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Impact of Grazing on Soil Seed Bank Replenishment under the Mediterranean Climate of Northern Syria

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Introduction:

Rangelands represent 70% of the semi-arid and arid Mediterranean land mass. It is a habitat for millions of people whose livelihood depends on animal husbandry. The revolutionary developments in the animal husbandry and veterinary medicines resulted in exponential increases in livestock and human populations living on and from dry lands. To respond to population growth, expansion on urbanization, transportation and road networks, land reform and rural development policies forced nomads to adopt sedentary lifestyles. The demographic changes coupled with national and international border crossing restrictions escalated opportunistic cultivation, and excessive exploitation of the scarce and slowly renewable vegetation cover of rangelands. In an attempt to stop and reverse the degradation process, large-scale re- vegetation programs based on transplanting and reseeding with perennial shrubs, resting and grazing management systems were devised and implemented. This study aimed to evaluate the impacts of the rehabilitation programs on the above-ground vegetation cover and soil seed bank replenishment in the Syrian rangelands. The underlying assumption of the rehabilitation program is that with a well-established perennial plant cover and proper grazing management, top soil is stabilized, soil moisture, nutrients and seed bank are replenished and organic matter is accumulated resulting in greater abundance, species richness and diversity of annuals. To test the above hypothesis, field and controlled environment based studies were carried out with quantitative data collection and processing on plant species abundance, richness and diversity of above-ground vegetation and soil seed bank for fully protected rotationally and continuously grazed areas of 10 rangeland sites in northern Syria for two consecutive seasons based on Hayashi, I. & Numata, M. (1964).

Materials and Methods:

The study was carried out on 10 range land sites in Syria (table1) during the autumn of 2006 and 2007 to assess grazing impacts on soil seed bank (SSB) size and composition in arid Mediterranean rangelands

under rehabilitation (fig1). Nine soil cores of 20 cm diameter and 5 cm depth were collected along grazing gradients in each of the 10 sites. The SSB size and composition were recorded using physical seed extraction and grow out tests methods on 2 and 3 sub-samples of 0.25 and 3 kg soil from each site, respectively. In the spring, plant density and richness data were collected from the same plots using quadrat and point intercept green cover study methods.

The number of species (richness), total number of seed, seedlings and flowering plants recorded from each sample representing grazing treatments within sites (abundance) were used to generate Shannon-Wiener and Simpson reciprocal indices of diversity then subjected to pairwise comparison (Johnson, N. L. & Kotz, S. (1969)). Datasets were unbalanced. A simple unbalanced ANOVA procedure based on regression analysis was carried out for plant density for GOT with logarithmic transformation and for plant density for Grow out Test with square root transformation, while richness data was untransformed. The various terms accounted were sites, years within sites, grazing method and its interaction.

Results and Discussion:

The soil seed bank data analysis using ANOVA showed no significant differences (also supported by Kassahun, A., Snyman, H. A. & Smit, G. N. (2009)) in the overall physical and germinable soil seed bank (GSB) size and diversity indices along the grazing gradient (table2). However, there was a significant grazing-by-site interaction (Fig2) for both and a significant grazing-by-year interaction (Fig3) for GSB size showing that the change in seed bank size is moderated by physical and environmental characteristics and human-induced disturbances. Continuous grazing treatments for some sites were located near human and livestock agglomerations, main roads and water points (table 1). Under such conditions the more disturbance-adapted ephemerons and non-palatable plants with limited constraints for seed setting dominated resulting in a larger soil seed bank under continuous compared to rotational and full protection grazing treatments (Fig3). For the more human-induced disturbance distanced sites, the soil seed bank diversity was larger or similar under full and/or rotational compared to continuous grazing (Fig4). Non-changing and changing soil seed bank size with degradation gradients have been reported from different habitats (Kassahun, A., Snyman, H. A. & Smit, G. N. (2009)).

