Open Journal of Ecology, 2022, 12, 162-174
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Ecology of Indigenous Plants in Abandoned Agricultural Areas in Tabuk Region, Saudi Arabia

Nadi Awad Al-Harbi

Biology Department, University College of Tayma, Tabuk University, Tabuk, Saudi Arabia
Email: nalharbi@ut.edu.sa

How to cite this paper: Al-Harbi, N.A. (2022) Ecology of Indigenous Plants in Abandoned Agricultural Areas in Tabuk Region, Saudi Arabia. *Open Journal of Ecology*, **12**, 162-174.
https://doi.org/10.4236/oje.2022.122010

Received: December 9, 2021
Accepted: February 21, 2022
Published: February 24, 2022

Abstract

Due to drought, low soil fertility, little rain fall, elevated levels of evapotranspiration, salinization of the soil and a lack of ground water, the problem of desertion of agricultural areas has developed in KSA in recent years (e.g. Tabuk region). In the Saudi Arabia, agricultural land abandonment's negative impact on the composition of perennial vegetation, soil quality, and the structure of population was investigated. In the several abandoned fields of the research region, eleven species of perennial plants pertaining to nine families, eleven genera were found. Following the use of the ordination of detrended correspondence analysis (DCA), four plant communities were found. *Zygophyllum hamiense*, *Prosopis farcta*, *Seidlitzia rosmarinus, Traganum nudatum.* The indicators were *Pulicaria undulate, Calligonum comosum*. Populations of *Calligonum comosum* and *Zygophyllum hamiense* were found to be either negatively skewed or inversely J-shaped, indicating fast-growing populations with strong reproductive potential, according to demographic research. *Traganum nudatum*, *Prosopis farcta* and *S. Rosmarinus*, on the other hand, have a nearly symmetrical size-frequency distribution (like a bell in shape). The current research highlights the importance of managing deserted agricultural fields in order to restore and improve range lands having adapted native plants to regional conditions like little water demand.

Keywords

Halophytes, Succulent, Ecology, Deserted Lands

1. Introduction

Economic conditions are changing (e.g. water scarcity, and climate change). They all contribute to the abandonment of agricultural areas around the world [1]. Several uncultivated plant species instinctively occupy fertile grounds with which plants compete for space, light, and nutrients [2]. Such species are agronomically thought-out a pest, but they have a fundamental ecological role through making a significant contribution to biodiversity support. The abandon of arable land generates a combination of social, economic and environmental impacts, especially in arid zones [3]. The abandonecy of agricultural lands revert to their former vegetation through natural succession or passive restoration. Passive restoration is a significant method of rehabilitating abandoned fields while also improving biodiversity and ecological services [4]. Active restoration does not always outperform passive restoration, as several examples have demonstrated [5]. Passive restoration, on the other hand, is a time-consuming process. For example, nearly a century after abandonment, certain abandoned green lands in the States have only 75% of the plant diversity of surrounding natural flora [6]. Plant diversity management through active restoration is frequently adopted, as indicated by the widespread use of monocultures in global reforestation initiatives [7]. In many areas, long-term changes in land use have an impact on vegetation structure and habitat. The shrubby vegetation usually has considerable environmental and ecological importance, is free to colonize the abandoned farmlands [8]. Grass and woody plant species, for example, are reliant on land-use disturbance regimes in abandoned fields, which are termed semi-natural environments. Different determinants, like the soil seed bank or group of biogeographic species, management style, the history of land-use, and might have a greater impact on plant variety [9].

Because of the lack of water resources in the region, many of the fertile fields in the KSA were abandoned. Previously, these areas were cultivated yet because of the aforementioned reasons were deserted for forty years up till now. New wild plant communities were developed. This work was carried out to check and examine the prevailing vegetation in terms of composition and structure.

2. Materials and Methods

Zone description

The study area is the Tabuk region which is located North West of KSA. The region is located 28˚23'50"N 36˚34'44"E (**Figure 1**).

Rangelands, which are normally grazed by domestic livestock, surround the research region. In general, the soil of the area is classified as arid soil, because there is no accumulation of clays or organic debris [1] [10]. The climate in the research region (**Figure 2**) is aridic, with scorching summers and chilly winters.

The wadies or valley basin deposits, on the other hand, are fine and deep textured, with a hard, muddy surface covered by flat vegetation supported by sand, rock, or phytogenic mounds every now and then [11]. The summer is typically scorching hot with average temperature of 45˚C, while winters are mild with average temperature of 20˚C.

