Assessment of the Flora and Vegetation of the Shaumari Wildlife Reserve, Jordan

Bilal A. Ayasrah[1], Hothifah Al- Zyout[2*], Asma F. Bzour[2], Mohammad Al- Zyoud[2] and Laya Majed[2]

[1] Fieldfare Ecology Company; [2] Nature conservation Monitoring Center NCMC/ The Royal Society for the Conservation of Nature RSCN, Jordan

Received: November 16, 2024; Revised: December 22, 2024; Accepted: December 29, 2024

Abstract: The Shaumari Wildlife Reserve, located 120 km east of Amman, is a natural protection site for dry ecosystems. It serves as a complete biodiversity station, with native animals and natural vegetation away from human disturbance. Several Field surveys were conducted in the reserve to collect plant specimens and data on habitat types and plant communities for the sake of mapping them. During this survey, random routes and quadrat analysis were used, and GPS records were taken. A geological map was prepared and modified. The reserve lies across three main formations: Azraq formation (AQ), Fluviatile deposits and gravel of Pleistocene (Pl/ Plg), and Holocene to recent alluvial sediments (Al). Four habitats were identified based on topography, soil type, and the distribution of dominant plant species as follows: Gravel plains with dwarf shrub vegetation habitats, Wadis wih sandy or gravel floors, and drainage channels habitat, Wadis with dike wall, and drainae channels and Urban areas.Two main vegetation types were determined in this reserve including Gravel Hammada and Saline vegetation. The reserve has thirteen different plant communities, primarily distributed within the Run-off hamada vegetation. A checklist of 197 recorded species belonging to 125 genera and 35 families has been prepared. Amongst the checklist species, two are globally endangered according to IUCN red list, (IUCN, 2024),namely *Bellevalia warburgii* and *Euphorbia grossheimii*. At the national level, seventeen rare species were recorded, and eleven species were endemic to Jordan. In addition, there were two species that are considered invasive plant species; *Xanthium spinosum* and *Xanthium strumarium* and are distributed in the northwest of the reserve. A total number of seventy-five plant species were collected and recorded from twenty-one quadrats. The analysis showed that *Anabasis articulata* scored the highest frequency value among the perennial species, while the highest density was recorded for *Atriplex halimus*, and the highest abundance was for *Halogeton alopecuroides*. Specimens of the collected plant species have been deposited in the Royal Society for the Conservation of Nature RSCN/NCMC Herbarium.

Keywords: Biodiversity, Plant species, Protected Areas, Habitat, NE Desert, Mapping, RSCN.

Introduction

The Shaumari Wildlife Reserve is located in the eastern desert of Jordan with a total area of 22 km² surrounded by a fence. The reserve is located about 120 km east of Amman, and 12 km southwest of the Azraq village. The Shaumari Wildlife Reserve is the oldest national reserve in Jordan established as a center and international biological station for the protection and rehabilitation of the locally extinct Arabian Oryx and endangered gazelles at the global level. It is considered an important example of natural protection as well as a living area for the protection of dry ecosystems. Moreover, it can be used as a complete biodiversity station since it has both native animals and natural vegetation that are away from human interference (Al-Eisaw, 1996).

The Shaumari Wildlife Reserve is situated after Tethys Sea regression and migration in the Hammada Plains, which is one of the regional geomorphological provinces in the Azraq area. The reserve consists of extensive

*Corresponding author: hothifah.alzyout@rscn.org.jo

flat or gently sloping plains with a distinctive ferret-dendritic drainage pattern (Abed *et al.* 2008). The plains are strewn with partially weathered fragments of limestone and flint or chert.

The oldest formation exposed in the reserve is the Azraq formation (AQ) dating to the middle Pleistocene age (Abed *et. al*, 2008; Abed and Hamidan, 2021). It is dominated by mud plains, unconformably covers of the Chert- Limestone and Chalk formations (Ibrahim, 1996). The overlying AQ consists of Fluviatile deposits and gravel of Pleistocene (Pl/ Plg) characterized by poorly sorted deposits of limestone and gravel mostly black chert lithology and is usually cemented by gypsum (Ibrahim *et al.* 2001). The Pl/ Plg is overlain by the most recent deposits from Holocene to Recent sediments (Al) (Figure 1); the sediments include alluvial and wadi sediments, alluvial mudflats, and siltflats (Fadda, 1996).

Soil parent materials in the reserve include limestone, chalk, calcareous sands, gypsum, marls, and Tertiary cherts. These soils, when occurring with dense flint pavement, are named "Hammada" by Gruneberg and Dajani (1964).

Hydrologically, occasional runoff in the reserve occurs during the wet season and is caused by short and heavy thunderstorms, which may lead to large floods. Three wadis drain into the reserve, including Wadi Al-Shaumari, Wadi Al-Dab'i, and Wadi Al-Ghadaf (Fadda, 1996 and Ibrahim *et al.* 2001).

The Shaumari Wildlife Reserve is located within the Saharo-Arabian biogeographical region (Figure 2) (Al-Eisawi, 1996). The reserve extends over flat land and consists of two main landscapes: the Gravel Hammada and the Runoff Hammada. The Gravel Hammada is the flat part of the reserve and is confined to the south and southwestern parts. This area is comprised of clayey loam covered by gravel with sparse vegetation. The Runoff Hammada represents wadi beds, including three main wadis: Al-Ghaddaf, Al-Dab'i, and Al-Shaumari wadis, which constitute the largest part of the reserve.

The Shaumari Wildlife Reserve in Jordan is a unique ecosystem with a sparsely vegetated area, dominated by shrubs and subshrubs with a low density of individuals. The reserve has been the subject of several environmental studies and field surveys, with the first survey conducted by John Clark in 1975-1979. These surveys documented 170 plant species belonging to thirty-five families, which were collected and deposited at the Herbarium of the Royal Society for the Conservation of Nature (RSCN).

The reserve is surrounded by a fence, which protects it against all threats such as overgrazing and contributes to increasing the vegetation cover inside the reserve two to three times compared to the outside of the reserve (Hatough *et al.* 1986). This protection from grazing has allowed the development of a structurally complex and species-rich plant ecosystem which supports a more diverse community of mammals, reptiles, and birds compared to the outside of the reserve (Al- Eisawi and Hatough, 1987). The vegetation analysis revealed a mean vegetation cover of 23% in the reserve and a plant height reaching 84.1 cm, while there is only 5% outside the reserve with a height of <20 cm. This indicates that the reserve contributes to the prevention of desertification and serves as a good example for the rehabilitation of degraded desert areas, such as reducing runoff, increasing soil fertility, and enhancing seed banks. Al-Eisawi (1996) indicated that Hammada vegetation is dominant in the reserve and four main subdivisions are recognized; (i) Gravel Hammada, (ii) Runoff Hammada, (iii) Mud flats vegetation restricted to small areas with a poor vegetation except on the margins, and (iv) Saline vegetation. RSCN (2002) conducted an ecological baseline survey at the reserve recording 193 plant species with two species classified as endemic: *Salsola jordanicola* and *Rheum palaestinum* and seven as rare species (Al- Eisawi *et al*., 2000). In 2015, Al-Eisawi and Abu Yahia documented a total of eighty-three plant species belonging to twenty-two families and sixty-four genera; two of which are classified as endemic species; *Rheum palaestinum*

