AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not Bot Hort Agrobot Cluj, 2011, 39(1):96-106

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Soil Seed Bank and Aboveground Vegetation in Grazing Lands of Southern Marmara, Turkey

Altıngül ÖZASLAN PARLAK, Ahmet GÖKKUŞ, Hasan Can DEMİRAY

Department of Field Crops, Agriculture Faculty, Çanakkale Onsekiz Mart University, Çanakkale 17020, Turkey; gulozaslan@yahoo.com, agokkus@yahoo.com, h.can.dmry@hotmail.com

Abstract

The composition and conservation of plant communities is greatly influenced by the soil seed bank. Information on the soil seed banks and the remaining vegetation in these ecosystems is crucial for guiding the restoration efforts. This study examines the size, species richness, diversity, uniformity, and similarity of soil seed banks and aboveground vegetation in 6 different grazing lands including coastal pasture, reseeded pasture, artificial pasture, lowland shrubland, ungrazed pasture, and hillside shrubland. Forty-eight soil samples were taken by cores with a diameter and depth of 10 cm from each of grazing lands in August of 2007. A vegetation survey was conducted using a 0.5 x 0.5-m quadrant in both the spring and fall. Eighty species were observed in soil seed banks and aboveground vegetation. The largest seed bank was observed in reseeded pasture (7,715 seed/m^2), while the smallest seed bank was found in coastal pasture (2,755 seed/m^2). Coastal pasture also possessed the least amount of aboveground vegetation (131 plants/m^2). The most aboveground vegetation was found in ungrazed pasture (155 plants/m^2). The most common species in seed banks were annual and perennial grasses in reseeded pasture, annual forbs in artificial pasture and hillside shrubland, and perennial forbs in low shrubland and ungrazed pasture. Species richness, diversity, and uniformity in seed banks were highest in lowland shrubland and lowest in artificial pasture. The seed bank and aboveground vegetation were similar in ungrazed pasture, coastal pasture, reseeded pasture, low shrubland, hillside shrubland and artificial pasture. Shrublands play an important role in species richness and the number of germinated seeds from seed banks of grazing lands in southern Marmara. The results showed that reseeding or a decrease in grazing pressure may improve the condition of grazing lands.

Keywords: aboveground vegetation, Mediterranean, soil seed bank, species diversity

Introduction

Southern Marmara has a Mediterranean climate; thus, shrublands (maquis) are common in the region (Yılmaz, 1993). Shrublands are composed of evergreen and deciduous shrubs and annual or perennial plants. Annuals generally grow in heavily grazed lands on dry, low yielding soils and are the most common vegetation in the Mediterranean (Yılmaz, 1996; Marcelo *et al.*, 2003). Mediterranean shrubs provide habitats for wildlife (Papachristou *et al.*, 2003) and are an important food source for domestic animals. Throughout the year, shrublands are grazed by sheep and goats. The combination of shrubs and herbaceous plants produce feed in the spring and fall. Goats that graze heavily on shrubs prefer green herbaceous varieties (Papachristou, 1994), and many grazing lands in the Mediterranean are composed entirely of herbaceous plants. The loss of shrubs from grazing land may be due to conversion to farmland, poor soil quality or exploitation. For instance, coastal land is composed of sandy soil with a low water holding capacity that suffers from drought in the summer. Drought resistant therophytes are dominant in these areas (Raunkiaer, 1934). Studies to improve the landscape have been conducted on abandoned lands due to the loss of natural and quality plants from these areas. Reseeding is the best method for improving abandoned areas (Altın *et al.*, 2005), leading to an increase in yield and quality and a decrease in species richness (Bakker, 1989; Tallowin, 1996).

Soil seed banks play an important role in the composition and conservation of plant communities (Grubb, 1977; Leck *et al.*, 1989; Wisheu and Keddy, 1991). The composition of the seed bank depends on the composition and production of current and previous plant communities, as well as the longevity of seeds under local conditions. Seeds that have been brought in from surrounding areas also contribute to the seed bank.

Seed production is dependent on land use and environmental factors: production can be diminished by a reduction in leaf area due to livestock grazing, the allocation of photosynthate to reproductive organs, or by the direct removal of flowers and seeds (Sternberg *et al.*, 2003). Ungrazed sites typically possess a greater number of species and higher species density in the seed bank compared to grazed sites (O'Cannor and Pickett, 1992; Jutila, 1998; Mayor *et al.*, 2003). Navie *et al.* (1996) found that

the total seed density in the soil seed bank of Queensland decreased with high levels of grazing and increased with intermediate grazing levels due to an increase in the number of annuals.