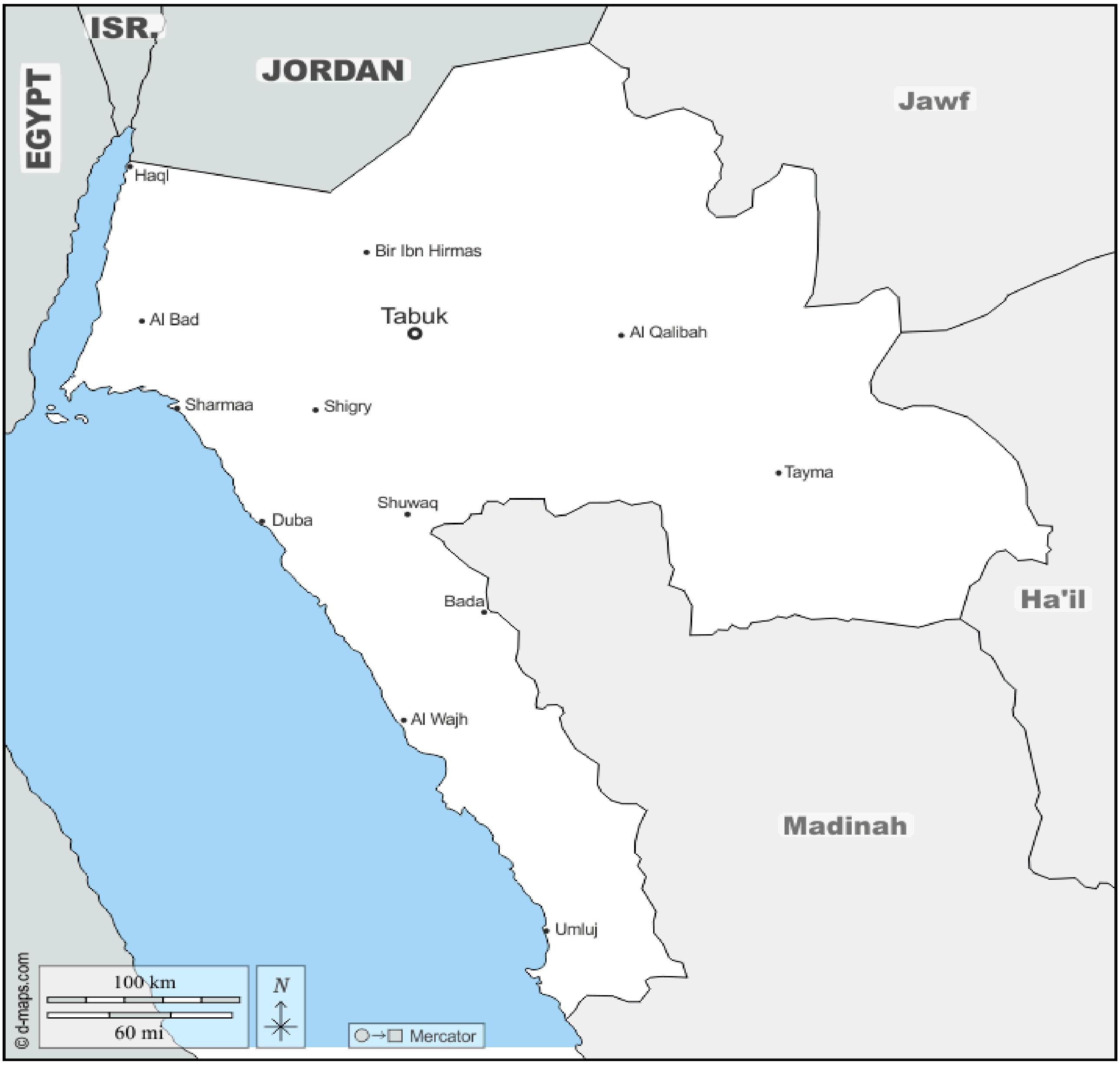

Figure 1. The location of the study region, Tabuk, KSA. https://d-maps.com/carte.php?num_car=208602&lang=ar.

The climate in Tabuk

The Tabuk area is characterized by a great diversity of geological structures (topography), which led to the containment of this region with many minerals and natural ingredients such as iron and granite (Al-Balawi, 2015) [11]. This area includes many morphological phenomena, including marine, plain, mountainous, valleys, and sand dunes. The percentage of areas covered by plateaus is 45.96%, mountains is 31.78% of the total area of the region. This topography represents a great indication of the nature of the geological structure of the region. Figure 2 shows the Climate change for the Tabuk region between the years 2012-2021. The amount of precipitation varies from one place to another, as well as locally from one part to another.

