Natural regeneration of severely degraded terrestrial arid ecosystems needs more than just removing the cause of the degradation

Louhaichi, M.*; Gamoun, M.*; AL Hashash, N.**; Al-Ameer, F.**; Alrashedi, D.**;
Redha, A. **; Alkandari, F**; Niane, A.***
*International Center for Agricultural Research in the Dry Areas (ICARDA), Tunisia
**Public Authority of Agriculture Affairs and Fish Resources (PAAF), Kuwait
***ICARDA, United Arab Emirates

Keywords: Therophytization, disturbance, natural restoration, Kuwait's rangeland

Abstract. Rangelands cover over 75% of Kuwait's total land area. Most of these rangelands are severely degraded because of overgrazing, poor anthropic utilization, and mismanagement. Restoring natural rangelands is a way to increase forage productivity, enhance biodiversity, and achieve sustainable development. When degradation has not reached the point of irreversibility, natural restoration through resting is one of the best low-cost restoration techniques. This study evaluated the effect of natural restoration on vegetation cover and species richness in the desert rangelands of Kuwait. The studied rangeland was a completely fenced area of 1 km^2. The percent of vegetation was measured using the line-intercept method. The cover of perennial species was the same in fenced and unfenced areas (0%), but annual species cover was 19.67% in fenced areas and 6% in unfenced areas. There was no significant difference in the contribution to the total cover of the dominant invasive species *Stipa capensis* between fenced (90%) and unfenced areas (83%). All recorded species are therophytes, which raises the disturbance index to 100%. This therophytization demonstrates an imbalance in the rangeland ecosystem and desertification due to the high anthropozoogene pressure. Under such a severely degraded ecosystem, natural restoration cannot restore vegetation. Reintroducing native species including *Helianthemum lipii, Haloxylon salicornicum, Rhanterium epapposum,* and *Calligonum comosum,* is required to restore the ecosystem, facilitate the growth of annual palatable species, and enhance the flora diversity.

Introduction

Rangelands cover over 75% of Kuwait's total land area, and they are generally flat or gently undulating deserts (Misak et al. 1999; Omar et al. 2001a). These rangelands have been severely degraded as evidenced by the destruction of vegetation cover and soil erosion caused by overgrazing and wind. The open grazing policy appears to be a major contributor to this degradation. The degradation is serious and the percentage of degraded and desertified land was estimated at 100% (UNEP 2000).

Despite Kuwait's desert rangelands offering little value to pastoralists, Kuwaitis, regard it as an important part of their natural and cultural heritage. For this reason, the government has made several interventions to improve rangeland health including establishing a rangeland restoration strategy, the continuing conservation of the environment, and combating desertification measures. The government has also made efforts in the most severely degraded rangeland areas by actively planting native shrubs. This natural restoration initiative is insufficient to restore severely degraded areas. This study assessed the effectiveness of natural restoration on vegetation cover and species richness in the desert rangelands of Kuwait.

Methods and Study Site

The study area is located 120 km north of Kuwait City (29°06'14.5"N 46°48'14.7"E) at an elevation of 276 m and has a desert climate. Data from 2007 to 2021 obtained from the meteorological station of Salmy showed an average rainfall of 84 mm. Temperatures are generally hot in the summer and cold in the winter with a mean annual of about 26° C. Maximum relative humidity levels are high during the winter months, frequently exceeding 80% in November.

The studied rangeland was 1 km^2 and it was ringed by chain link fences higher than 2 m. The soil type is flat Petrogypsids which is the most vulnerable soil (Al Saleh 2019). Historically, rangelands are dominated by *Haloxylon salicornicum*. These rangelands have deteriorated because of centuries of overgrazing by sheep, goats, and camels and are a favored habitat for invasive plants, particularly for the most common grass *Stipa capensis*.

Three sites were randomly placed within the fenced rangeland. There were three 50-meter transects in each site and three line transects installed in the unfenced area to compare the differences between fenced and unfenced areas. Vegetation cover and species composition were estimated using the line-intercept method (Daget and Poissonet 1971). The sampling was done in March when the forage resources were at their peak. Each of the 100 hits/line within each transect was recorded according to plant species and type of ground: stones, litter, or bare ground. The species richness in each area was also recorded.

The percent of species cover was obtained by dividing the number of points at which a particular species was encountered by the total taken for all species and multiplying by 100. The contribution of each species, total vegetation cover, and palatability factor was used to calculate the forage units (FU) by

$$\mathrm{P} = 1.5 \sum_{i=1}^{n} \mathrm{SC}i \ \mathrm{x}\ \mathrm{PF}i \ \mathrm{x}\ \mathrm{TPC}/100$$

Where P is total rangeland production in forage units (FU)/ha/year, SC*i* is species cover *i* (%), PF*i* is the palatability factor of species *i*, and TPC is total percent of plant cover.