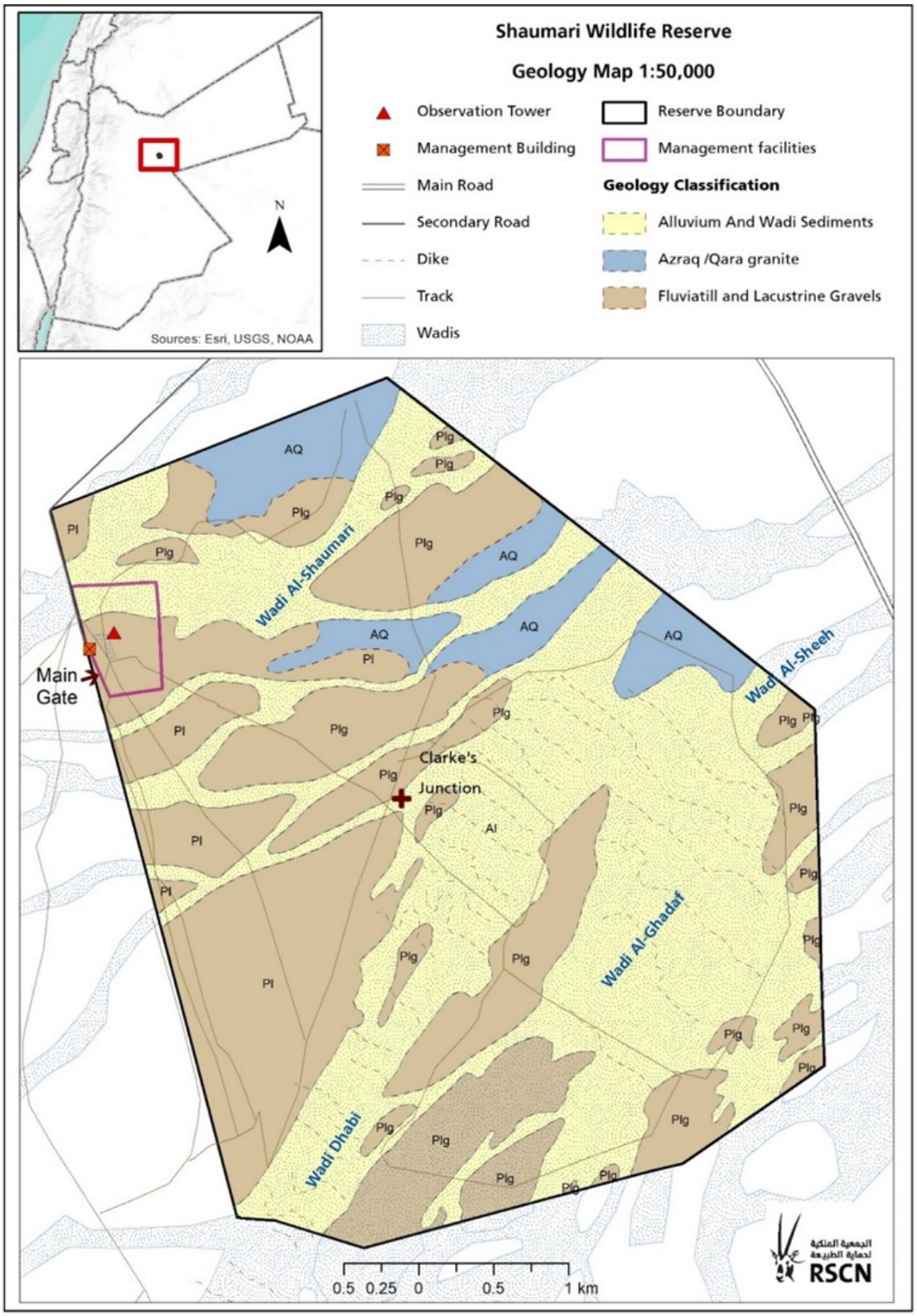

Figure 1. A modified geological map of the Shaumari Wildlife Reserve.

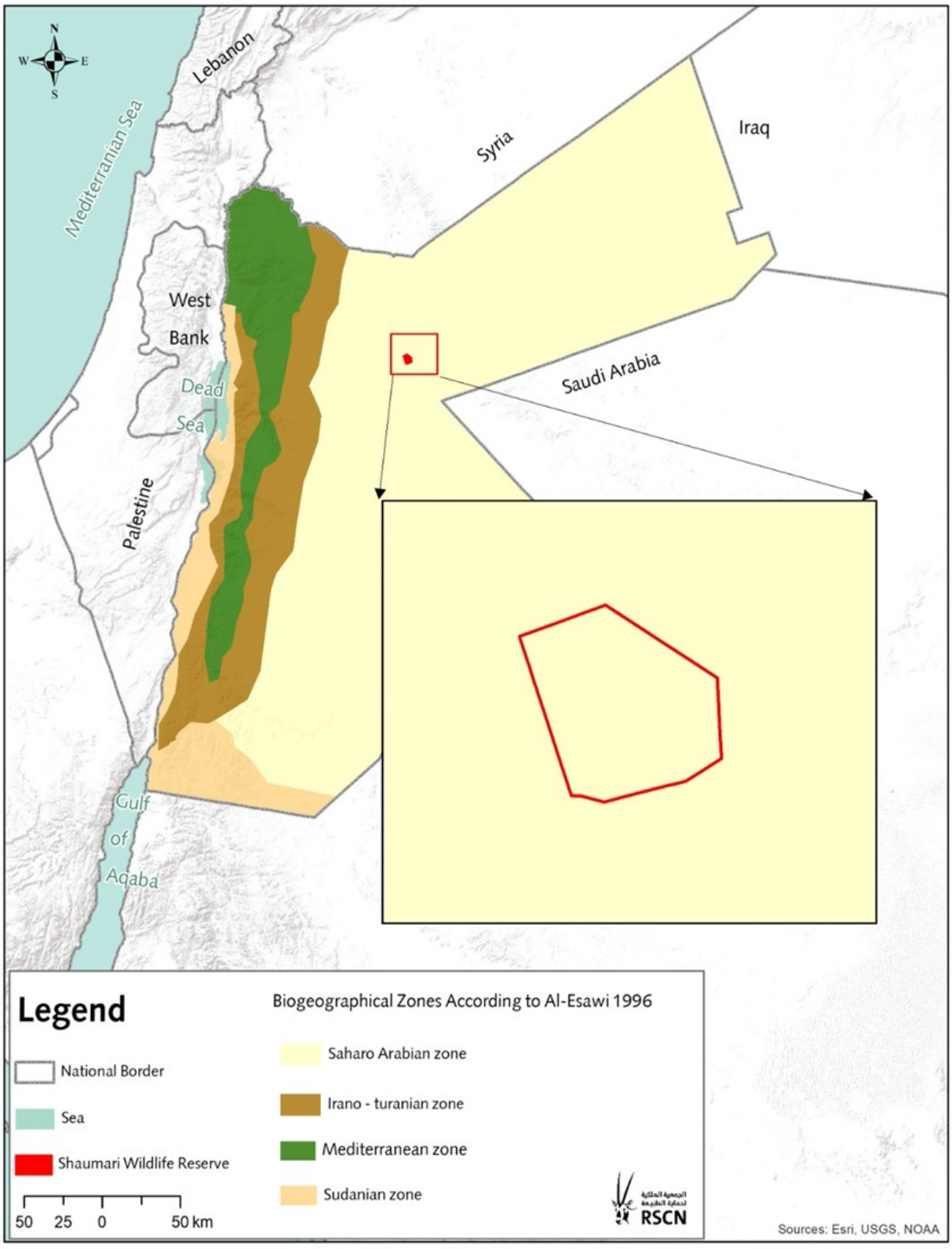

Figure 2. The biogeographical zone to which belongs the Shaumari Wildlife Reserve according to Al-Eisawi, 1996.

and *Salsola jordanicola,* and four as rare species at the national level; *Girgensohnia oppositiflora, Halocnemum strobilaceum, Suaeda fruticosa*, and *Pseuderucaria clavata*. The most recent study of flora and vegetation cover in the reserve was conducted in 2023. The vegetation cover in the reserve was assessed using satellite sensor data from the period between 1991 and 2022 (Majed, and Othman, 2023). The NDVI-Landsat showed that 70% to 94% of the reserve is classified as bare soil across the growing seasons (March to July) and over the study period. Additionally, in July-August (1991-2022), the percentage of reduction in vegetation cover area (compared to March) ranged from 1% (1994) to 20% (2004). The study concluded that a moderate and significant relationship between vegetation cover density and rainfall was found during the growing season in the reserve.

Despite all these studies conducted in the reserve, no plant specimens were collected except for Clark's in 1976. The study aims to evaluate the vegetation cover, including plant species and vegetation communities, and provide recommendations for supporting the management and conserving ecosystems of the reserve. Additionally, it aims at collecting plant specimens representative of each species present within the reserve and deposit them at the Herbarium of the Royal Society for the Conservation of Nature (RSCN).

Materials and Methods

Fieldwork

In 2023, Several field trips to different locations were conducted during the late winter and spring from April to May while five field trips were made throughout the summer. Two sampling methods, transects and quadrates, were applied, and each addressed specific elements of the vegetation and flora. Specimens were also collected using these two methods.

Line Transects

To evaluate the flora and vegetation across the landscape, plant specimens were collected. Also, data on the distribution, density, and other significant vegetation features, including vegetation communities, vegetation types, and habitat determination were gathered and processed.

The random route transects were conducted along eleven routes, covering a total distance of 51 km. This approach was aimed at surveying the largest possible area and collecting plants representative of each vegetation type within the reserve. This method allowed the teams to move freely, gather extensive data, and collect samples from all habitats within the reserve (Figure 3A). A representative specimen of each of the floral species recorded along the transects was collected for deposition in the herbarium and for taxonomy verification. The coordinates of the collection localities were recorded to produce flora and plant community maps of the reserve. All floral and vegetation data were recorded using a handheld GPS device (Garmin GPSMAPS 73s).

