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# Seed stocks of grazed and ungrazed rangelands on Palandoken Mountains of Eastern Anatolia

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**Abstract**

The seed stocks in soil of rangelands community was studied in order to provide a basis for a better understanding of the background of botanical composition. Soil seed stocks changed depending on management strategies efforts and some environmental factors in rangeland sites. Knowledge about soil seed banks and vegetation in these ecosystems was crucial for guiding the restoration efforts. This study examined the size, composition and species richness of the soil seed banks in grazed and ungrazed sites. Forty seven species of botanical composition of the seed stocks were identified, 29 species of them were common to both sites. Seedling number in grazed site was higher than in ungrazed site in the soil stocks. Seeds of desirable grasses and legume species were higher in the grazed site. Similarity index of seedling composition between grazed and ungrazed site was 57.11%. The results implied that under current grazing condition on the rangelands in the region, range vegetation was not extremely degraded and may be regenerated by soil seed stocks in the case of unexpected degradation event.

***Key words:*** Soil seed bank, species number and composition.

## Introduction

The rangelands occupy about 28% of terrestrial area of Turkey. Total rangeland area decreased almost half during fifties due to converting to the other land, especially cultivated land. However, animal number did not change during this period and some increases during the fallowed decades and grazing pressure increased at least two folds after this time on the rangelands [1]. This increase caused over grazing intensity and as a consequence of this progress serious rangeland degradation occurred all around of Turkey. According to Genckan *et al.* [2], Turkey rangelands have lost 90% of climax vegetation.

The importance of protecting natural ecosystems and conserving their diversity is well recognized [3]. Rangeland researchers believed that restoration of degraded rangeland needs more labor and cost and on the other hand, return of cost takes a long time and never establish ex-biodiversity [4-6]. The soil seed stocks play a significant role in the succession trend of plant communities and their conservation [7]. Recently, seed stocks have received considerable attention in relation to the conservation, management and restoration of natural ecosystems because soil seed stocks are an important component of vegetation dynamics and resilience [8].

Grazing can reduce seed production either by reducing allocation of photosynthate to reproductive organs due to harvesting leaves or by the removal of flowers and seeds [9]. Grazing alters density and diversity of the species in the botanical composition; consequently it changes seed abundance and composition and also germinability in the soil seed stock on the rangelands [10]. While seed number of palatable species such as perennial grasses and legumes decrease in seed stocks of soil, seed number of annual and ungrazed plants increase in soil seed stocks under the grazing condition [11, 12]. As a result of these factors, succession trend can be altered in the natural rangelands.

Composition and density of the seed stocks seem to be affected by physiographic factors [13] as well as grazing [14]. Generally, harshness of environment at higher altitudes and latitudes and heavy grazing could reduce seed production and encourage on vegetative reproduction [15]. Composition of vegetation and soil seed stocks shows often a discrepancy due to seed longevity, variable dormancy and persistence among species [16, 17]. Some species being abundant in vegetation can represent a rare percentage in seed stocks due to reliance on vegetative spreading[15]. As grazing intensity increased dispersed seed number decrease linearly [18].

The information on characteristics of the seed stocks may contribute to predict the potential effects of management practices and trend of succession after any unexpected degradation in the rangelands. There are no research publications on seed stocks of Eastern Anatolia rangelands. The aim of this study was to determine the seed stocks of a grazed and an ungrazed rangeland and making comparison between them and making interpretation about their future.

## Materials and Methods

***Experimental sites:*** The study was conducted on two adjacent range sites, grazed and ungrazed on Palandoken Mountains in Erzurum. Ungrazed range site was located in the campus area of Atatürk University located on foot hills of Palandoken Mountains (39°54'N, 41°13'E) and grazed range site in Tuzcu village (39°51'N, 41°12'E), 3-4 km away from the campus on similar topographic position in the year of 2005.

Site, soil, plant material, vegetation, altitude etc., and environmental characteristics were similar to each other apart from grazing taking places on the grazed site. The ungrazed site has been exclosured to grazing for at least 30 years while a traditional grazing system has been performed on the grazed site for a century. The vegetation in the sites is typically steppe, and dominant species are sheep fescue (*Festuca ovina* L.) although some differences are observed in abundance of the other species. The region is characterized with a semi arid continental climate. Long-term average of annual precipitation is 425 mm, average annual temperature 5.7°C, average relative humidity 63.6% and altitude approximately 2000 m.