Results from pair-wise comparisons showed a simultaneous decline and surge in diversity indices of physical and germinable soil seed bank size of annuals and those of perennials under the grazing treatments over sites (Fig4). This suggests relative differences in root competition and gap exploitation characteristics among plant functional groups (Noy-Meir & Kaplan, 2002) these differences could be considered indicative to rangeland status and a guide to vary herbivores in order to maintain optimum plant species diversity in the target rangelands.

Physical seed extraction from soil samples collected from continuous grazing resulted in lower soil seed banks size of perennial grasses than that of the germinable one. This is probably due to seed setting failure resulting from overgrazing compensated by vegetative reproduction. The widely used phanerophytes in the rangeland rehabilitation program had a physical soil seed bank size ranging from 59.7 to 119 seed m^{-2} but had a zero germinable one. This shows high complementarity between physical seed extraction and grow out test methods for monitoring rangeland status.

High Morisita-Horn and Sørensen similarities were recorded between the above ground vegetation measurements with each of physical and germinable soil seed banks. However, the similarity indices of the above ground vegetation measurements were higher with the germinable seed bank than with the physical soil seed bank. This suggests that grow out test is more suitable for monitoring the status of arid Mediterranean rangeland than physical soil seed bank (Table2).

Conclusion:

Impacts of the grazing management component of the rehabilitation program on the floristic composition of the physical and germinable soil seed bank in the study area is strongly moderated by temporal and spatial variability in the biophysical site characteristics and precipitation. This calls for incorporation of herbivory variation and inter- seasonal rotational grazing into the arid rangeland grazing management calendars.

The simultaneous decline and surge in physical and germinable soil seed bank size of annuals and perennials under the same grazing treatments suggests root competition and gap exploitation among functional groups. Plant species facilitation and association relationship between functional groups moderated by grazing practices is another justification for incorporating herbivore variation to maintain integrity in plant community composition of arid Mediterranean rangelands.

The study showed a high complementarity of physical seed extraction and grow out test methods for soil seed bank assessment. Grow out test neutralizes the seed extraction associated limitations of over/under estimation of seed bank size by including none germinable seed or excluding vegetative reproduction propagules. The combination revealed the shift in species with different proportional abundance under the different grazing treatments as well as the limitations of germination method for phanerophytes. Nonetheless, the grater species richness captured, simplicity and higher similarity indices of GSB with vegetation measurements makes it a good monitoring tool for species richness and abundance in arid rangelands.