Measures of Species Population and Distribution

Systematic methods were used to produce area-based samples (quadrats) that could be allocated to a map. An assessment of the vegetation cover in the reserve was undertaken using quadrat sampling. In these sampling sites, the reserve area was subdivided into 1x1 km² grids. At the center of each grid, a sampling plot of 10x10 m² was assigned. A total of twenty-one plots were selected for the study, with ten quadrats excluded because more than 60% of their area lay outside the reserve boundaries (Figure 3B). Once the location for a quadrat was selected, the four corners were determined using a tape measure. At each quadrat, a data sheet was completed to record a series of attributes necessary for calculating quantitative measures of ecological parameters, including abundance,

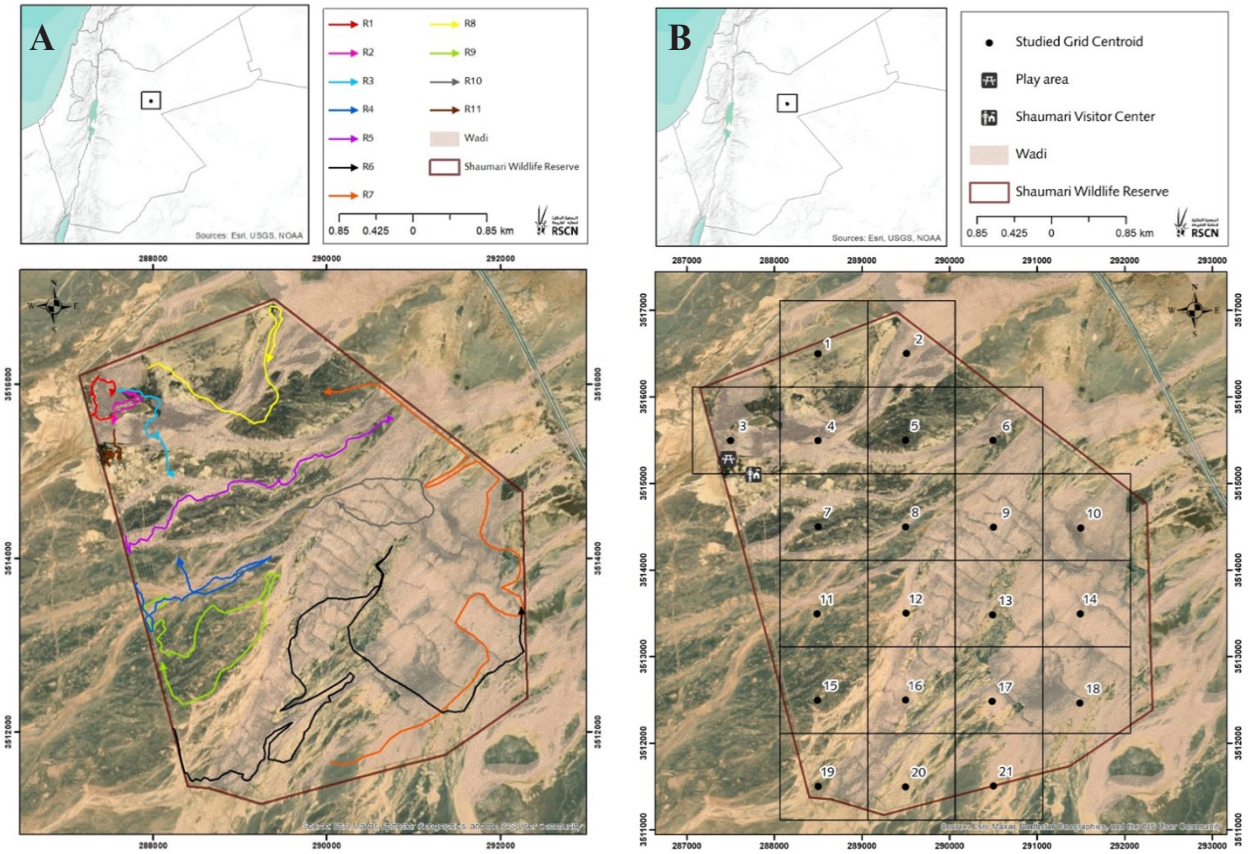

Figure 3. **A**: Random Routes Transects conducted in the Shaumari Wildlife Reserve. **B**: Location of quadrats conducted for the assessment of the flora in the Shaumari Wildlife

density, and frequency using the formulas based on (Ludwig and Reynolds, 1988).

Herbarium specimens' collection

All plant species recorded were collected, pressed, and assigned a reference number (Figure 4). The specimens were then identified in the laboratory using a dissecting microscope (40x magnification power) and based on Flora palaestina (volume 1, 2, 3, and 4) (Zohary 1966 and Feinbrun, 1986). The plant Names were revised according to the plant world online website (Kew, 2021). The plant species were poisoned chemically using a mixture of 150 g mercuric chloride (HgCl) and 350 g ammonium chloride (NH4Cl), dissolved in as little water as possible, with 10 L of 96% ethanol. The specimens were labeled, mounted, and a voucher specimen was deposited at the Herbarium of the Royal Society for the Conservation of Nature (RSCN) for each species.

Results

A total of 197 plant species were recorded in the Shaumari Wildlife Reserve, belonging to thirty-five families and 125 genera. Two species are evaluated as globally Endangered, namely *Bellevalia warburgii* and *Euphorbia grossheimii* (IUCN red list 2024). At the national level seventeen rare species were recorded in the reserve and eleven species were identified as endemic to Jordan including *Verbascum transjordanicum* (Figure 5). A list of the endangered and rare species is given in Table 1 (Al – Eisawi *et. al*., 2000). Based on their human uses, there are twenty-one plants used for medicinal purposes, thirteen edible species, thirty-two palatable plants, four poisonous species, and six woody plants. In addition, there are two species that are considered invasive plant species; *Xanthium spinosum* and *Xanthium strumarium* which are distributed in the northwest of the reserve and extend beyond the fence.

Figure 4. Herbarium specimen vouchers for the plant species collected from the Shaumari Wildlife Reserve. **(A)** *Limonium lobatum*, **(B)** *Bromus danthoniae*

Figure 5. *Verbasum transjordanicum*, an endemic species recorded from the Shaumari Wildlife Reserve.

Table 1. A List of Endemic and Rare Plant Species recorded from the Shaumari Wildlife Reserve

Species	Status at the national level
Achillea fragrantissima (Forssk.) Sch.Bip.	Near Endemic
Anthemis pseudocotula Boiss.	Rare
Astragalus transjordanicus Sam. ex Rech.f.	Endemic
Avena longiglumis Durieu.	Rare
Bellevalia warburgii Feinbrun.	Endemic
Brassica aucheri Boiss.	Rare
Bromus lanceolatus Roth var.lanatus Kerguelen.	Rare
Caroxylon tetragonum (Delile) Moq.	Rare
Centaurea ammocyanus Boiss.	Rare
Centaurea dumulosa Boiss.	Endemic
Ducrosia flabellifolia Boiss.	Rare
Echinops philistaeus Feinbrun & Zohary.	Endemic
Echinops polyceras Boiss.	Rare
Erodium arborescens (Desf.) Willd.	Rare
Euphorbia grossheimii (Prokh.) Prokh.	Rare
Galium aparine L.	Rare
Halocnemum strobilaceum (Pall.) M.Bieb.	Rare
Haplophyllum blanchei Boiss.	Near Endemic
Oloptum miliaceum (L.) Röser & Hamasha	Rare
Onopordum macrocephalum Eig	Endemic
Phalaris minor Retz.	Rare
Polygonum palaestinum Zohary.	Endemic
Rheum palaestinum Feinbrun.	Endemic
Sisymbrium damascenum Boiss. & Gaill.	Rare
Sisymbrium septulatum DC.	Rare
Sonchus suberosus Zohary & P.H.Davis	Endemic
Suaeda fruticosa Forssk. ex J.F.Gmel.	Rare
Verbascum transjordanicum Murb.	Endemic

Habitat Type

The field survey indicated that the reserve consists of four terrestrial habitats based on topography, soil type, and the distribution of dominant plant species (Figure 6) as follows:

Gravel plains with dwarf shrub vegetation habitat: It is flat land covered by gravel, constituting only a small area of about 48.9% of the total surface area of the reserve and is located in the Pl/Plg formation within the reserve. Vegetation in this habitat is sparse and is characterized by dwarf shrubs dominated by *Haloxylon salicornicum, Soda rosmarinus,* and *Anabasis articulata* (Figure 7A).