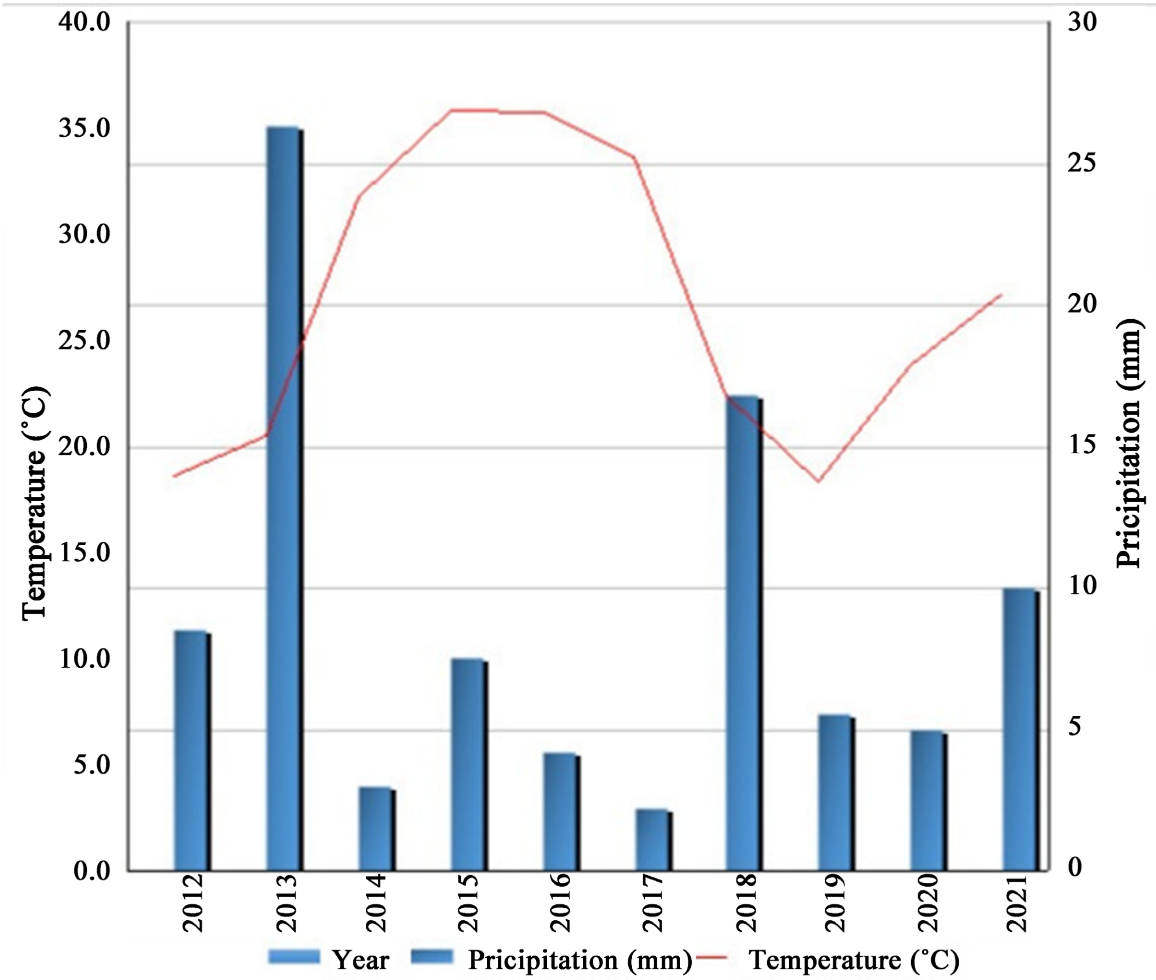

Figure 2. Shows the Climate change for the Tabuk region between the years 2012-2021.

The climate of the Tabuk region is one of arid desert climates. Temperatures in summer average are up to 40 degrees Celsius and drop in winter to an average of 7.6 degrees with annual rainfall, not more than 50 mm. The Tabuk area is characterized by a great diversity of geological structures (topography), which led to the containment of this region with many minerals and natural ingredients such as iron and granite (Al-Balawi, 2015) [11]. This area includes many morphological phenomena, including marine, plain, mountainous, valleys, and sand dunes. The percentage of areas covered by plateaus is 45.96%, mountains is 31.78% of the total area of the region. This topography represents a great indication of the nature of the geological structure of the region. The climate of the Tabuk region is one of arid desert climates. Temperatures in summer average are up to 40 degrees Celsius and drop in winter to an average of 7.6 degrees with annual rainfall, not more than 50 mm.

Soil sampling and analysis

The study was carried out in 2021. At three random spots in each stand, the representative samples of soils were obtained from a depth of 0 - 50 cm and blended as a mixed sample. Before sieving (with a 2 mm sieve) the materials, samples were air-dried. The calculation of the organic matter was carried out using ignition loss at 450˚C according to [12]. The values of Ec and pH were determined using 1:50 ratio of w/v distilled water.

The HCO_3^-, Cl^-, and SO_4^{2-} contents of the soil were determined using titration methods, while the $CaCO_3$ contents of the soil were determined employing [13] method. Flame photometry (Jenway PFP7 Flame Photometer, Chelmsford, Essex, England) was used to estimate both of K and Na. atomic absorption spectrometer (A Perkin-Elmer, Model 2380, Waltham, MA, USA) was used to estimate Ca^{2+} and Mg^{2+}. The N and P contents were estimated employing a spectrophotometer model ICP MSEOS 6000 Series, Cambridge CB5 8BZ, UK.

Analysis and sampling of plants

Plant samples were collected at the period from February to April, 2021 taking into consideration that they represent the dominant plant communities. Each species' number of plants for each unit area was calculated, as well as the percentage of plant cover for every species was calculated using Braun-ordinal Blanquet's cover classification scheme [14]. Each species' significance value was computed as the sum of its relative density and relative cover [15]. Cover values were used to arrange the data in an 80 quadrat 11 species matrix.

Analysis of the Structure of Species

Within the studied quadrats (each studied quadrat with an area of 1 m^2 at a depth of one foot), each particular dominant plants (with a high frequency and abundance) had their height (H) and mean crown diameter (CD) measured. Crisp and Lange's [16] modified form of (H + CD)/2 were used to calculate the plant size index.

Statistical analysis

To determine the vegetation groups, Cluster analysis (two-way indicator species analysis) was performed on the matrix (TWINSPAN). The matrix data set was subjected to detrended correspondence analysis (DCA) to create an effective representation in graphics of the biological identified vegetation's structure categories [17]. The PC-ORD software tool, version 5.5, was used to perform DCA according to [18]. A one-way analysis of variance was used to analyze the variation in soil characteristics in connection to the plant community (ANOVA). This has been carried out to different means of different parameters in order to determine whether there is statistical evidence that the means are significantly different.

3. Results

Composition of the vegetation

In the research area's several abandoned fields, an overall of eleven species of perennial plants pertaining to nine families, eleven genera were discovered (**Table 1**). Chenopodiaceae had the highest percentage of representation (27.3%). The additional eight families (Polygonaceae, Zygophyllaceae, Papilionaceae, Ephederaceae, Asclepiadaceae, Mimosaceae, Convolvulaceae, and Asteraceae) had 9.09

percent each. The highest mean density was found in *Prosopis farcta* (35.84 ± 12.3 plants/25 m^2) among the species studied, then *Zygophyllum hamiense* (18.57 plants/25 m^2). *Convolvulus cephalopodus*, on the other hand, had the least average cover and density (1.53 percent, 1.18 individuals/25 m^2). *Seidlitzia rosmarinus* (succulent) had the greatest average cover (55.38 percent).