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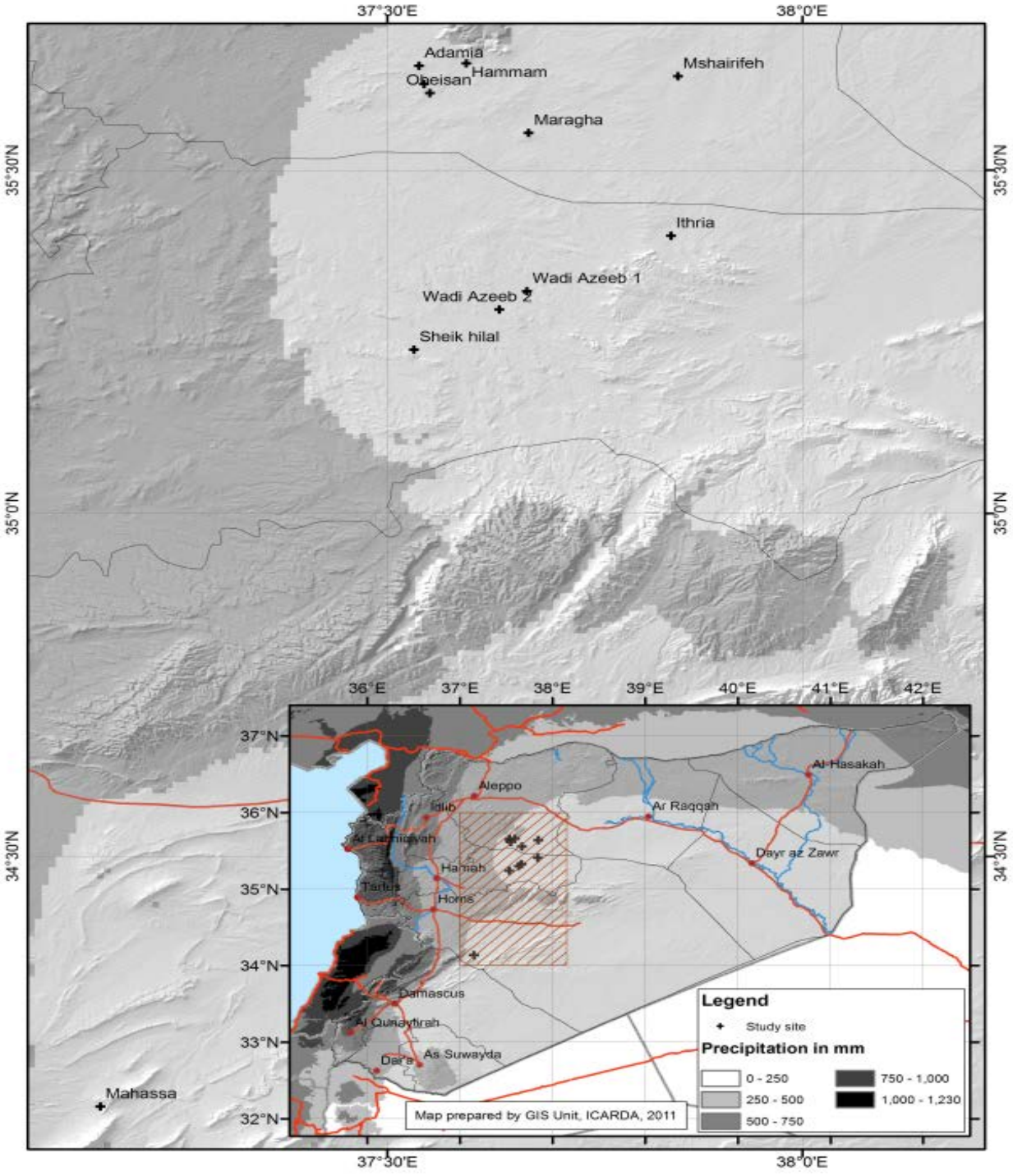

Figure 1: Precipitation map of Syria showing the study sites under 0-250 rainfall area. Map provided by the ICARDA GIS unit

Table 1: Range sites, years of protection and grazing treatments, Northern Syria

Provinces	Sites	Years of protection	Shrub planting	Anthropogenic factors[1]	Grazing treatments[2]	Study seasons[3]
Aleppo	Obeisan	0	No	1, 4	Continuous	3
		20	Yes	1, 4	Protected	3
		20	Yes	1, 4	Rotational	3
	Adamia	0	No	1, 2	Continuous	3
		10	Yes	1, 2	Protected	3
		10	Yes	1, 2	Rotational	3
	Hammam	0	No	1, 2	Continuous	3
		5	No	1, 2	Protected	3
		5	No	1, 2	Rotational	3
	Wadi Azeeb1	0	No	1, 2, 3	Continuous	3
		40	Yes	1, 2, 3	Protected	3
		40	Yes	1, 2, 3	Rotational	3
	Wadi Azeeb2	0	No	2	Continuous	3
		5	Yes	2	Protected	3
	Maragha	0	No	1, 2	Continuous	3
		20	Yes	1, 2	Rotational	3
	Mshairifeh	0	No	1, 4	Continuous	3
		20	Yes	1	Rotational	3
Hama	Ithria	0	No	1, 2, 3	Continuous	3
		40	Yes	1, 2, 3	Protected	3
	Sheik hilal	0	No	1, 2	Continuous	2
		5	Yes	1, 2	Protected	2
Homs	Mahassa	0	No	2	Continuous	2
		5	Yes	2	Protected	2

[1]: Numbers represent anthropogenic factors as follows: 1 = near people and animal agglomerations; 2 = near main road; 3 = near water point; 4 = cultivation. [2]: 0.03 m^3 of soil from 9 cores of 20 cm diameter and 10 cm depth on 3 transects of 100 m long, each were collected annually from every grazing treatment. [3]: Data collection during 2006/07, 2007/08 and 2008/09.