Wadis with sand or gravel floors and drainage channels: This habitat type accounts for 24.1% of the reserve area and consists of the main wadis covered by bushes, shrubs, and herbs with a very good vegetation cover. This habitat is located in the Alluvial and wadi deposits formation (Figure 7B).

Wadis with dike walls, and drainage channels: This habitat type accounts for 26.2% of the reserve area and consists of the wadi with a series of dike walls, about 2 meters in height (Figure 7C).

Urban areas: This habitat consists of reserve buildings and other infrastructure covering a small area of about 0.8% of the reserve.

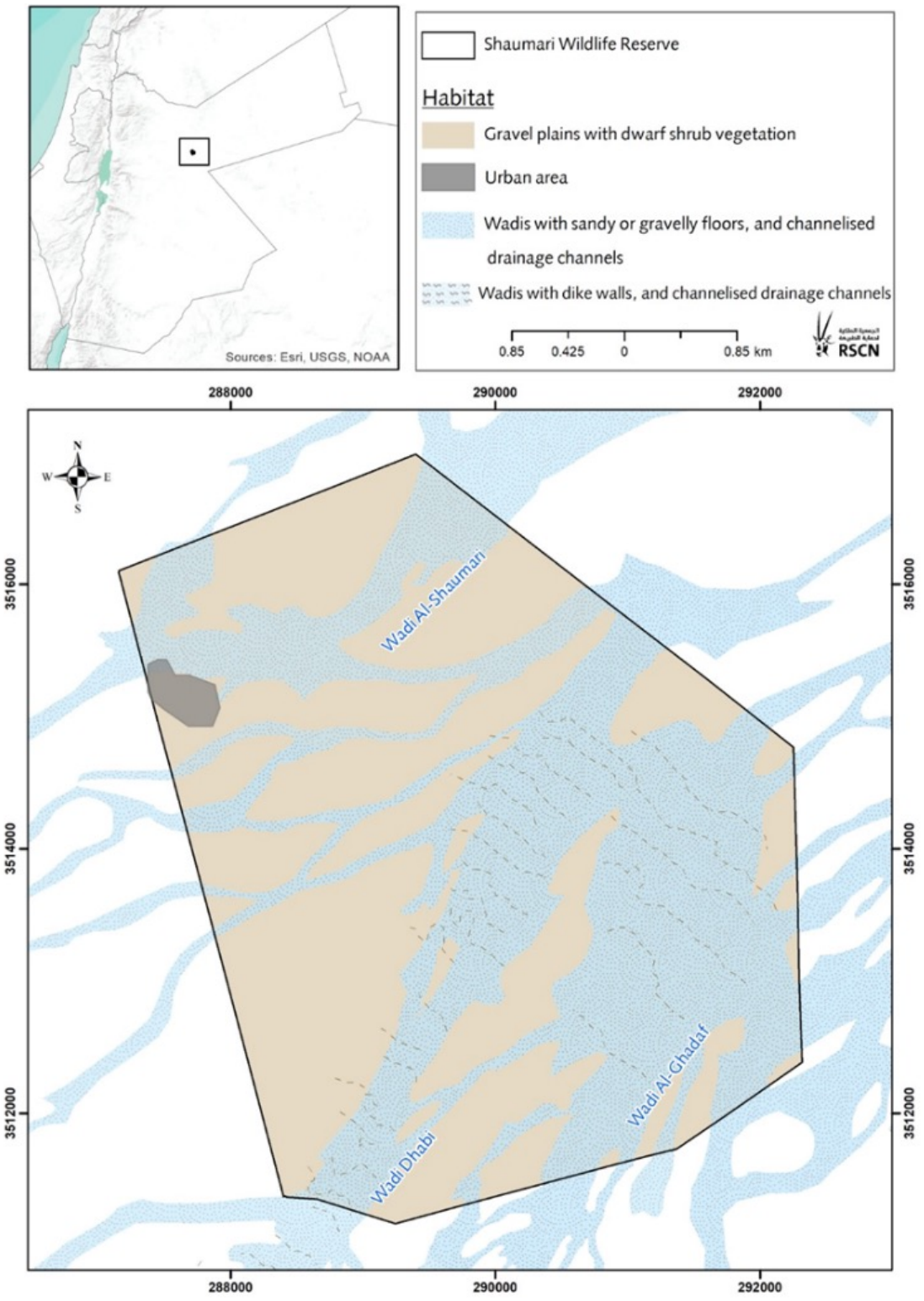

Figure 6. Habitat types in the Shaumari Wildlife Reserve.

Vegetation Types

Based on the topography and distribution of the dominant vegetation elements species in the Shaumari Wildlife Reserve, two main vegetation types were defined including Hammada and Saline vegetation. The Hammada vegetation is divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada shown in Figure 8 as follows:

Run-off Hammada: This vegetation represents wadi beds including three main

Figure. 7: Different habitat types in the Shaumari Wildlife Reserve, (A) Gravel plains with dwarf shrub vegetation, (B) Wadi with sand or gravel floors, and drainage channels, (C) Wadis with dike wall, and drainage channels

wadis; Al-Ghaddaf, Al-Dab'i, and Al-Shaumari wadis covering the largest part of the reserve and extending beyond the borders of the reserve with a dense vegetation cover dominated by shrubs such as *Atriplex halimus*. Most of the plant species were recorded from this vegetation type (Figure 9A).

Gravel Hammada Vegetation: This type is covered by gravel with a sparse vegetation not exceeding 10% of the area. It is characterized by low shrubs such as *Haloxylon salicornicum, Soda rosmarinus,*and *Anabasis articulata* (Figure 9B).

Sandy Hammada Vegetation: This type covers flat areas comprised of a mixture of gravel and small pebbles with sand. The vegetation cover is greater than that of the Gravel Hammada reaching about 20 to 25% of its area. It is characterized by low shrubs and some herbs. (Figure 9C).

Saline Vegetation: It can be found in the eastern part of the reserve, specifically in the Wadi Al-Ghadaf area, and is dominated by pure gypsum overlain with a thin layer of silt forming salt crusts on the surface. This vegetation is primarily dominated by *Tamarix passerinoides* and *Nitraria retusa*, with associated species such as *Limonium pruinosum* and *Alhagi maurorum* (Figure 9D).