The Vegetation-Soil Interaction

There were substantial differences in soil factors among the four recognized communities, according to analysis of variance. The *Calligonum comosum-Pulicaria undulata* community had the highest sand content (90.12 percent), but the lowest clay content (5.89 percent) (**Table 2**) (**Figure 3**). The highest salinity (6.36 dS/m) and pH (8.64) were found in the *Seidlitzia rosmarinus-Zygophyllum hamiense* community, as well as the greatest $CaCO_3$ (17.38 percent), chloride (9.88 meq/L), Na^+ (46.4 meq/L), Mg^{2+} (7.28 meq/L), sulphate (37.8 meq/L), K^+ (5.16 meq/L), and bicarbonate (12.5 meq/L) concentrations (**Table 3**) (**Figure 3**).

Table 1. The study area's common perennial plant density and cover (mean ± SD).

Species	Family	Cover (percentage)	Density/25m^2
Seidlitzia rosmarinus	Chenopodiaceae	55.38 ± 23.2	10.44 ± 3.33
Traganum nudatum	Chenopodiaceae	13.23 ± 6.34	47.92 ± 10.2
Halothamnus lancifolius	Chenopodiaceae	5.72 ± 2.64	10.45 ± 4.17
Zygophyllum hamiense	Zygophyllaceae	19.02 ± 4.27	42.12 ± 7.375
Prosopis farcta	Mimosaceae	28.34 ± 10.23	35.84 ± 12.3
Calligonum comosum	Polygonaceae	12.44 ± 3.24	29.01 ± 11.11
Pulicaria undulate	Asteraceae	8.73 ± 2.13	6.48 ± 2.12
Leptadenia pyrotechnica	Asclepiadaceae	3.05 ± 1.62	2.19 ± 1.55
Alhagi graecorum	Papilionaceae	2.31 ± 1.01	3.44 ± 1.21
Ephedra alata	Ephederaceae	1.38 ± 0.44	1.91 ± 0.35
Convolvulus cephalopods	Convolvulaceae	1.23 ± 0.23	1.36 ± 0.32

Table 2. The Physical characteristics of soils of the four communities.

Physical characteristics of soils	*Seidlitzia rosmarinus-Zygophyllum hamiense*	*Seidlitzia rosmarinus-Traganum nudatum*	*Prosopis farcta-Traganum nudatum*	*Pulicaria undulate-Calligonum comosum*
pH	6.92 ± 0.33^a	7.99 ± 0.23b	8.32 ± 0.83^c	8.05 ± 0.30^d
EC (dSm^{-1})	5.76 ± 0.99^a	3.00 ± 0.98^b	3.02 ± 0.96^c	3.15 ± 0.35^d
Organic matter (%)	0.43 ± 0.10^a	0.39 ± 0.16^b	0.48 ± 0.51^c	0.28 ± 0.11^d
Sand (%)	77.17 ± 1.41^a	84.01 ± 7.32^b	89.02 ± 3.03^c	89.48 ± 5.04^d
Clay (%)	13.53 ± 0.43^a	8.63 ± 1.73^b	7.55 ± 2.18^c	6.29 ± 2.040^d
Silt (%)	8.87 ± 2.01^a	6.97 ± 3.44^b	2.95 ± 1.54^c	3.95 ± 3.06^d

^{a,b,c,d}Raws with different superscripts differ significantly.

Table 3. The Chemical characteristics of soils of the four communities.

Physical characteristics of soils	*Seidlitzia rosmarinus-Zygophyllum hamiense*	*Seidlitzia rosmarinus-Traganum nudatum*	*Prosopis farcta-Traganum nudatum*	*Pulicaria undulate-Calligonum comosum*
Phosphorus (mg/kg)	8.99 ± 0.65^a	10.04 ± 2.86^b	7.01 ± 0.23^c	6.59 ± 1.02^d
Nitrogen (mg/kg)	3.92 ± 2.09^a	5.89 ± 2.08^b	14.01 ± 5.05^c	8.95 ± 0.22^d
Ca^{2+} (meq/L)	16.23 ± 3.19^a	8.85 ± 1.75^b	7.45 ± 2.94^c	20.41 ± 4.16^d
Mg^{2+} (meq/L)	6.78 ± 5.19^a	4.23 ± 1.15^b	4.15 ± 1.32^c	2.54 ± 1.03^d
Na^{+} (meq/L)	55.23 ± 4.02^a	24.12 ± 9.29^b	5.48 ± 1.46^c	5.35 ± 1.99^d
K^{+} (meq/L)	6.01 ± 2.85^a	2.15 ± 1.46^b	2.14 ± 1.29^c	2.49 ± 1.27^d
HCO_3^- (meq/L)	13.43 ± 4.09^a	8.93 ± 6.91^b	4.83 ± 2.07^c	3.33 ± 0.71^d
Cl^- (meq/L)	10.18 ± 4.24^a	4.21 ± 2.11^b	2.94 ± 1.52^c	3.98 ± 0.64^d
SO_4^{2-} (meq/L)	41.56 ± 3.72^a	15.23 ± 4.22^b	16.72 ± 3.59^c	13.17 ± 5.16^d

^{a,b,c,d}Raws with different superscripts differ significantly.