***Methods:*** Three composite soil samples were taken from surface layer of the sites and analyzed for some physical and chemical properties. Particle size distribution was determined by the hydrometer method [19], pH of soil in 1:1 soil/water suspension by pH meter [20], lime content by Scheibler calcimeter [21], plant available P by Olsen method [22], plant available K by flame photometry [23] and soil organic matter by Smith-Weldon method [24]. Soil of grazed site was of sandy-loamy texture, neutral pH, poor in lime and phosphorus, rich in potassium and contained 2.1% of organic matter, soil of ungrazed site was of sandy-clay texture, poor in lime and phosphorus, rich in potassium and contained 2.7% of organic matter.

Soil seed stocks sampling was performed at following the procedure described by Pugnaire and Lazaro [25], during the summer dormancy period in the beginning of August 2000. Sixty soil cores in diameter of 10 cm were sampled randomly to a depth of 6 cm from each site and samples put into cloth-bag after removal of gravel, litter and roots. All samples were air-dried and stored in the dark condition up to beginning of March 2006 at room temperature. Seed stocks were determined using a germination method commonly used for field survey of soil seed stocks [25]. To germinate seeds in the stocks, the soil cores were spread into plastic tray (25 cm diameter with 6 cm deep) to a depth of about 2 cm. The trays were placed in a greenhouse under semi-controlled condition and under natural light, and temperature ranged between 15 and 30°C. The trays were watered once or twice daily with tap water to keep the surface moist during the 90 days experimental period. As seedlings emerged, they were identified and counted as soon as possible. They were then removed from tray. Number and composition of soil seed stocks were calculated using number of emerged seedlings and the results presented for seedling size and number and percentage of botanical composition. Similarity index [26] and life form of seedlings [27] were determined. Differences between the sites in seed number in the stock and their composition were analyzed using Mann-Whitney U test.

## Results and Discussion

Total number of species, seedling number of species, composition and some other properties present in the soil seed stocks for the sites are shown in Table 1 and 2. A total of 47 species were identified of which 8 were grasses, 6 were legumes (Table 1) and rest of them was the other families in the soil stocks (Table 2). The number of species on the ungrazed site was 40 and 35 on the grazed site (Tables 1 and 2). Total seed number per $m^2$ was 4747 on the ungrazed site and 5444 on the grazed site. Annual species percentage was 13.99 and 16.57% on the grazed and ungrazed site, respectively. Seed number per $m^2$ of perennial grasses was higher in the ungrazed site than on the grazed site, but it was conserved with respect to the other families' perennials. Annual legumes percentage in total seedlings was extremely low except for *Trigonella foenum-graecum* (an annual legume). Seedling number per $m^2$ of the other families was higher on the grazed site and total seedling number showed similarity. The similarity index

**Table 1.** Botanical composition and life form of the seedling on the sites (seedling number % $m^2$).

| Plant species | Life span | Seed number $m^2$ | | Composition % | | Significance |
|---|---|---|---|---|---|---|
| | | Grazed | Ungrazed | Grazed | Ungrazed | |
| Grasses | | | | | | |
| *Agropyron intermedium* | P | 12 | 17 | 0.22 | 0.38 | ns |
| *Bromus tectorum* | A | 9 | 6 | 0.16 | 0.13 | ns |
| *Bromus tomentallus* | P | 14 | 147 | 0.26 | 3.12 | ns |
| *Catabrocella parviflora* | P | 87 | 220 | 1.56 | 4.64 | 0.01 |
| *Dactylis glomerata* | P | 6 | - | 0.10 | - | - |
| *Festuca ovina* | P | 427 | 468 | 7.70 | 9.87 | ns |
| *Koeleria cristata* | P | 92 | 225 | 1.66 | 4.76 | 0.05 |
| *Poa bulbosa* | P | 442 | 861 | 7.96 | 18.15 | 0.01 |
| | | 1089 | 1944 | 19.62 | 41.05 | 0.01 |
| Legumes | | | | | | |
| *Astragalus lineatus* | P | - | 9 | - | 0.19 | - |
| *Coronilla orientalis* | P | 12 | 6 | 0.22 | 0.14 | ns |
| *Medicago papillosa* | P | - | 3 | - | 0.09 | - |
| *Medicago varia* | P | 9 | 34 | 0.16 | 0.45 | ns |
| *Onobrychis* sp. | P | - | 12 | - | 0.25 | - |
| *Trigonella foenum-graecum* | A | 20 | 462 | 0.36 | 9.74 | 0.01 |
| | | 41 | 526 | 0.74 | 10.85 | 0.01 |

P Perennial, A Annual, B Biannual.