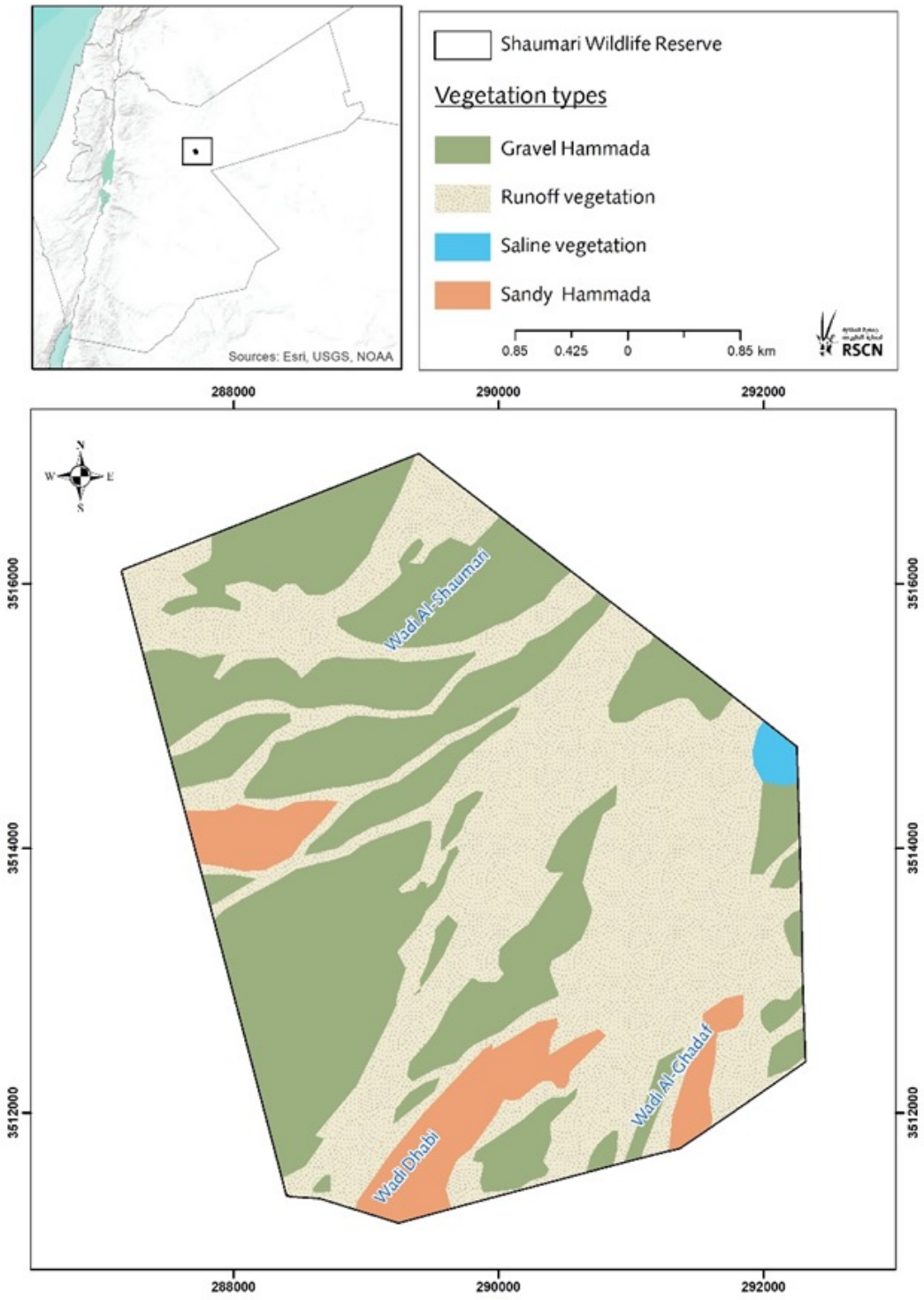

Figure 8. Vegetation types of the Shaumari Wildlife Reserve.

Vegetation Communities

The reserve is characterized by a mosaic of dwarf shrubland communities containing thirteen different plant communities, primarily distributed within the Run-off vegetation. These variations are presumed to arise from differences in soil type, texture, and salinity (Figure 10).

Vegetation Analysis

A total of thirty-three families were recorded in the Shaumari Wildlife Reserve. The Asteraceae family is the largest with a total of thirty-six species followed by Poaceae with twenty-eight species, Chenopodiaceae with twenty-three species, Brassicaceae with twenty species, and Fabaceae with fifteen species (Figure 11).

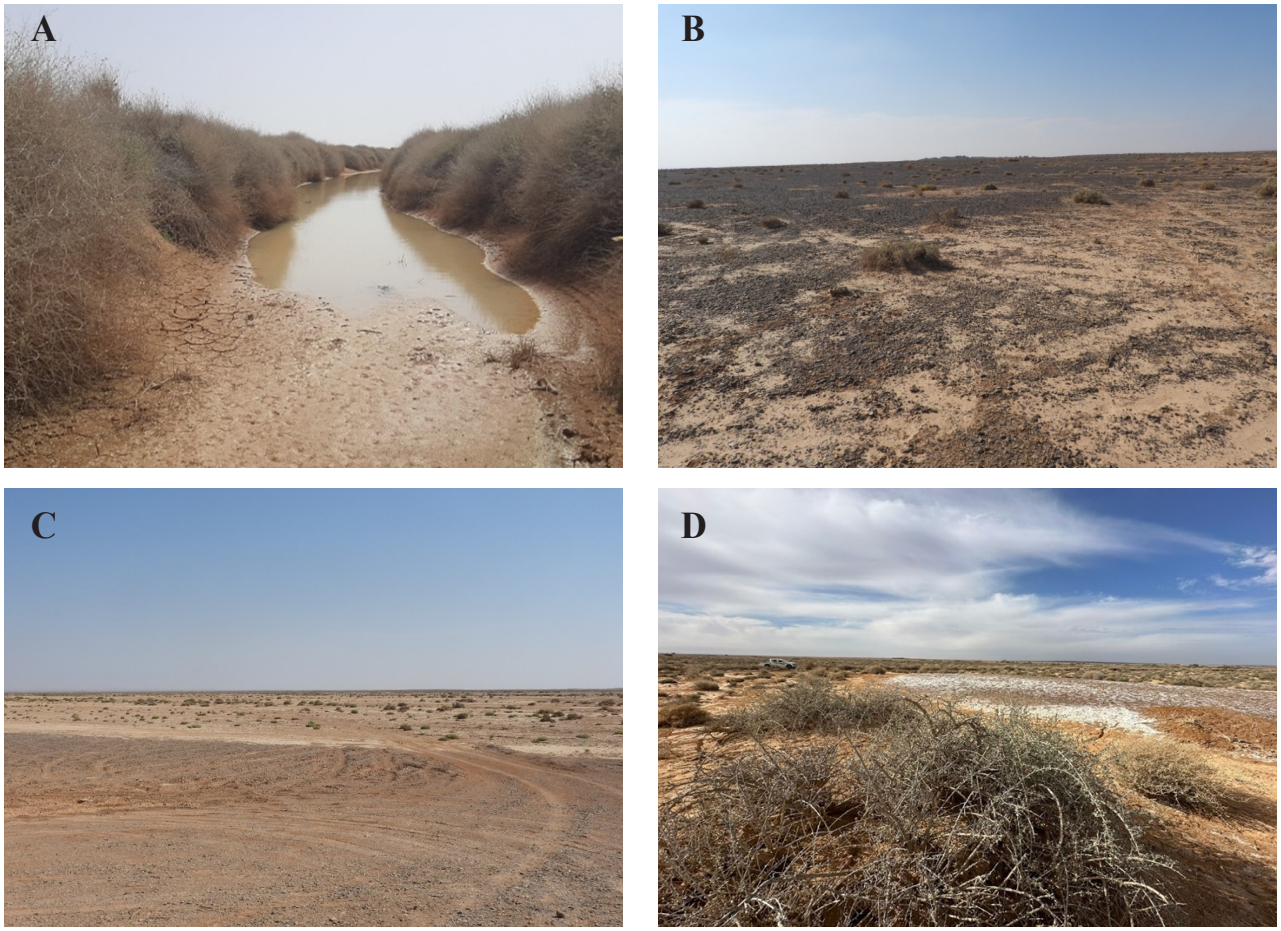

Figure 9. The different vegetation types identified in the Shaumari Wildlife Reserve (**A)** Run- off Hammada vegetation type in the Shaumari Wildlife Reserve (**B)** Gravel Hammada vegetation type in the Shaumari Wildlife Reserve (**C)** Sandy Hammada vegetation type in the Shaumari Wildlife Reserve (**D)** Saline vegetation type in the Shaumari Wildlife Reserve.

Vegetation attributes

Parameters such as abundance, frequency, and density were used to describe the status and structure of vegetation communities and the associations of flora species within the reserve. The total number of individuals in all studied plots of each species ranged from one for twenty-five individuals such as *Zygophyllum arabicum, Savignya parviflora,* and *Suaeda fruticosa* to 1041 individuals for *Plantago ovata*. As for plant community abundance, *Carduus australis* recorded the highest value among the species followed by *Plantago ovata* and *Bromus tectorum* (Figure 12). In relation to the species frequency (proportion of quadrats with species present), *Anabasis articulata* showed the highest value followed by *Erucaria boveana, Salsola rosmarinus,* and *Atriplex halimus* (Figure 13). Regarding density, *Plantago ovata* recorded the highest density among the species followed by *Malva parviflora*, *Plantago amplexicaulis,* and *Phalaris minor* (Figure 14).

Herbarium Specimen Collection

A total of 600 specimens of shoots and root material were collected to represent all plant species recorded throughout this survey. The specimens were identified, labeled, and mounted. A voucher specimen of each species was deposited at the herbarium of the Royal Society for the Conservation of Nature (RSCN) as mentioned earlier under materials and methods.