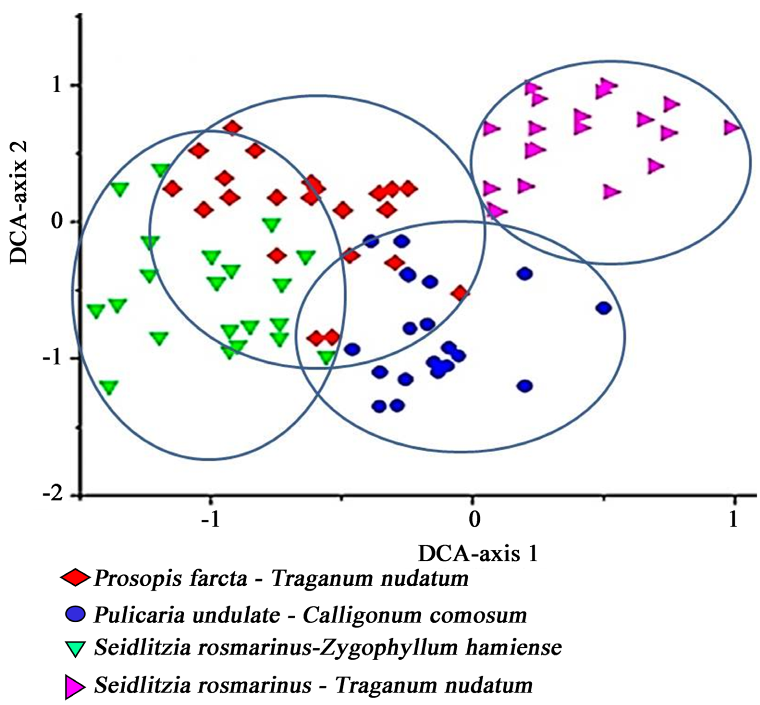

Figure 3. DCA-derived dissemination of four recognized groups in research area.

In community *Calligonum comosum-Pulicaria undulata*, the lowest values of these variables were recorded.

It seems that that a positive correlation exists between species richness and plant density as related to organic matter as well as sand content [19] [20]. On the contrary, a negative correlation was present with cation and anions concentrations and pH, EC. Sand percentage, plant density, and organic matter content all had a substantial negative association with plant cover, while EC, pH, Cl as well as SO_4, cation and anion concentrations all had a significant positive correlation [21] [22].

Al-Rowaily *et al.*, [1] conducted a similar study and found that the populations of *Seidlitzia rosmarinus* showed the biggest size index, average diameter and as well as the lowest height/diameter ratio, according to the data. They found that greatest average diameter to be 181.73 cm with size index of 128.93 cm. This indicated the agreement of the studies which conducted in the area. They also discovered that *Prosopis farcta* populations, *Seidlitzia rosmarinus*, and *Traganum nudatum*, had roughly well proportioned (like a bell in shape) size dispersion across all sizes.

4. Discussion

Four plant communities were identified as a result of the classification of vegetation stands. Because these plants are physiologically and morphologically adapted to saline and dry environments, [1] [23] the domination of succulent shrubs (Chenopodiaceae) in the area of study follows the salinized environment's nature of soil of the deserted fields. Low rainfall during the sampling season could be the reason that the annual species were not found. Succulent bushes predominate in the Desert's abandoned pastures in different parts of the world [24] [25] [26] [27] [28]. These communities have a hamiense floristic composition, which is similar to that of plant communities found in Al-bordering Kharj's natural regions, such as raudhas (meadows), (ephemeral watercourses), and sand dunes [29]. The research area, however, is substantially more dominated by xerophytic and succulent halophytes [30]. This might be because of the invasion of seeds from the surrounding area into the former arable land. The four communities were clearly separated, indicating that the succulent halophytes bushes were represented on the first axis of the DCA diagram (*i.e. Zygophyllum hamiense-Seidlitzia rosmarinus and Traganum nudatum-Seidlitzia rosmarinus*). The *Calligonum comosum-Pulicaria undulata* community was separated on the right side of the DCA. It was an old sequence of sandy fields that have been abandoned where *Caligonum comosum* bushes grew on dunes and dry sandy soils. The shrub is extremely resilient to moisture conditions and poor soil. It may be grown by cutting and layering and has root suckers. Clay content, high silt and high salinity as well as pH, and high chloride, SO_4, and mineral concentrations were found in the succulent communities' soil (*i.e. Zygophyllum hamiense-Seidlitzia rosmarinus*). These findings of the current study match those of in the Qinling Mountains, China [31], the catchment of Serra de Rodes [32], Passeier Valley, north Italy [33] and the Minnesota sand plain [34]. In contrast, [35] [36], and McLauchlan [37], noted that organic carbon, total nitrogen increased, then, heaped up in the soil after a long period of field abandonment. These reported results may explain the accumulation of *Traganum nudatum-Prosopis farcta, Prosopis farcta* shrub roots are able to boost soil fertility by immobilizing nitrogen as indicated by [38] [39]. Because of interspecific and intraspecific competition between species, the relationship between the contents of organic carbon, total nitrogen, and plant density were negative [1]. Because most halophytic species, (e.g. *Zygophyllum hamiense, Seidlitzia rosmarinus, and Traganum nudatum*), are suited to salinized environments, plant cover, most likely, had positive relationship with the presence of soil minerals [40]. The communities of plants within the deserted areas of the ponder area were distinguished by the next distance across than tallness. Many desert shrubs use this method to cope with the extreme heat. The size structure populations of *Calligonum comosum* and *Zygophyllum hamiense* may exhibit an inverted J-shape or positive distortion, indicating highly fertile and rapidly growing populations. This may come as no surprise given that little plants have greater reproduction rates and colonisation abilities [41] [42] [43] [44]. The populations of *Prosopis farcta, Seidlitzia rosmarinus*, and *Traganum nudatum*, on the other hand, had a roughly well proportioned (*i.e.*, like bell) distribution of size structure; this meant that the proportion of small and elderly plants was similar to a high distribution of intermediate-sized plants, [45]-[52]. Sukontaprapun *et al.* [53] found that low pH and high total acidity may be the reason for the sour taste of plant fruits