**Table 2.** Botanical composition and life form of the seedling on the sites, other family samples (seedling number % $m^2$).

| Plant species | Life span | Seed number $m^2$ | | Composition % | | Sign. |
|---|---|---|---|---|---|---|
| | | Grazed | Ungrazed | Grazed | Ungrazed | |
| *Acanthalimon caryophyllaceum* | P | - | 3 | - | 0.07 | - |
| *Achilla bieberstieni* | P | 6 | 6 | 0.10 | 0.13 | ns |
| *Alyssum desertorum* | A | 133 | 9 | 2.39 | 0.18 | 0.05 |
| *Alyssum murale* | P | 23 | - | 0.42 | - | - |
| *Anchusa arvensis* | A | - | 9 | - | 0.18 | - |
| *Arabis caucasica* | P | 861 | 713 | 15.51 | 15.08 | ns |
| *Arabis hirsuta* | A | 1300 | 650 | 23.41 | 13.69 | 0.05 |
| *Areneria gypsophiloides* | P | 26 | 49 | 0.47 | 1.05 | ns |
| *Carex aerophilla* | A | 9 | 3 | 0.16 | 0.08 | ns |
| *Cerastium cerastoides* | P | 350 | 20 | 6.29 | 0.43 | 0.01 |
| *Cichorium intybus* | P | 3 | - | 0.05 | - | - |
| *Eryngium campestre* | P | 3 | - | 0.05 | - | - |
| *Falcaria vulgaris* | A-B | 3 | 3 | 0.05 | 0.06 | ns |
| *Filago pyramidata* | A | 194 | 43 | 3.48 | 0.93 | 0.05 |
| *Galium verum* | P | - | 3 | - | 0.06 | - |
| *Herneria glabra* | A-B | - | 12 | - | 0.25 | - |
| *Lamium macrodon* | A | 12 | 17 | 0.21 | 0.39 | ns |
| *Myosotis lithospermifolia* | A | 173 | 234 | 3.12 | 4.94 | ns |
| *Pilosella echioides* | P | - | 23 | - | 0.49 | - |
| *Potentilla bifurca* | P | 23 | - | 0.42 | - | - |
| *Poterium sanguisorba* | P | - | 29 | - | 0.61 | - |
| *Ranunculus illyricus* | A | 23 | 40 | 2.44 | 0.85 | 0.05 |
| *Ranunculus testiculus* | A | 23 | 46 | 0.73 | 0.97 | ns |
| *Ranunculus strigillosus* | A | 9 | - | 0.42 | - | - |
| *Rochelia disperma* | A | 40 | 104 | 0.16 | 2.19 | ns |
| *Scariola viminia* | A-B | - | 12 | - | 0.24 | - |
| *Scleranthus perennis* | P | 1002 | - | 18.04 | - | - |
| *Taraxacum officinalis* | P | 3 | 3 | 0.05 | 0.06 | ns |
| *Teucrium polium* | P | - | 12 | - | 0.24 | - |
| *Thymus parviflorus* | P | 9 | 3 | 0.16 | 0.06 | ns |
| *Veronica orientalis* | P | 69 | 20 | 1.25 | 0.43 | 0.05 |
| *Xeranthemum annum* | A | 17 | 208 | 0.31 | 4.38 | 0.01 |
| Total | | 4314 | 2277 | 79.64 | 48.10 | 0.01 |
| | | 5444 | 4747 | 100 | 100 | |

A Annual, B Biannual, P Perennial.

of soil seed banks between the grazed and ungrazed sites was 57.11 (Table 3).

The dominated species in the soil stocks was *Arabis hirsuta* (an annual forb) accounting for 23.41% of the total seedlings for the grazed site while it was *Poa bulbosa* (short-lived perennial) for the ungrazed site with 18.15%. The percentage of grasses and legumes seedlings in the botanical composition was higher for the ungrazed site but percentage of the other families was higher in the grazed site. The seedling number and percentage in the composition of 11 of 47 species showed statistically significant differences. The results of statistical comparison with respect to seedling number per $m^2$ and their composition are given in Table 2. Although it was statistically insignificant, seedling number per $m^2$ and the percentage in the composition of palatable species like *Agropyron intermedium, Bromus tomentallus, Koeleria cristata* and *Medicago varia* were higher in the ungrazed site than in the grazed site. Significant increases were recorded for seedling number of unpalatable species, belonging mainly to the other families for the ungrazed site.