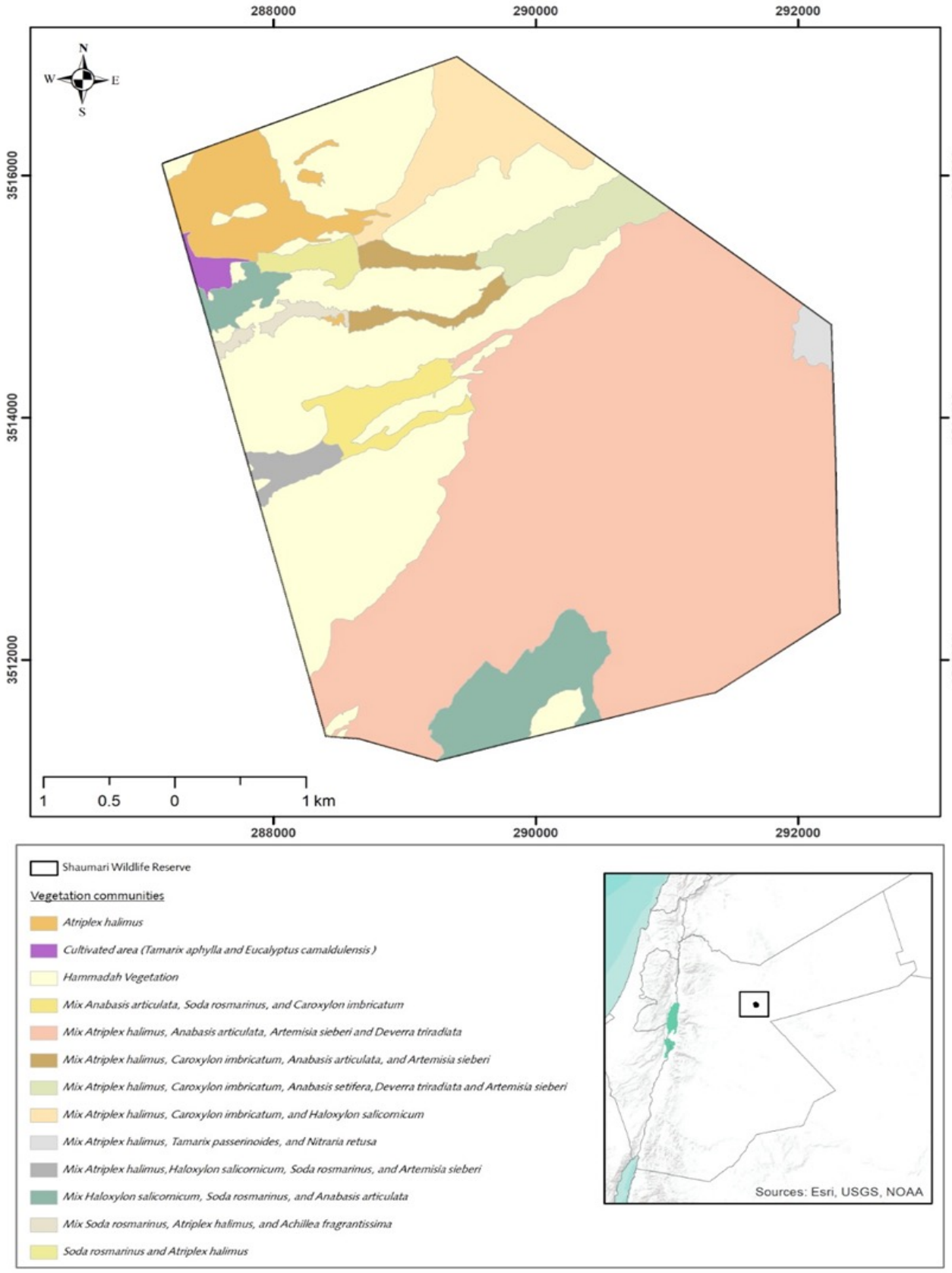

Figure 10. Vegetation Communities in the Shaumari Wildlife Reserve based on the current study.

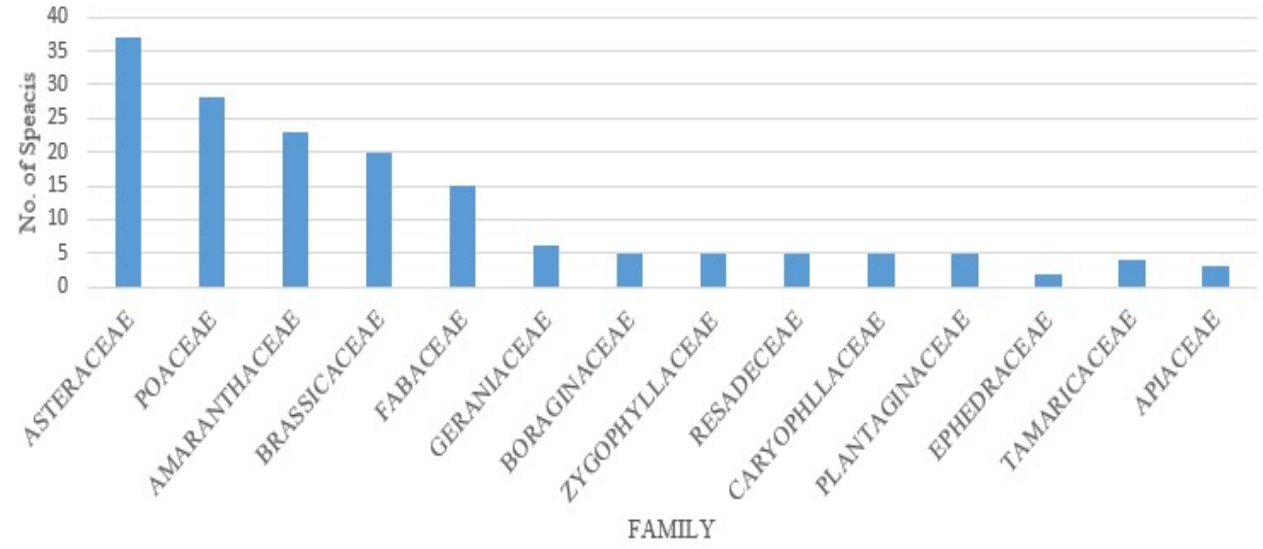

Figure 11. The largest families recorded in the Shaumari Wildlife Reserve.

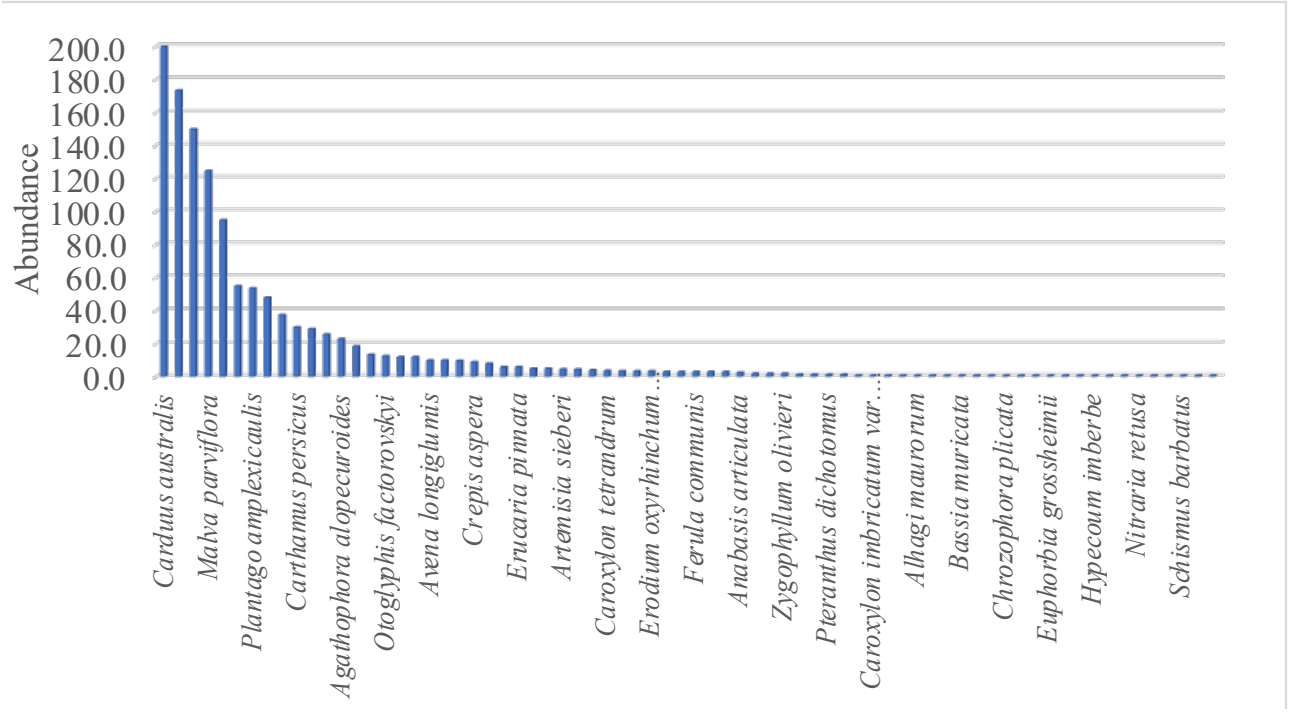

Figure 12. The species with the highest abundance values within the Shaumari Wildlife Reserve