Table 2: Accumulated analysis of variance for physical and germinable soil seed bank size and richness

Method	Factors	d.f.	Plant density		Richness		Method	Shannon		Simpson	
			Var. ratio	F pr.	Var. ratio	F pr.		Var. ratio	F pr.	Var. ratio	F pr.
Seed extraction	Year	2	27.49	<.001	2.17	0.161	Quadrat	1.56	<.001	0.96	0.494
	Sites	9	8.81	<.001	1.64	0.216		**14.08**	**<.001**	**7.91**	**0.003**
	Grazing	2	0.01	0.986	1.04	0.387		2.81	<.001	1.19	0.322
	Year .Sites	8	2.72	0.063	0.70	0.687		0.97	0.020	0.81	0.660
	Year .Grazing	3	1.46	0.279	1.46	0.280		1.57	0.043	1.22	0.331
	Sites .Grazing	12	3.74	0.018	0.36	0.955		0.94	0.542	0.47	0.755
	% CV		8.5 (log10)		27.8			29.9			
Grow out test	Year	2	287.34	<.001	29.40	<.001	Point intercept	0.56	<.001	0.78	0.635
	Sites	9	23.77	<.001	28.14	<.001		**10.88**	**<.001**	**8.03**	**0.002**
	Grazing	2	0.91	0.432	1.94	0.189		1.34	0.001	0.68	0.517
	Year .Sites	8	6.55	0.003	4.22	0.015		2.01	0.044	1.10	0.407
	Year .Grazing	3	4.70	0.024	0.96	0.444		0.74	0.041	0.35	0.969
	Sites .Grazing	12	3.55	0.022	4.85	0.007		1.01	0.712	0.65	0.631
	% CV		9.7 (S)		11.7			18.1			

v.r. = variance ratio. F pr = p-value based on F-distribution. Error components not included.

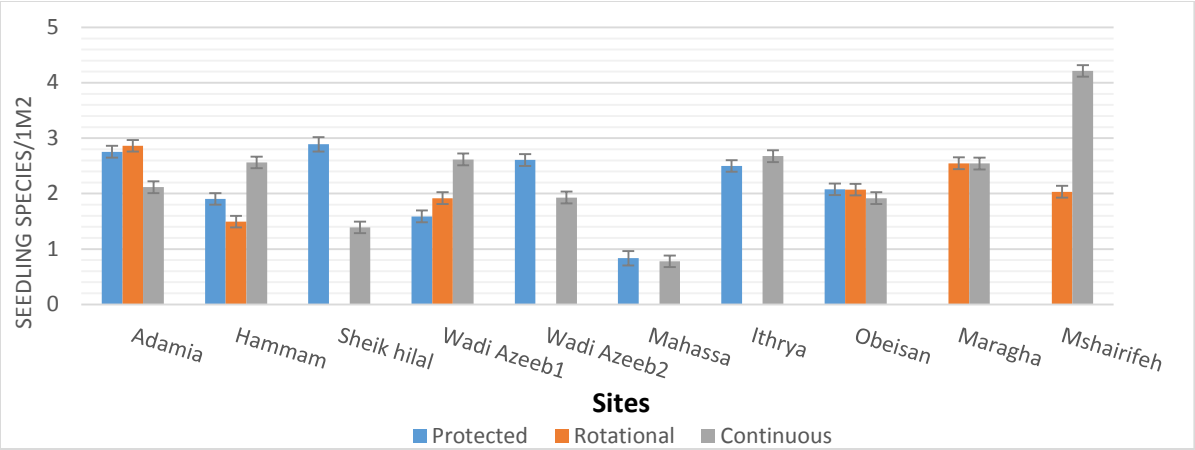

Figure 2: Species richness measured using quadrat method across a grazing gradient within 10 rangeland sites in Northern Syria averaged over three consecutive seasons with standard error bars of means