5. Conclusion

Significant discrepancies were found in the population structure of these ecosystems' indicator species. Following the departure of arable fields, the dominant species was *Prosopis farcta*. In the Tabuk region, the abandoning of agricultural land provides for the restoration of natural perennial plants in the wild. In the research region, the discovered plant communities were four, with soil salinity and nutrients serving as the primary determinants of species composition. As a result, we anticipate this plant colonizing and dominating abandoned lands in the future. The new study emphasizes the importance of keeping an eye on abandoned farms, as well as restoring and upgrading range lands with endemic species that have adapted to their surroundings like little water demand. Consequently, public policy should aim to obtain services and benefits from these habitats/ecosystems by using resources without altering their natural characteristics.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Al-Rowaily, S.L., Al-Dosari, D.H., Assaeed, A.M., Abd-ElGawad, A.M., El-Sheikh, M.A., El-Bana, M.I. and Al-Taisan, W.A. (2020) Native Perennial Plants Colonizing Abandoned Arable Fields in a Desert Area: Population Structure and Community Assembly. *Agriculture*, **10**, 550. https://doi.org/10.3390/agriculture10110550

[2] Wong, N.K., Morgan, J.W. and Dorrough, J.A. (2010) Conceptual Model of Plant Community Changes Following Cessation of Cultivation in Semi-Arid Grassland. *Applied Vegetation Science*, **13**, 389-402.

https://doi.org/10.1111/j.1654-109X.2010.01080.x

[3] Fredh, E.D., Lagerås, P., Mazier, F., Björkman, L., Lindbladh, M. and Broström, A. (2019) Farm Establishment, Abandonment and Agricultural Practices during the Last 1,300 Years: A Case Study from Southern Sweden Based on Pollen Records and the LOVE Model. *Vegetation History and Archaeobotany*, **28**, 529-544. https://doi.org/10.1007/s00334-019-00712-x

[4] Hernandez, R.R., Armstrong, A., Burney, J., Ryan, G., Moore-O'Leary, K., Diédhiou, I., Grodsky, S.M., Saul-Gershenz, L., Davis, R. and Macknick, J. (2019) Techno-Ecological Synergies of Solar Energy for Global Sustainability. *Nature Sustainability*, **2**, 560-568. https://doi.org/10.1038/s41893-019-0309-z

[5] Yang, Y., Hobbie, S.E., Hernandez, R.R., Fargione, J., Grodsky, S.M., Tilman, D., Zhu, Y.-G., Luo, Y., Smith, T.M. and Jungers, J.M. (2020) Restoring Abandoned Farmland to Mitigate Climate Change on a Full Earth. *One Earth*, **3**, 176-186. https://doi.org/10.1016/j.oneear.2020.07.019

[6] Isbell, F., Tilman, D., Reich, P.B. and Clark, A.T. (2019) Deficits of Biodiversity and Productivity Linger a Century after Agricultural Abandonment. *Nature Ecology & Evolution*, **3**, 1533-1538. https://doi.org/10.1038/s41559-019-1012-1

[7] Porensky, L.M., Perryman, B.L., Williamson, M.A., Madsen, M.D. and Leger, E.A. (2018) Combining Active Restoration and Targeted Grazing to Establish Native Plants and Reduce Fuel Loads in Invaded Ecosystems. *Ecology and Evolution*, **8**, 12533-12546. https://doi.org/10.1002/ece3.4642

[8] Shiferaw, W., Demissew, S. and Bekele, T. (2018) Ecology of Soil Seed Banks: Implications for Conservation and Restoration of Natural Vegetation: A Review. *International Journal of Biodiversity and Conservation*, **10**, 380-393. https://doi.org/10.5897/IJBC2018.1226

[9] Stadler, J., Trefflich, A., Brandl, R. and Klotz, S. (2007) Spontaneous Regeneration of Dry Grasslands on Set-Aside Fields. *Biodiversity and Conservation*, **16**, 621-630. https://doi.org/10.1007/s10531-005-0604-z

[10] Al-Harbi, K.M. (2010) Monitoring of Agricultural Area Trend in Tabuk Region—Saudi Arabia Using Landsat tm and Spot Data. *The Egyptian Journal of Remote Sensing and Space Science*, **13**, 37-42. https://doi.org/10.1016/j.ejrs.2010.07.005

[11] Chaudhary, S.A. and Le Houérou, H.N. (2006) The Rangelands of the Arabian Peninsula. *Science et changements planétaires/Sécheresse*, **17**, 179-194.

[12] Piper, C.S. (1947) Soil and Plant Analysis. Interscience Publishers, Inc., New York.

[13] Loeppert, R.H. and Suarez, D.L. (1996) Carbonate and Gypsum. In: Bigham, J.M., Ed., *Methods of Soil Analysis: Chemical Methods*, Soil Science Society of America, Madison, 437-474. https://doi.org/10.2136/sssabookser5.3.c15

[14] Kent, M. (2011) Vegetation Description and Data Analysis: A Practical Approach. John Wiley & Sons, New York.

[15] Collenette, S. (1999) Wildflowers of Saudi Arabia. National Commission for Wildlife Conservation and Development (NCWCD), Riyadh.

[16] Crisp, M.D. and Lange, T.T. (1976) Age Structure, Distribution and Survival under Grazing of the Arid Zone Shrub Acacia Burkei. *Oikos*, **27**, 86-92. https://doi.org/10.2307/3543436

[17] Hill, M.O. (1979) Decorana—A Fortran Program from Detrended Correspondence Analysis and Reciprocal Averaging. Cornell University, Ithaca.