Results and Discussion

Grazing exclusion increased total vegetation cover in fenced compared to unfenced areas (p=0.03). The effect is positive but remained below the threshold of irreversibility at 19.67% (Figure 1). The vegetation cover has slowed down in the fenced areas, but this was expected after three years of fencing. This is possibly due to damage from overgrazing where rangeland degradation leads to crossing the threshold (vegetation cover is less than 20% to 25%) and increasing areas of bare ground that are a symptom of unhealthy rangeland that is difficult or impossible to reverse.

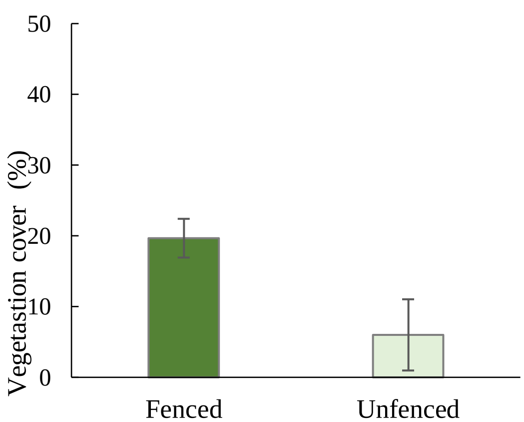

Figure 1. Total vegetation cover in fenced and unfenced areas (%)

Using fences to exclude livestock increased the cover of annual species but did not alter perennial cover after three years. In fenced rangeland, the percent cover of perennial species was the same as that in unfenced areas, but annual species cover was 19.67% in fenced areas and 6% in unfenced areas. There was no significant difference in the contribution to the total cover of the dominant specie *Stipa capensis* between fenced (90%) and unfenced areas (83%) (Figure 2).

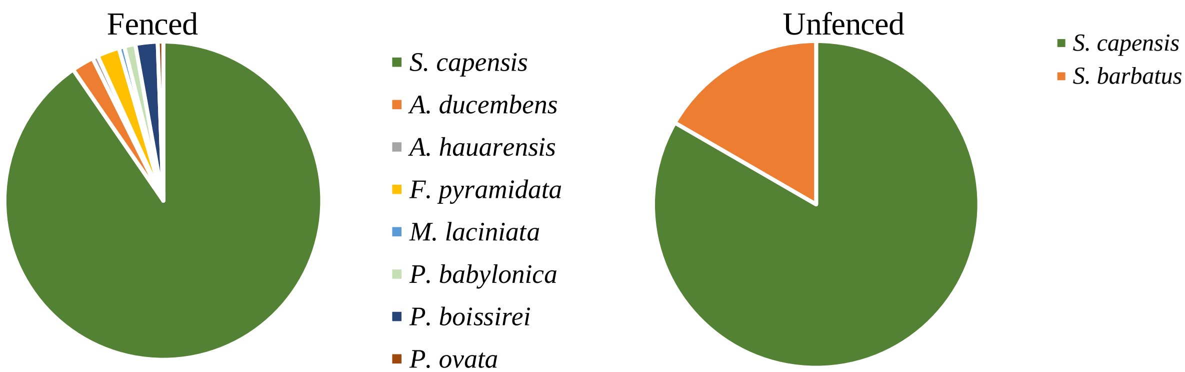

Figure 2. Relative contribution of each species to the total cover

Under severe disturbance, perennial species such as *Haloxylon salicornicum* and *Stipagrostis plumosa* communities have disappeared, allowing annual grass species such as *Stipa capensis* to dominate (Omar et al. 2001b). This species is the most visible plant and covers large swaths of the desert plain of Kuwait, especially during wet springs (Brown and Schoknecht 2001). *S. capensis* caryopses have a high emergence rate (Tavili et al. 2017) and are well adapted to harsh environments. They can penetrate dense crust and small cracks caused by dehydration of biological soil crusts during seed dispersal periods in early summer.

The dominance of therophytes as *S. capensis* often qualified therophytization which indicates their adaptation to newly disturbed areas. This disturbance leads to the decrease of perennial species and their replacement by annual species (Ouled Belgacem et al. 2008). Therophytization in the study zone at 100% is an indicator of high disturbance and imbalance of the plant community, making it difficult to achieve ecological equilibrium.