On the other hand, soil features (humidity, texture, etc.) determine the composition of vegetation and amount of seeds produced by plants. Due to the prevalence of drought in sandy soils, annual species are common, and the seed number in the seed bank is generally low (Staaf *et al.*, 1987). Alternatively, water resources are not limited in low areas during dry seasons. Perennials are able to grow and produce enough seeds to perpetuate themselves, even under heavy grazing.

Due to deep root systems, shrubs in the Mediterranean region are able to adapt and can provide invaluable food to grazing animals and sustain soil productivity (Bochet *et al.*, 1999). Because shrubs endure under grazing conditions, they also enable the survival of many herbaceous species: perennial herbaceous species can mature under the canopy of shrubs.

There are many studies on the botanical composition, yield (Ozaslan Parlak *et al.*, 2011), and animal performance (Tölü *et al.*, 2007) of grazing lands in southern Marmara. However, studies on seed banks in the region have not been conducted. The objectives of this study were to determine the size, composition, species richness and diversity of the seed bank and aboveground vegetation of different grazing lands representing southern Marmara region and to describe the relationship between the seed bank and existing vegetation within grazing lands.

Materials and methods

The study was conducted on Çanakkale grazing lands, located in northwest part of Turkey. Çanakkale has a typical Mediterranean climate (Türkeş *et al.*, 2002): the mean annual precipitation is 615.5 mm and falls mainly in the winter and spring. The rainy season typically begins in October and ends in May, while summers are dry and hot. The mean annual temperature is 15°C.

Six different grazing lands located in southern Marmara were chosen as study sites, including coastal pasture, reseeded pasture, artificial pasture, low shrubland, ungrazed pasture, and hillside shrubland.

Coastal pasture: The dominant plant species in coastal pasture are annual and perennial grasses including *Briza minor*, *Hordeum marinum marinum*, *Avena fatua*, *Poa pratensis*, *Bromus hordeaceus*, *Cyperus capitatus.* Legumes present in coastal pasture include *Medicago marina* and *Trifolium resupinatum*. The soil is sandy, pH=7.65, EC= 2.52 dSm, $CaCO_3$=4.89%, organic matter= 1.14%, available phosphorus and potassium 8.16, 100.6 mgkg respectively.

Reseeded pasture: Originally, reseeded pastures possessed a large amount of *Paliurus spina-christi*; however, these plants were removed because they restricted grazing. Subsequently, the land was reseeded with *Lolium perenne*, *Bromus inermis, Medicago sativa,* and *Lotus corniculatus* in 2005 and fertilized with N and P. Controlled grazing practice are applied in this site. The soils of reseeded pasture are loamy, pH=7.27, EC= 0.29 dSm, $CaCO_3$=4.29%, organic matter= 5.16%, available phosphorus and potassium 62.80, 469 mg kg respectively.

Artificial pasture: Artificial pasture was tilled after which wheat was grown. An artificial pasture is composed of a mixture of 20% *Medicago sativa*, 20% *Lotus corniculatus*, 30% *Lolium perenne*, and 30% *Bromus inermis*. These species are the most common in grazing lands, although other types of herbaceous plants have also been found. Artificial pasture is grazed under controlled conditions. The soil is loamy sand, pH=7.38, EC= 0.38 dSm^{-1}, $CaCO_3$=11.90%, organic matter= 3.98%, available phosphorus and potassium 29.74, 394 mg kg^{-1} respectively.

Lowland shrubland: Low shrubland has been heavily grazed by goats and contains *Paliurus spina-christi, Sarcopoterium spinosum*, *Dactylis glomerata, Poa pratensis*, *Avena barbata, Lolium perenne*, *Aegilops sp*, *Trifolium campestre*, *Plantago* sp.*,* and *Crepis sp*. The soil is a slightly alkaline clay loam that is pH=7.59, EC= 0.21 dSm^{-1}, $CaCO_3$=4.12%, organic matter= 3.51%, available phosphorus and potassium 45.2, 205 mg kg^{-1} respectively.