**Table 3.** Distribution of seedling number in the rangelands among families and similarity index (SI) between grazed and ungrazed site seedling composition.

| Mean number of species per $m^2$ in seed bank | Site | |
|---|---|---|
| | Grazed | Ungrazed |
| Annual grasses | 9 | 6 |
| Perennial grasses | 1080 | 1938 |
| Annual legumes | 20 | 462 |
| Perennial legumes | 21 | 64 |
| Annual the other families | 1936 | 1393 |
| Perennial the other families | 2378 | 884 |
| Total annuals | 1965 | 1861 |
| Total perennials | 3479 | 2886 |
| Total | 5444 | 4747 |
| Similarity index | 57.11 | |

Seed stocks can contribute to understanding of succession trend of rangeland under current condition and it has also significant role on recovery of the vegetation after unexpected degradation

of the natural vegetation such as ploughing, wildfire, etc. Our finding suggests that seed stocks in Eastern Anatolia rangelands, which are not degenerated extremely, may support successfully plant regeneration from the seed stocks. Vallentine [4] suggests that 10 or more desirable seedlings per $m^2$ are enough for successful revegetation establishment. According to these criteria, we can imply that seed stock of the grazed site may support successfully regeneration in the case of any degradation event under current condition. Because the plants such as *Agropyron intermedium, Bromus tomentallus, Koeleria cristata* and *Medicago varia*, which are considered as decreaser (palatable and productive) with respect to range condition classification, have 133 seedling per $m^2$ in the grazed site samples. On the other hand, seedling number of the decreaser plants per $m^2$ on the ungrazed site was higher than in the grazed site, but there was no statistically significant differences recorded for their seedling number per $m^2$ between the sites except for *Koeleria cristata*. These results can be interpreted that *Koeleria cristata* are more sensitive to adverse effect of grazing on the plant vigority. We recorded a rich seed number and biodiversity in experiment on the contrary of Thompson [15] findings, because he argued that richness and size of the seed in the stock decrease in line with increased altitude.

In this study, grasses and legumes seedlings number was found higher on the ungrazed site. The other families seedlings number were about twice higher on the grazed site than on the ungrazed one. Also total seedling number per $m^2$ was higher on the grazed site. These differences might be consequences of grazing, because grazing changes competition condition among the plants and also fauna diversity [5]. Because grazing decrease vigority of the palatable plants, undesired (mainly the other families) plants take competition advantage and thus they might produce more seeds. On the other hand, hoof action of grazing animals might contribute to bury the seeds in the soil [6] or grazing animals might decrease seed predator (bird, rodentist, etc.) diversity [28]. With this perspective, more seeds may be consumed by the predators on the ungrazed site and as a consequence of this less seed buried in the stocks on ungrazed site. These factors might contribute to explain why seedlings size was higher on the grazed site. The differences between the sites with respect to seedling number also reflected to botanical composition of seed stocks. Heavy grazing over several decades has affected both size and composition of the germinable seed stocks, and hence size and composition are affected by grazing [10, 14, 18]. The differences of botanical composition of the seed stock can be attributed to the effect of grazing on seed production. Indeed, the similarity index of sites' seed stocks verified the effect of grazing on the seed stocks. The seed stock of rangeland had high portion of pioneer species [29]. Likewise, higher percentage for annual species, (*Arabis hirsuta, Filago pyramidata* and *Alyssum desertorum* for the grazed site and *Trigonella foenum-graecum* for ungrazed site) which they considered pioneer plants for the region rangelands, were recorded in this study.

In conclusion, grazing has altered the seed composition in the soil seed stocks on the advantage of ungrazed plants, but desired plants can produce some seeds, enough to ensure recovery, and they contribute to the seed stocks under moderate or light grazing pressure. Our findings suggest that under current grazing condition on the rangelands which are not degraded extremely may be recovery by soil seed stocks in eastern Anatolia although vast majority of the seed in the stocks belong to the other families (undesired) plants recovery.

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