[18] Mucina, L., Rutherford, M.C., Schmiedel, U., Esler, K., Powrie, L., Desmet, P., Milton, S. and Jürgens, N. (2006) Succulent Karoo Biome. Strelitzia 19.

[19] Li, X., Hu, W. and Yu, Z. (2021) Importance of Soil Organic Matter and the Species Pool for Local Species Richness in Montane Ecosystems. *Sustainability*, **13**, 10634. https://doi.org/10.3390/su131910634

[20] Chun, J.-H. and Lee, C.-B. (2018) Diversity Patterns and Phylogenetic Structure of Vascular Plants along Elevational Gradients in a Mountain Ecosystem, South Korea. *Journal of Mountain Science*, **15**, 280-295. https://doi.org/10.1007/s11629-017-4477-x

[21] Wagensommer, R.P., Medagli, P., Turco, A. and Perrino, E.V. (2020) IUCN Red List Evaluation of the Orchidaceae Endemic to Apulia Region (Italy) and Considerations on the Application of the IUCN Protocol to Rare Species. *Nature Conservation Research*, **5**, 90-101. https://doi.org/10.24189/ncr.2020.033

[22] Carmo, D.L., Silva, C.A., Lima, J.M. and Pinheiro, G.L. (2016) Electrical Conductivity and Chemical Composition of Soil Solution: Comparison of Solution Samplers in Tropical Soils. *Revista Brasileira de Ciência do Solo*, **40**, e0140795. https://doi.org/10.1590/18069657rbcs20140795

[23] Allbed, A., Kumar, L. and Sinha, P. (2018) Soil Salinity and Vegetation Cover Change Detection from Multi-Temporal Remotely Sensed Imagery in Al Hassa Oasis in Saudi Arabia. *Geocarto International*, **33**, 830-846. https://doi.org/10.1080/10106049.2017.1303090

[24] Mucina and Rutherford (2006) The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South Africa National biodiversity Institute, Pretoria.

[25] Dimmitt, M.A. (2020) Plant Ecology of the Sonoran Desert Region. https://www.desertmuseum.org/books/nhsd_plant_ecology.php

[26] Castellanos, A., Martinez, M., Llano, J., Halvorson, W., Espiricueta, M. and Espejel, I. (2005) Successional Trends in Sonoran Desert Abandoned Agricultural Fields in Northern Mexico. *Journal of Arid Environments*, **60**, 437-455. https://doi.org/10.1016/j.jaridenv.2004.06.004

[27] El-Sheikh, M.A. (2005) Plant Succession on Abandoned Fields after 25 Years of Shifting Cultivation in Assuit, Egypt. *Journal of Arid Environments*, **61**, 461-481. https://doi.org/10.1016/j.jaridenv.2004.10.006

[28] Kirschner, G.K., Xiao, T.T. and Blilou, I. (2021) Rooting in the Desert: A Developmental Overview on Desert Plants. *Genes*, **12**, 709. https://doi.org/10.3390/genes12050709

[29] Hayati, A.A. and Al-shammary, F.H. (2011) Abiotic Soil Factors Affecting Plant Distribution at Jubail Wildlife Sanctuary in the Eastern Region of Saudi Arabia. *Sacha Journal of Environmental Studies*, **1**, 101-115.

[30] Beauchamp, V.B. and Shafroth, P.B. (2011) Floristic Composition, Beta Diversity, and Nestedness of Reference Sites for Restoration of Xeroriparian Areas. *Ecological Applications*, **21**, 465-476. https://doi.org/10.1890/09-1638.1

[31] Zhang, K., Dang, H., Tan, S., Wang, Z. and Zhang, Q. (2010) Vegetation Community and Soil Characteristics of Abandoned Agricultural Land and Pine Plantation in the Qinling Mountains, China. *Forest Ecology and Management*, **259**, 2036-2047. https://doi.org/10.1016/j.foreco.2010.02.014

[32] Dunjó, G., Pardini, G. and Gispert, M. (2003) Land Use Change Effects on Abandoned Terraced Soils in a Mediterranean Catchment, NE Spain. *Catena*, **52**, 23-37. https://doi.org/10.1016/S0341-8162(02)00148-0

[33] Zeller, V., Bahn, M., Aichner, M. and Tappeiner, U. (2000) Impact of Land-Use Change on Nitrogen Mineralization in Subalpine Grasslands in the Southern Alps. *Biology and Fertility of Soils*, **31**, 441-448. https://doi.org/10.1007/s003740000200

[34] Knops, J.M. and Tillman, D. (2000) Dynamics of Soil Nitrogen and Carbon Accumulation for 61 Years after Agricultural Abandonment. *Ecology*, **81**, 88-98. https://doi.org/10.1890/0012-9658(2000)081[0088:DOSNAC]2.0.CO;2

[35] Du, F., Shao, H.-B., Shan, L., Liang, Z.-S. and Shao, M.-A. (2007) Secondary Succession and Its Effects on Soil Moisture and Nutrition in Abandoned Old-Fields of Hilly Region of Loess Plateau, China. *Colloids and Surfaces B*: *Biointerfaces*, **58**, 278-285. https://doi.org/10.1016/j.colsurfb.2007.04.002

[36] Osman, A.K. and Abdein, M.A. (2019) Floristic Diversity of Wadi Ar'ar, Saudi Arabia. *Journal of Taibah University for Science*, **13**, 772-789. https://doi.org/10.1080/16583655.2019.1634177

