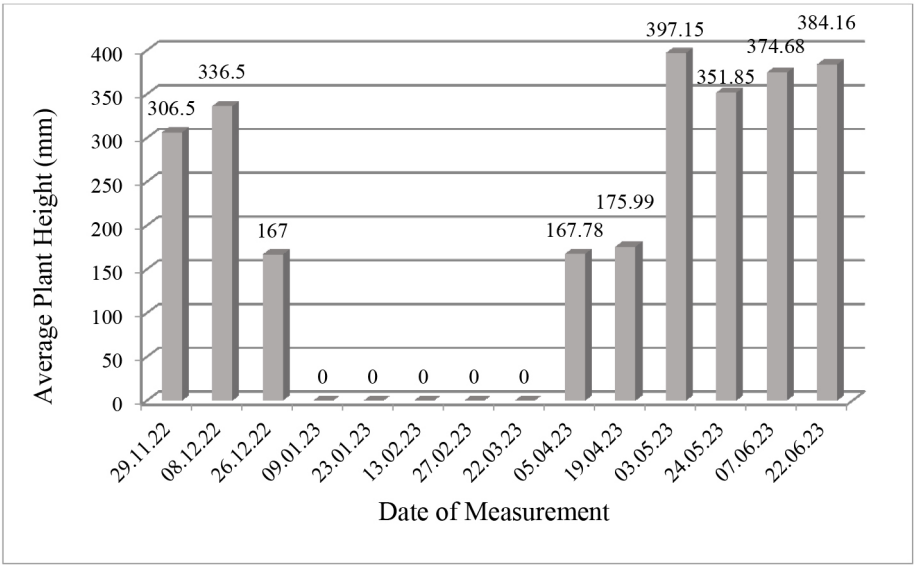


Figure 10. Average plant height for *Iris* sp. propagated from bulbs

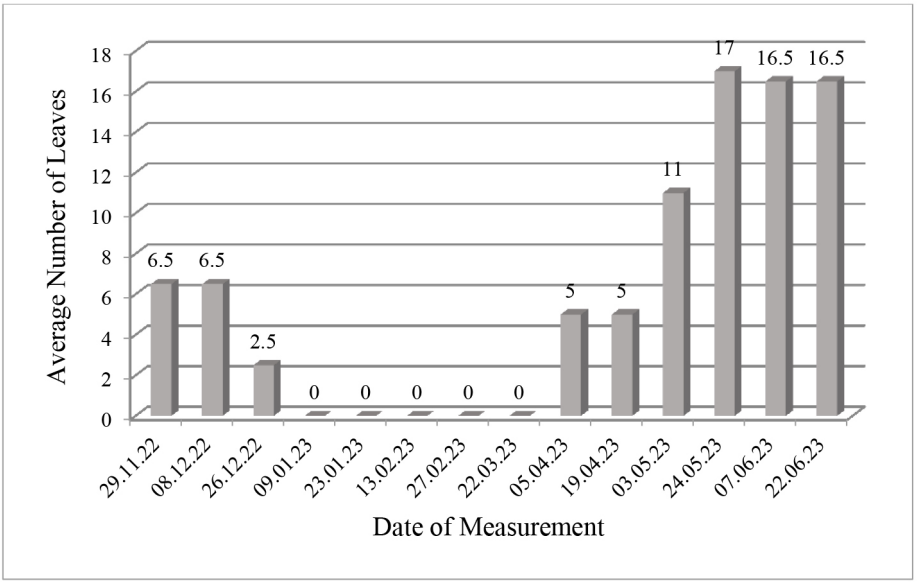


Figure 11. Average number of leaves for *Iris* sp. propagated from bulbs

Ipomoea sagittata, a climbing vine, was propagated from stem cuttings. The number of leaves produced by the vine are provided in the following graph (Figure 12). *Ipomoea sagittata* managed to grow successfully under experimental conditions. However, the 2nd plant eventually began to dry out and died from unknown reasons. In addition, during periods when the water level in the growth tanks were high, the leaves that touched the water body experienced decay. In addition, in extremely hot conditions, the leaves began to turn yellow. Notably, after the 6th measurement, some leaves decayed, but with the weather warming up, new leaves began to emerge. The average leaf counts measured from all plants are provided in Figure 12.

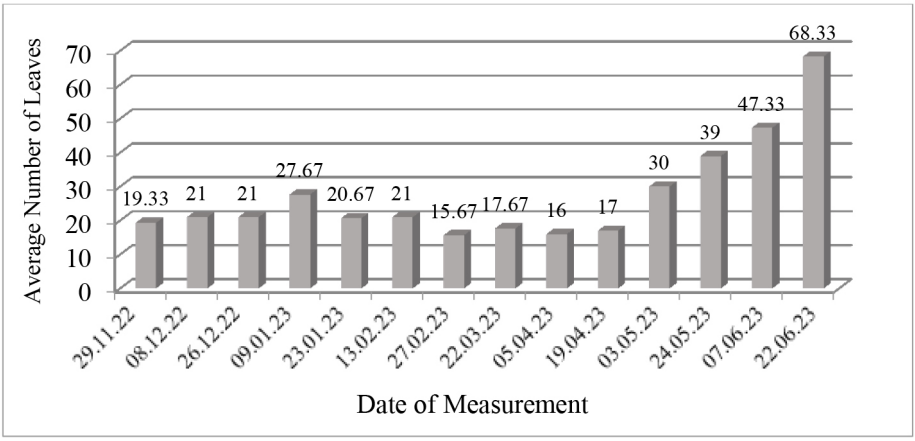


Figure 12. Average number of leaves of the *Ipomoea sagittata* cuttings

As can be seen from the graph (Figures 13), *Sparganium erectum* did not show any growth during the months of winter and late spring but suddenly started to reveal themselves during the summer. Due to the warm weather, multiple plants emerged and began to develop. Their growth continued throughout the summer. One of these plants showed signs of insect damage and unfortunately did not survive, eventually drying out. The remaining 2 plants did not encounter any issues and continued to grow.