Ungrazed pasture: Ungrazed pasture is covered with *Quercus infectoria*, *Quercus coccifera, Phillyrea latifolia,* and *Paliurus spina-christi*. Other common species on ungrazed pasture include grasses such as *Dactylis glomerata*, *Lolium perenne*, *Hordeum spantaneum* and *Avena clauda* legumes such as *Trifolium campestre,* and other species including *Anagallis arvensi,* and *Crepis zacinta.* The soil is sandy loam that is pH=7.06, EC= 0.42 dSm^{-1}, $CaCO_3$=6.80%, organic matter= 3.12%, available phosphorus and potassium 25.20, 404.17 mg kg^{-1} respectively.

Hillside shrubland: Hillside shrubland has been heavily grazed by goats and sheep throughout the year and contains *Phillyrea latifolia, Thymus longicaulis, Paliurus spina-christi, Sarcopoterium spinosum,* and *Olea oleaster*. Grass species such as *Dactylis glomerata, Poa pratensis*, and *Koeleria lobata*, and legumes including *Medicago lupulina* and *Trifolium stellatum* are also common. The soil is sandy loam, pH=7.17, EC= 0.17 dSm^{-1}, $CaCO_3$=2.37%, organic matter= 1.37%, available phosphorus and potassium 14.09, 167.14 mg kg^{-1} respectively.

Seed bank sampling

The seed bank was sampled in August 2007 before fall rains and the onset of germination. Four plots were chosen from each of the six types of grazing lands. Twelve randomly sampled soil cores were obtained from each plot. Cores had a diameter and depth of 10 cm. Soil cores samples were stored in a dark, cold storage area (1°C) for 6 months. The samples were sorted to eliminate plant fragments and stones. Soil from each plot was combined and

spread onto a plastic tray (25 x 50 x 7 cm) containing 2 cm of sterile potting soil in February of 2008.

Trays were placed in a greenhouse with natural light and temperature (between 14 and 25°C) and watered frequently. Trays were rotated monthly to a different area of the greenhouse to reduce any effect of placement. Four control trays filled with sterilized potting soil were also randomly placed in the greenhouse to test for contamination. Germination was not observed in control trays.

Seedlings were identified immediately after germination and were counted and removed, or, if they were not immediately identified, transplanted into pots for further growth. After two months, soil samples were carefully turned over to facilitate the emergence of new seedlings (Roberts, 1981). Germination trials lasted for approximately 8 months.

Vegetation survey

Vegetation was sampled twice by recording the species present in a 0.5 x 0.5-m quadrant randomly placed 10 times on the surface of each type of pasture. The first survey was conducted on May 4, 2007, when Mediterranean plants were in the flowering stage. The second survey was conducted on November 4, 2007, when plants were in the reproductive stage. Only herbaceous plants germinated in the experiment; thus, the composition of these plants was used exclusively in the vegetation survey.

Data analyses

To determine species diversity, the Shannon-Wiener index, Simpson index, and Hurlbert's probability of intraspecific encounter were determined. The Pielou index was used to indicate species uniformity (Shannon and Weaver, 1949; Pielou, 1975).

Simpson diversity index: $D = 1\text{-}\sum P_i^2$

Shannon-Wiener diversity index: $H' = -\sum P_i \ln P_i$

Probability of intraspecific encounter:

$PIE = \sum[(N_i / N)(N\text{-}N_i)/(N\text{-}1)]$

Pielou evenness index: $J = D/ (1\text{-}1/S)$

Where S = species richness, N_i = number of the ith species, N = number of all species, and P_i = proportion of the ith species.

Soil seed bank density, aboveground vegetation density, and soil properties of grazing lands were compared by a one-way analysis of variance (ANOVA) and Duncan's multiple-range test with p = 0.05. All analyses were conducted with MINITAB Release 14.13 (Minitab INC., 1972-2004). Before conducting ANOVA, all data were calculated as the mean ± standard error.

Seed bank and aboveground vegetation were assessed for similarity using Jaccard's similarity coefficient based on the presence or absence of species (Jaccard, 1912). This coefficient was calculated for all types of vegetation.

$C_j = a/(a + b + c)$

where a = the number of species in sample A and B, b = the number of species present in A and absent in B, c = the number of species present in B and absent in A. Jaccard's coefficient ranges from 0, indicating a lack of mutual species, to 1, denoting complete concurrence.