Discussion

Flora Checklist

During this survey, a total of 197 plant species were recorded from the Shaumari Wildlife Reserve. This represents the highest number of plant species documented in the reserve surpassing previous studies. Clark (1997) recorded 168 plant species, while Al-Eisawi and Abu Yahya (2014) documented only eighty-one species throughout their study. The significant differences in species numbers among these studies may be attributed to several factors, including the timing and methodology of the surveys. Al-Eisawi and Abu Yahya (2014) conducted their survey between February and April, which may have been during an off-season for some species, whereas this survey was conducted during late winter and spring, from April to May, with additional field trips conducted throughout the summer. This timing difference could have resulted

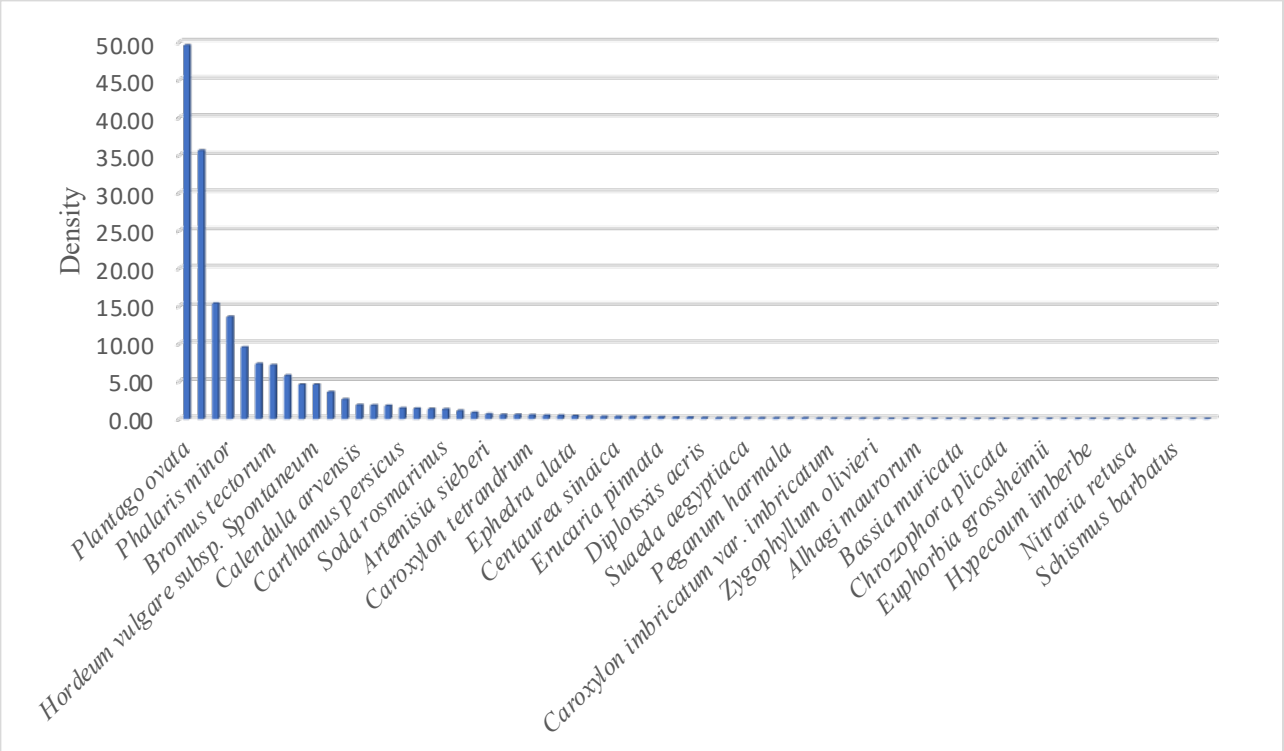

Figure 13. The species with the highest densities within the Shaumari Wildlife Reserve

in the underrepresentation of certain species, particularly those that are seasonal or less visible during specific months.

In contrast, the higher number of species recorded in this survey may reflect more favorable environmental conditions or more extensive sampling methods. This emphasizes the importance of conducting surveys at different times of the year and using varied sampling techniques to capture the full diversity of plant species in an area.

Despite the differences in species numbers, the studies share similarities in that they all reflect the dynamic nature of the reserve's plant communities. The variations in species composition over time highlight the influence of factors such as climate, rainfall, and ecological succession on the reserve's flora. These findings also underscore the importance of continued monitoring to better understand how plant communities evolve in response to environmental changes.

Two species are evaluated as globally Endangered: *Bellevalia warburgii* and *Euphorbia grossheimii* (IUCN Red List, 2023). Both species were previously recorded by Al-Eisawi, (2013) and Taifour *et al.* (2017) in Jordan, but this survey presents their first documentation within the Shaumari Wildlife Reserve. The new records of these endangered species in the reserve are significant as they contribute to the understanding of the distribution of rare and threatened species within protected areas. The presence of *Bellevalia warburgii* and *Euphorbia grossheimii* highlights the ecological importance of the reserve in conserving biodiversity and underscores the need for continued monitoring and the protection of these endangered species in their natural habitats.

Throughout the study, two species, *Xanthium spinosum* and *Xanthium strumarium*, were documented as invasive plant species in the Shaumari Wildlife Reserve. These species are highly invasive weeds capable of growing under a variety of environmental conditions. They can readily establish themselves in cultivated land and pastures posing a significant threat to native and endemic flora and fauna (Sharkas, 2011; Maxie, 2015; Kew, 2021). Notably, these two species have not been recorded in any previous studies conducted within the reserve. Their presence marks a new concern for the reserve's biodiversity highlighting the need

for monitoring and management strategies to prevent their spread and mitigate their impact on the native plant communities.

Habitat and Vegetation Types

Four terrestrial habitats were identified and delineated: Gravel plains with dwarf shrub vegetation habitat, Wadis with sandy or gravel floors, and drainage channels habitat, Wadis with dike wall, and drainage channels and Urban areas. These habitats are similar to those presented by (Clark, 1977), where he outlined the presence of wadis, hammada, dikes, and roads. However, the boundaries of these habitats were redrawn, and reserve buildings were identified. These habitats and topography were affecting the distribution of the dominant vegetation element species in the Shaumari Reserve and vegetation cover. Two vegetation types were identified in the Shaumari Reserve: Hammada and Saline vegetation types; this is consistent with (Al-Eisawi,1996) in describing the Badia desert of Jordan in general and the Shaumari Reserve in particular. The Hammada vegetation was further divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada. The presence of dikes along Wadi Dhabi and Wadi Ghadaf led to the deposition of a thin layer of sand on the ground surface between them, which can be described as the Sandy Hammada vegetation. This allows for the growth of some annual plants in that area (Peters, 2002 and Okin *et al.,* 2001). Additionally, the elevation in the reserve ranges from 500 to 529 meters above sea level from south to north. Water flows from south to north, with the lowest point in the northeastern part of the reserve. Water has pulled very fine soil particles and some silt, forming salt crusts on the surface. This area has become solid and salty forming Saline vegetation dominated by halophytic plants including *Tamarix passerinoides* and *Nitraria retusa* associated with *Limonium pruinosum* and *Alhagi maurorum* (Menzel *et al.,* 2013). The detailed map describing the distribution of vegetation types in the Shaumari Wildlife Reserve revealed a convergence in the occupied areas of both Run-off Hammada and Gravel Hammada vegetation types, which together form the total area of the reserve; this agrees with RSCN, 2002 and Al-Eisawi and Abu Yahia, 2014 results. It is noteworthy to mention that dense and diverse vegetation within the Shaumari Reserve is found around the wadi systems and along them. This wadi system, known as the Run-off Hammada vegetation, is well covered by bushes, shrubs, and herbs of leading species including *Atriplex halimus*. While the Gravel Hammada vegetation occupies the flat areas surrounding the wadi systems with sparse vegetation not exceeding 10% of the area.

Vegetation Communities

The reserve is characterized by a mosaic of dwarf shrubland communities which belong to the major type occurring in the Saharo-Arabian biogeographic region in Jordan. As mentioned previously, the whole class of vegetation cover is divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada. There are variations between plant association and, therefore, plant communities based on differences in soil quality, texture, humidity, and salinity. The *Atriplex halimus* is the most dominant plant species in the reserve present in most recorded plant communities. Despite agreeing with previous studies, there are differences in plant communities within it (RSCN, 2002 and Al-Eisawi and Abu Yahia, 2014). As previously mentioned, the vegetation cover and plant species are affected by sharp fluctuations in rainy seasons in the reserve. Moreover, it is evident that during this survey, some species have increased their dominance within the reserve, greatly impacting other species and their distribution.