Several studies have reported that therophytization is the final stage of vegetation degradation (Quezel 2000). Establishing an indicator called an index of disturbance could be useful to determine rangeland degradation (Loisel and Gamila 1993). This index was developed to assess the degree of therophytization of each rangeland within a given climatic region.

$$ID = \frac{Number\ of\ therophytes + Number\ of\ chamaephytes}{Species\ richness\ (S)} \text{ x } 100$$

All plants recorded are therophytes, which raises the disturbance index to 100%. This demonstrates a disturbance and imbalance in the rangeland ecosystem due to the high anthropozoogene pressure. As well, changes in plant community composition and the distribution of species make the rangeland more homogenous, and over 90% of the rangelands were covered by *S. capensis*. These changes in rangeland cover and its spatial homogeneity indicate the degradation of soil and vegetation.

Total rangeland productivity (forage production) was higher in the fenced area (61.83 FU/ha/year) than in unfenced areas (21 FU/ha/year) (Figure 3). Rangeland production was very low because it is provided by therophytes and especially from *S. capensis* which is not palatable. This demonstrates that rangeland management using grazing exclusion is undesirable because little forage is produced and cannot support livestock. Overgrazing in a desired site can damage the rangeland so controlling the number of livestock on the land is important.

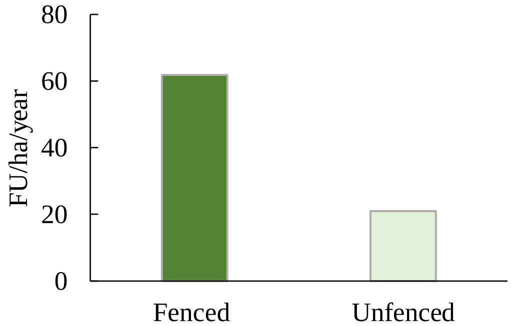

Figure 3. Rangeland production variations across grazing management (FU/ha/year)

Conclusion

These results show that for severely disturbed rangelands, fencing alone is ineffective in safeguarding the functionality of the primary ecological processes, forage production, species richness and diversity, and carrying capacity. Restoration of the biodiversity in degraded rangelands requires the transplantation of native shrubs and palatable grasses despite its significant cost. Introducing other shrubs and grasses such as *Helianthemum lipii* and *Haloxylon salicornicum*, can reduce the competitive ability of invasive species such as *S. capensis*, facilitate the growth of annual palatable species and enhance the flora diversity in the rangeland. If this policy achieves its goals, it will affect livelihoods, nutrition, and ecological systems.

Acknowledgments

This study was conducted within the framework of the collaborative research program between the GCC countries and ICARDA. Special thanks go to the Public Authority of Agriculture Affairs and Fish Resources in Kuwait and to the Livestock and Climate initiative of the OneCGIAR for their support.

References

Al Saleh, A.H., Misak, R.F., Al Tamimi, S.A., Al Baker, H. and Malek, M.J. 2019. Characterization and mapping land degradation hotspots in the terrestrial ecosystem of Kuwait. *Biomed. J. Sci. Technol. Res.*, 14(1): 1-12.

Brown, G. and Schoknecht, N. 2001. Off-road vehicles and vegetation patterning in a degraded desert ecosystem in Kuwait. *J. Arid Environ.*, 49(2): 413-427.

Daget, P. and Poissone, P. 1971. Une méthode d'analyse phytoécologique des prairies. Critères d'applications. *Ann. Agron.*, 22(1): 5-41.

Loisel, R. and Gomila, H. 1993. Traduction des effets du débroussaillement sur les écosystèmes forestiers et préforestiers par un indice de perturbation. *Ann Soc Sci Nat Archeol Toulon Var.*, 45: 123-132.

Misak, R., Al-Awadhi, J.M. and Al-Sudairawi, M. 1999. Assessment and controlling land degradation in Kuwaiti desert ecosystem. In: *Proceedings of the conference on the impact of environmental pollution on the development in the Gulf region*, Kuwait, March 15-17.

Omar, S.A., Misak, R., Minkarah, H., King, P., Kwarting, A., Abo-Rizq, H. and Roy, W. 2001a. Land-use mapping for the State of Kuwait using the geographical information system (GIS). *Arab Gulf J. Sci. Res.*,19(2): 59-65.

Omar, S.A., Misak, R., King, P., Shahid, S.A., Abo-Riz, H., Grealish, G. and Roy, W. 2001b. Mapping the vegetation of Kuwait through reconnaissance soil survey. *J. Arid Environ.*,48(3): 341-355.

Ouled Belgacem, A., Salem, B.H., Bouaicha, A. and El-Mourid, M. 2008. Communal rangeland rest in arid area, a tool for facing animal feed costs and drought mitigation: The case of Chenini community, Southern Tunisia. *J. Biol. Sci.*, 8(4): 822-825.

Quezel, P. 2000. *Réflexions sur l'évolution de la flore et de la végétation au Maghreb méditerranéen*. Ed. Ibis. Press, Paris.

UNEP. 2000. *Global environment outlook 2000*. United nations environment programme (UNEP), Routledge.