Results

Overall richness and density of the soil seed bank and vegetation

A total of 12,000 seedlings (1,039 in coastal pasture, 2,911 in reseeded pasture, 1,640 in artificial pasture, 2,382 in low shrubland, 1,646 in ungrazed pasture, and 2,382 in hillside shrubland) and 80 species (29 in coastal pasture, 33 in reseeded pasture, 23 in artificial pasture, 34 in low shrubland, 33 in ungrazed pasture, and 32 in hillside shrubland) were observed. The largest seed bank was found in reseeded pasture (7,715 seeds/m^2), followed by hillside shrubland, low shrubland (6,314 seeds/m^2), ungrazed pasture (4,363 seeds m^{-2}), and artificial pasture (4,347 seeds/m^2). The smallest seed bank was observed in coastal pasture with 2,755 seeds/m^2. Annual and perennial grasses were predominant in reseeded pasture. However, grasses were rare on artificial pasture and annual forbs were the most common plant (3,105 plant/m^2). Annual forbs were also widespread in hillside shrubland (2,444 plant/ m^2) but were lowest in reseeded pasture (581 plant/m^2). Low shrubland and ungrazed pasture contained the highest level of perennial forbs. The occurrence of legumes on different types of land was not statistically significant (Tab. 1).

A total of 80 species of aboveground vegetation were observed. Of these species, 36 were found in coastal pasture, 29 in reseeded pasture, 25 in artificial pasture, 29

Tab. 1. Nummer of germinated seedlings/m^2 in soil seed bank in different grazing lands of Southern Marmara

Grazing lands	Annual grasses	Annual forbs	Perennial grasses	Perennial forbs	Legumes	Total
Coastal pasture	701±279.0 bc	1,624±470.0 ab	247±121.5 c	169±9.19 b	167±20.0	2,755±96.0 c
Reseeded pasture	4,044±737.0 a	581±183.5 b	2,675±520.5 a	287±110.5 b	127±68.8	7,715±1103.5 a
Artificial pasture	255±46.9 c	3,105±548.5 a	223±39.0 c	342±116.0 b	422±234.0	4,347±826.0 bc
Lowland shrubland	1,345±425.0 bc	1,624±307.5 ab	1,640±433.5 b	1,457±259.0 a	247±84.6	6,314±829.0 ab
Ungrazed pasture	573±121.5 bc	1,879±500.5 ab	820±143.5 bc	995±319.5 a	95±36.7	4,363±890.5 bc
Hillside shrubland	1,879±522.0 b	2,444±626.0 a	1,481±259.5 b	382±135.0 b	127±50.3	6,313±708.5 ab

With each column, values (Mean number ±Standart error) followed by different letters are statistically different at p<0.05.

in lowland shrubland, 24 in ungrazed pasture, and 20 in hillside shrubland (Tab. 5). The highest density of plants (plant/m^2) were observed in ungrazed pasture (155) and the lowest density was found in coastal pasture (131) (Tab. 2). Statistical differences were not significant between annual grasses, annual forbs and legumes in the aboveground vegetation of different types of land. Perennial grasses were lowest in coastal pasture; however, similar levels were observed in other grazing lands. In ungrazed pasture and hillside shrubland, the density of perennial forbs was 15 and 16 plants/m^2, respectively. As shown in Tab. 2, reseeded and artificial pastures displayed the lowest density of perennial forbs.

Properties of the soil seed bank and aboveground vegetation

The seed banks and aboveground vegetation of artificial pasture had the lowest species richness. The highest number of species was found in low shrubland (34), reseeded pasture (33), ungrazed pasture (33) and hillside shrubland (32). Coastal pasture had the highest number of species (36) in aboveground vegetation; however, there were less species in seed banks of coastal pasture and artificial pasture compared to aboveground vegetation. Alternatively, other types of grazing lands contained more species in seed banks than in vegetation. The highest seed bank diversity (D = 0.958 and PIE = 0.957) was observed in lowland shrubland, while diversity was the lowest in the seed bank and aboveground vegetation of artificial pasture (D = 0.842, 0.854 and PIE = 0.838, 0.839, respectively). The highest diversity (D and PİE) in aboveground vegetation was found in coastal pasture. Artificial pasture displayed the lowest uniformity in both the seed bank and vegetation (J = 0.881, 0.890). The highest value of uniformity was found in the seed bank of lowland shrubland (J = 0.987) and in vegetation of coastal pasture (J = 0.961) (Tab. 5).