[37] McLauchlan, K.K. (2006) Effects of Soil Texture on Soil Carbon and Nitrogen Dynamics after Cessation of Agriculture. *Geoderma*, **136**, 289-299. https://doi.org/10.1016/j.geoderma.2006.03.053

[38] Carrera, A.L., Mazzarino, M.J., Bertiller, M.B., del Valle, H.F. and Carretero, E.M. (2009) Plant Impacts on Nitrogen and Carbon Cycling in the Monte Phytogeographical Province, Argentina. *Journal of Arid Environments*, **73**, 192-201. https://doi.org/10.1016/j.jaridenv.2008.09.016

[39] Davies, K.W., Pokorny, M.L., Sheley, R.L. and James, J.J. (2007) Influence of Plant Functional Group Removal on Inorganic Soil Nitrogen Concentrations in Native Grasslands. *Rangeland Ecology & Management*, **60**, 304-310. https://doi.org/10.2111/1551-5028(2007)60[304:IOPFGR]2.0.CO;2

[40] Al-Jaloud, A.A. and Hussain, G. (2006) Sabkha Ecosystem and Halophyte Plant Communities in Saudi Arabia. In: Khan, M., Böer, B., Kust, G. and Barth, H., Eds., *Sabkha Ecosystems*, Springer, Dordrecht, 1-7. https://doi.org/10.1007/978-1-4020-5072-5_1

[41] Abdein, M.A. and Osman, A.K. (2020) Plant Diversity Assessment of Wadi Al-Hilali, Northern Border Region, Saudi Arabia. *International Journal of Botany Studies*, **5**, 87-95. http://www.botanyjournals.com/download/548/5-2-24-656.pdf

[42] Osman, A.K. and Abdein, M.A. (2019) Karyological and Molecular Studies between Six Species of Plantago in the Northern Border Region at Saudi Arabia. *Journal of Taibah University for Science*, **13**, 297-308. https://doi.org/10.1080/16583655.2019.1571400

[43] Rayan, A.M., Abdein, M.A. and Ibrahim, A.A. (2020) Associated Weeds of Some Agroecosystems in the Northern Border Region, KSA. *International Journal of Botany Studies*, **5**, 345-351. http://www.botanyjournals.com/archives/2020/vol5/issue3/5-3-76

[44] Abdein, M.A., Nassr, H.W. and Osman, A.K.E. (2020) Genetic Characterization of Genus Tephrosia Pers. Based on Molecular Markers in KSA. *International Journal of Botany Studies*, **5**, 203-209. http://www.botanyjournals.com/download/568/5-2-26-266.pdf

[45] Al-Harbi, N.A.A. (2021) Comparative Study on the Kinds of Weeds of Palm Plantations in Tabuk and Al-Qassim Regions in Saudi Arabia. *Iraqi Journal of Agricultural Sciences*, **52**, 763-773. https://doi.org/10.36103/ijas.v52i3.1368

[46] Al-Harbi, K.M. (2005) Detecting and Monitoring Desertification Processes in the Western Tabuk Province, Saudi Arabia Using Remote Sensing and Ancillary Data. *Journal of the Gulf and Arabian Peninsula Studies*, **31**, 11-33.

[47] Al-Harbi, N.A. (2017) Diversity and Taxonomic Composition of Weeds in Olive Orchards in Tabuk Region, Saudi Arabia. *Arid Ecosystems*, **7**, 203-208.

https://doi.org/10.1134/S2079096117030064

[48] Al-Harbi, N.A. (2017) Diversity of Medicinal Plants Used in the Treatment of Skin Diseases in Tabuk Region, Saudi Arabia. *Journal of Medicinal Plants Research*, **11**, 549-555. https://doi.org/10.5897/JMPR2017.6438

[49] Al-Harbi, N.A. (2017) Survey of Plant Species of Medical Importance to Treat Digestive Tract Diseases in Tabuk Region, Saudi Arabia. *Journal of King Abdulaziz University*, **29**, 51-61. https://doi.org/10.4197/Sci.29-1.6

[50] Al-Harbi, N.A., Abdein, M.A., El-Hallous, E.I., Mohammadein, A. and Hamad, A.A. (2021) Performing Some Inbred Lines of Squash for Earliness and Vegetative Growth Traits in Different Locations. *Ecology, Environment and Conservation*, **27**, 18-24. http://www.envirobiotechjournals.com/article_abstract.php?aid=11800&iid=338&jid=3

[51] Al-Harbi, N.A., Awad, N.S., Alsberi, H.M. and Abdein, M.A. (2019) Apoptosis Induction, Cell Cycle Arrest and *in Vitro* Anticancer Potentiality of *Convolvulus spicatus* and *Astragalus vogelii*. *World Journal of Environmental Biosciences*, **8**. https://environmentaljournals.org/storage/models/article/zrbD6O1vWnaM7WssIve6ClH3ev4Yp7pOWZ1zxypXWbAmuzrKHrTmV9USYQbe/apoptosis-induction-cell-cycle-arrest-and-in-vitro-anticancer-potentiality-of-convolvulus-spicatus.pdf

[52] Alqahtani, M.M., Abdein, M.A. and Abou El-Leel, O.F. (2020) Morphological and Molecular Genetic Assessment of Some Thymus Species. *Biosciences Biotechnology Research Asia*, **17**, 103-113. https://doi.org/10.13005/bbra/2815

[53] Sukontaprapun, B., Charoenkiatkul, S., Thiyajai, P., Sukprasansap, M., Saetang, P. and Judprasong, K. (2019) Key Organic Acids in Indigenous Plants in Thailand. *American Journal of Plant Sciences*, **10**, 1855-1870. https://doi.org/10.4236/ajps.2019.1010131