Vegetation Parameters

These results indicate that the reserve plays a role in preventing desertification and serves as a good example for the rehabilitation of degraded desert areas, while studies on the

Badia and surrounding region of the reserve have shown that the vegetation cover is very weak and scattered, accounting for only 5%, with heights ranging from 20 cm to 70 cm (Al- Eisawi and Hatough, 1987). Thus, the vegetation cover in the reserve appears dense compared to its surrounding area.

In all parameters, there is a clear decline in the dominance of *Atriplex halimus* in the reserve, with both *Anabasis articulata* and *Suaeda rosmarinus* advancing, compared to the study by (Al-Eisawi and Abu Yahia, 2014), which indicated that *Atriplex halimus* was dominant in all data. It is most likely that the *Atriplex halimus* reached its peak at that time and has since declined. This raises concerns since *Atriplex halimus* is an important pastoral species in the reserve (RSCN, 2009). There was some regeneration of *Atriplex halimus* recorded in the southwestern part of the reserve, especially in the area affected by the fire that occurred in 2017, while regeneration in the northeastern and central part of the reserve was very weak or non-existent. This contradicts the documented regenerations of *Atriplex halimus* in the Grazing Capacity study of the reserve (RSCN, 2009). Finally, the community competition between species continues and is moving in favor of *Anabasis articulata* and *Suaeda rosmarinus* both of which are considered weak pastoral species. This will significantly impact the reserve and the species within it in the future.

Conclusion

The Shaumari Wildlife Reserve plays a role in preventing desertification and serves as a good example for the rehabilitation of degraded desert areas. The vegetation cover in the reserve is very dense compared to its surrounding areas. A total of 197 plant species belonging to thirty-five families and 125 genera have been recoded. Two species, *Bellevalia warburgii* and *Euphorbia grossheimii*, have been evaluated as globally endangered according to the IUCN Red List of Threatened Species (IUCN, 2024). Twenty-eight species hold ecological importance at the national level, as they are classified within the list of Endemic and are range-restricted (rare) in Jordan.

The reserve has different types of habitats and vegetation: Hammada flat areas, wadis, wadis including sandy dikes, and urban areas surrounding the visitor center. Thirteen different plant communities are distributed within the runoff vegetation in the reserve.

The *Atriplex halimus* community is declining in the reserve, with both *Anabasis articulata* and *Suaeda rosmarinus* taking the lead. There was some regeneration of *Atriplex halimus* recorded in the reserve, especially in the area affected by the fire that occurred in 2017. The community competition between species continues and is moving in favor of *Anabasis articulata* and *Suaeda rosmarinus*. This will significantly impact the reserve and the species within it in the future.

Recommendations

During this study, two species (*Xanthium spinosum* and *Xanthium strumarium*) were identified as invasive plant species. They are highly invasive weeds capable of growing under a variety of environmental conditions. It is important to eliminate and control the distribution of these species within the reserve.

The teamwork recommends creating 20m x 20m quadrates along the Wadis where all shrubs are cut to allow the species to grow again. These quadrates should be monitored every two years.

Additionally, the team recommends constructing rainwater harvesting structures for the Gravel Hammada vegetation including micro dams or ponds to collect rainwater, ensuring that the size of these structures does not exceed 2m. The installation of these structures will assist in gathering certain amounts of water, subsequently promoting the growth of annual species within these areas. Furthermore, this can help retain water for use during dry seasons. These structures can be constructed individually.

Acknowledgment

The Royal Society for the Conservation of Nature/ RSCN and The Shaumari Wildlife Reserve staff have provided valuable support, which is highly appreciated. The authors would like to thank Dr. Nashat Hamidan, head of the Nature Conservation Monitoring Centre/ NCMC, for his assistance and support during the process of this study. The authors also would like to thank Tamir Aqaili, Researcher at the Azraq Wetland Reserve for his assistance in the fieldwork.

References

Abed, A and Hmaidan, N. 2020. **The basics of Geology of Jordan Made Brief and Simple**. Royal Society for the Conservation Nature RSCN, Amman 106p [in Arabic].

Abed, A M. 2017. **Geology of Jordan, Environments and Water**. Dar Wael for Publish and Distribution, Amman 583p [in Arabic].

Abed, AM, Yasin, S, Sadaqa, R and Al-Hawari, Z. 2008. The paleoclimate of the eastern desert of Jordan during marine isotope stage 9. *Quaternary Research*, **69** (3), pp.458-468.

Al- Eisawi, D. 1996. V**egetation of Jordan.** UNESCO- Regional Office for Science and Technology for the Arab States. Cairo.

Al- Eisawi, D. 2013. **Flora of Jordan Checklist-revised edition**. The University of Jordan Press, Jordan

Al- Eisawi, D, Oran, S, El- Oqlah, A and Lahham, L. 2000. "**Jordan Country Study on Biological Diversit**y": Plant Biodiversity and Taxonomy, General Corporation for Environmental protection (GCEP) & UNDP

Al- Eisawi, D. and Hatough, A. 1987. Ecological Analysis of the Vegetation of Shaumari Reserve in Jordan. *Dirasat*, **XIV**: 12.

Al-Eisawi, D M, Abu Yahya, A and Ananbeh, Y. 2014. Flora and Vegetation of Shaumari Wildlife Reserve, A Baseline Survey (2014). RSCN. Amman, Jordan.

Al-Eisawi, D. M. and Abu Yahya, A. 2015. Flora of Shaumari Wildlife Reserve, Jordan, *Jordan Journal of Natural History*, **2**: 8- 21.

Austin, M. 2007. Species distribution models and ecological theory: a critical assessment and some possible new approaches. E*cological Modelling*, **200** (1-2): 1-19.

Clarke, J. 1977. Shaumari Wildlife Reserve / management plan.

Fadda, E. 1996. The geology of Wadi El Ghadaf area: Map sheet 3353-II. The NRA, Amman.

Feinbrun, N. 1986. **Flora Palaestina**. Vol. III, IV. The Israel Academy of Sciences and Humanities. Jerusalem.

Gruneberg, F and Dajani, F. 1964. The soil of Azraq area. Germ. Geol. Missionin Archive, BGR, Hannover, Germany.

Hatough, AM, Al-Eisawi, DM and Disi, AM., 1986. The effect of conservation on wildlife in Jordan. E*nvironmental Conservation*, **13** (4):331-335.

Ibrahim, K M. 1996. The regional geology of Al Azraq area map sheet No. 3553 I. Naticra/ Resources Authority, Geological Mapping Division, Bulletin 36. 67.

Ibrahim, K, Rabba, I and Tarawneh, K. 2001. Geological and mineral occurrences map of the northern Badia region, Jordan, scale 1: 250,000. A Joint Report of the Higher Council for Science and Technology and the NRA, 136.

The IUCN Red List of Threatened Species 2024. Version 2024-2. https://www.iucnredlist.org.

Kew, R B G. 2021. Plants of the World Online. [Online] Available at: https://powo.science.kew.org/ [Accessed December 2021].

Ludwig, JA. and Reynolds, JF. 1988. **Statistical Ecology: A Primer**

in Methods and Computing (Vol. 1). John Wiley & Sons.

Majed, L and Othman, YA. 2023. Vegetation Cover Assessment at Shaumari Wildlife Reserve Using Satellite Sensors Data, 10(2), pp.21-31.

Maxie, G. 2015. Jubb, **Kennedy and Palmer's Pathology of Domestic Animals**: volume 2 . Elsevier Health Sciences.

Menzel, U and Lieth, H. E. L. M. U. T. 2013. Halophyte Database Versi 2.0 in alphabetical order including some updates. **Cash Crop Halophytes: Recent Studies**, 221-250.

Okin, G S, Murray, B, and Schlesinger, W H. 2001. Degradation of sandy arid shrubland environments: observations, process modelling, and management implications. *Journal of Arid Environments*, **47** (2): 123-144.

Peters, D P. 2002. Plant species dominance at a grassland–shrubland ecotone: an individual-based gap dynamics model of herbaceous and woody species. *Ecological Modelling*, **152** (1): 5-32.

Sharkas, O. 2001. **Vegetation degradation in northeastern Jordan**. *In:* Sustainable land use in Deserts (pp. 208-217). Springer Berlin Heidelberg.

Taifour, H, El-Oqlah, A and Ghazanfar, SA. 2017. **The Plants of Jordan: An Annotated Checklist** (pp. 242-pp).

The Royal Society for the Conservation of Nature (RSCN). (2002). Shaumari Wildlife Reserve / Ecological Baseline Survey.

The Royal Society for the Conservation of Nature (RSCN). (2009). Determination of Grazing Capacity for Shaumari Wildlife Reserve.

Zohary, M. 1966. **Flora Palaestina**. Vol. I, II, III. The Israel Academy of Sciences and Humanities. Jerusalem.