Out of the six plants that were successfully rooted and transplanted to outdoor pots, *Lythrum salicaria* did not survive the winter and died in February, likely due to the air temperature falling below 0°C.

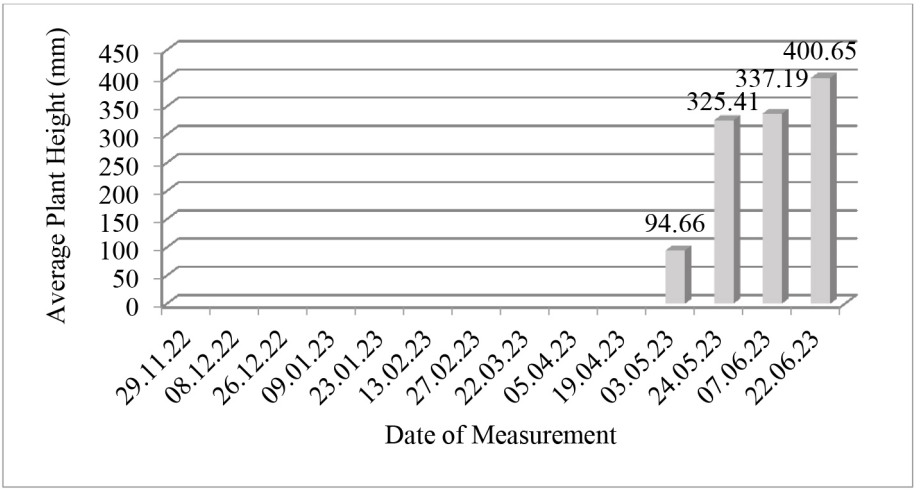


Figure 13. The average plant height of *Sparganium erectum*

10. Conclusion

Concerns of drought and water scarcity worldwide, have led topics such as water reclamation and treatment to gain importance. As a result, practices such as wetland restoration, rainwater harvesting, and wastewater treatment have been widely supported and adopted in many countries. In Turkey, it has been observed that such initiatives are particularly in progress with regards to wetland restoration. However, within the landscape architecture discipline, concerned with practices such as rain gardens, biological pools, and ponds, it is evident that the water-purifying capabilities of plants are not sufficiently utilized.

The primary reasons for this include the lack of awareness regarding the water purification capacities of plants and the continued preference for mechanical and chemical treatment methods in many applications. Additionally, there are limited efforts towards cultivating aquatic plants, which have the capacity to clean water. This study, therefore, aimed to cultivate emergent aquatic macrophytes that can naturally grow in the Marmara Region.

For this purpose, ten plant species that grow naturally around Lake Manyas, which are suitable for use in landscape designs for both their nutrient removal capacity and aesthetic value (flowering, form, and leaf density), were identified, located, and transferred for propagation. Among these macrophytes, herbaceous species (*Butomus umbellatus, Carex* sp., and *Juncus effusus*) failed to propagate through leaf cutting. Among the woody species that succeeded in rooting, *Lythrum salicaria* died after being transplanted to the outdoor environment, likely due to a drop in temperatures. The species identified and rooted as *Alisma plantago-aquatica* was later suspected to be misidentified, and thus, not included.

It was found that *Mentha aquatica*, known for both its nutritional value and fragrance, could be easily propagated and cultivated outside its natural habitat. From the perspective of potential use in landscape architectural practices, the expected form of this species was not achieved when grown in a pot. It is recommended, however, to plant this species in open areas and monitor its development over time, also to understand it invasive capacity.

In conclusion, four species of emergent macrophytes (*Ipomea sagittate, Iris sp., Mentha aquatica, Sparganium erectum*) have successfully been cultivated outside their natural habitats in this study. The successfully cultivated plants in this study might replace exotic plants used in landscape designs. For instance, *Ipomea sagittata* could be used instead of climbing plants that are used traditionally. *Mentha aquatica* could also potentially be used in these practices,

while also attracting public attention. They should be used in caution, however, after having better knowledge of their invasive capacity in the areas of practice.

It is suggested that future studies can benefit from and build upon this study. The species that could not be cultivated in this study might thrive under better conditions or if taken from their natural habitat and immediately planted. In this study, some species might not have established because they spent several hours in transit from their natural habitat. Future studies could yield better results with collaboration with botanists or horticulturists. By working together with other professional disciplines to cultivate aquatic macrophytes from similar other lakes or wetlands, more efficient results could be achieved. Different propagation and production techniques could be tested on plants, potentially enabling the cultivation of species that could not be propagated in this study.

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