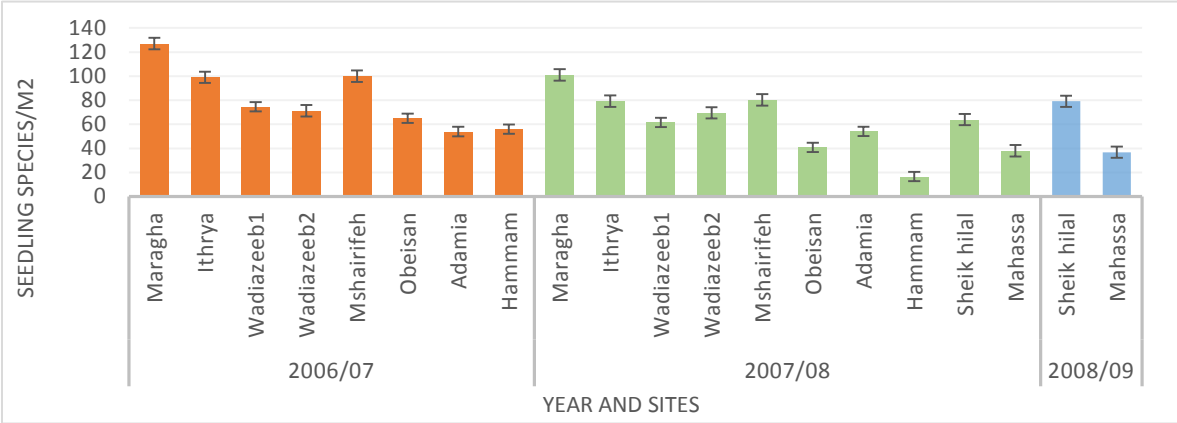

Figure 3: Trends of change in germinable soil seed bank richness in three different seasons with standard error of mean bars

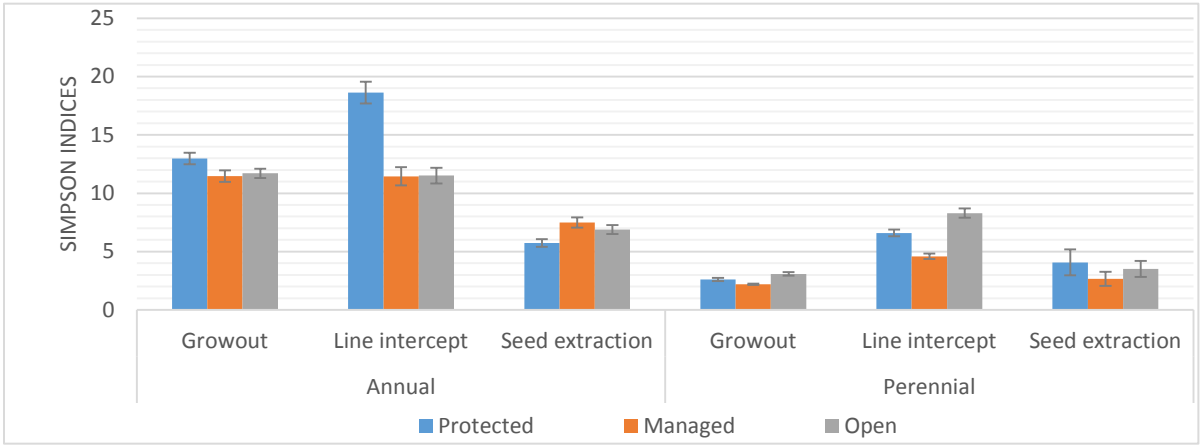

Figure 4: Trends of change in germinable soil seed bank richness in three different seasons with standard error of mean bars

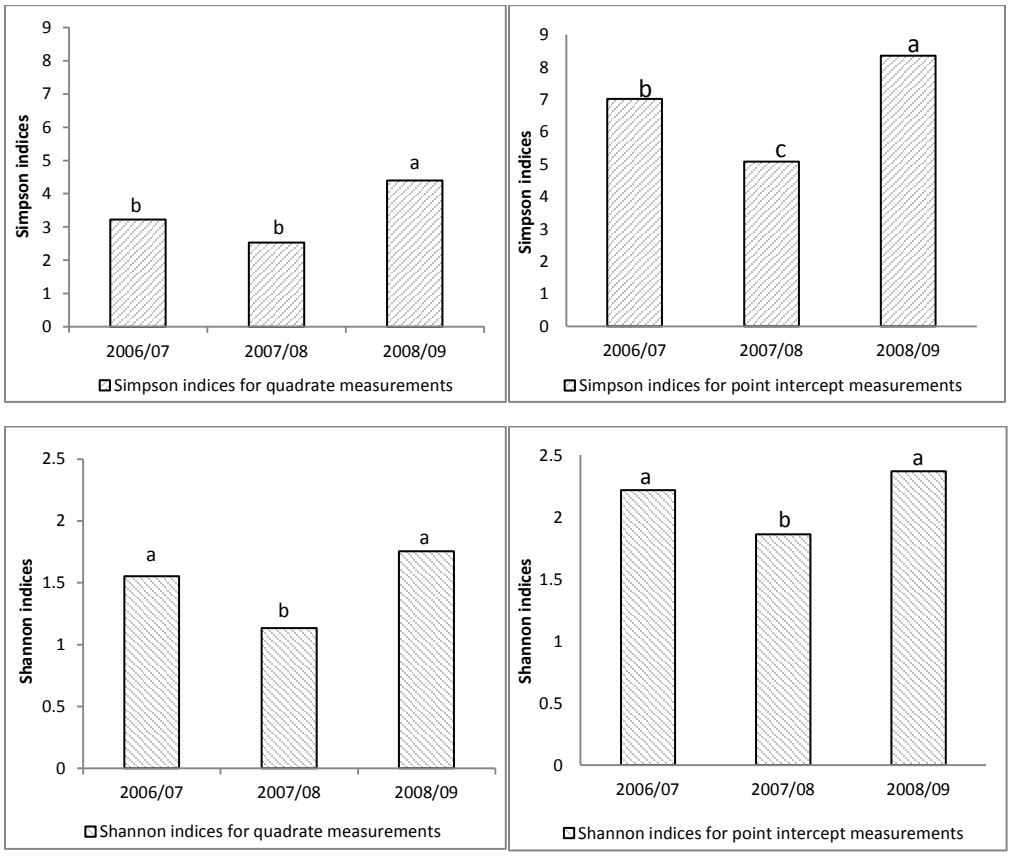

Figure 4: Shannon and Simpson reciprocal indices of plant species diversity over 10 sides in three consecutive seasons, different letters indicate significant differences based on approximate normal distribution of pair-wise differences.

Table 3: Similarity indices for species diversity of aboveground vegetation, physical and germinable soil seed banks along grazing gradients in 10 rangeland sites in northern Syria

Index	Methods	Quadrat	Point intercept	Germinable seed bank	Physical seed bank
Morisita-Horn	Quadrat	1	0.63	0.47	0.08
	Point intercept		1	0.52	0.26
	Germinable seed bank			1	0.60
	Physical seed bank				1
Sørensen	Quadrat	1	0.21	0.19	0.11
	Point intercept		1	0.60	0.29
	Germinable seed bank			1	0.60
	Physical seed bank				1