Tab. 2. Number of plants/m^2 in aboveground vegetation in different grazing lands of Southern Marmara

Grazing lands	Annual grasses	Annual forbs	Perennial grasses	Perennial forbs	Legumes	Total
Coastal pasture	45.8±6.96	25.2±7.31	20.9±4.40 b	11.6±5.35 ab	27.5±4.42	131.0±3.44 c
Reseeded pasture	45.2±11.65	12.8±5.46	66.8±7.59 a	3.1±0.94 b	22.8±8.23	150.7±6.94 ab
Artificial pasture	35.8±7.33	6.0±3.74	73.2±6.27 a	3.0±0.63 b	28.8±11.0	146.8±3.70 abc
Lowlan shrubland	50.8±16.95	6.7±7.08	56.8±29.11 a	12.7±3.93 ab	16.9±3.63	144.0±6.56 abc
Ungrazed pasture	65.0±6.13	8.5±2.11	57.8±28.90 a	15.3±4.33 a	7.9±3.18	154.5±5.14 a
Hillside shrubland	28.5±2.88	13.0±1.21	60.0±30.04 a	16.2±1.68 a	18.0±2.16	135.7±4.25 bc

With each column, values (Mean number ±Standart error) followed by different letters are statistically different at p<0.05

Composition of the soil seed bank and aboveground vegetation

Bromus arvensis, Anagallis arvensis, Dactylis glomerata, Poa pratensis, and *Galium* sp. were germinated from soil seed banks of all grazing lands. Germinating seeds of *Aira coryophyllea, Bromus hordeceus, Gaudinia fragilis, Hordeum marinum, Polypogon monspeliensis, Lagurus ovatus, Geranium dissectum, Silene gallica, Cyperus capitatus, Astragalus homosus,* and *Trifolium repens* were found exclusively in coastal pasture. *Bromus tectorum, Phalaris paradoxa, Eryngium creticum,* and *Medicago rigidula* germinated from seed banks of reseeded pasture, while *Solanum nigrum, Anchusa azurea, Cichorium intybus,* and *Prunella laciniata* were germinated from seed banks of lowland shrubland. Seeds of *Fumoria densifolia, Turgenia latifolia, Carlina corymbosa, Centaurium erythraea, Foeniculum vulgare,* and *Verbascum sp*. germinated from ungrazed pasture and *Filago pyramidata, Mercurialis annua, Velezia quadridentata, Dianthus leptopetalus, Salvia verbenacea, Teucrium scordium*, and *Trifolium stellatum* seeds germinated from soil obtained from hillside shrubland (Tab. 3). *Polypogon monspeliensis, Trchynia distochya, Vulpia ciliata, Euphorbia helioscopia, Kickxia elatina, Mercurialis annua, Ranunculus ficaria, Solanum nigrum, Sonchus oleracus, Alchemilla mollis, Achusa azurea, Bellis perennis, Carlina corymbosa, Cichorium intybus, Foeniculum vulgare, Prunella laciniata,* and *Teucrium scardium* germinated exclusively from seed banks and were not found in aboveground vegetation. On the other hand*, Aegilops umbellulata, Echinaria capitata, Gaudinia fragilis, Poa bulbosa, Taeniatherum caput-medusae, Carduus pycnocephalus, Filaga pyramidata, Xeranthemum annuum, Briza sp., Chrysopogon gryllus, Cirsium arvense, Oenanthe silaifolia, Rumex scutatus, Scorzonera cana, Thymus longicaulis, Hippocrepis unisiliquosa, Hymonocarpus circinnatus, Onobrychis sp.,* and *Scorpiurus muricatus* were found in vegetation but did not germinate from seed banks (Tab. 3, 4).

Similarity and relationship between soil seed bank and aboveground vegetation

Similarity between soil seed bank and aboveground vegetation was strong. The values of Jaccord's coefficient of community ranged from 0.411 to 0.676 (with a mean of 0.518) (Tab. 6). Fluctuations in similarity were observed between different grazing lands in vegetation quadrants and seed banks. The similarity between different types of aboveground vegetation varied between 0.100 and 0.410

100

Tab. 3. Characteristics of the soil seed bank (means, seeds/m^2) of the grazing lands

Species	Coastal pasture	Reseeded pasture	Artificial pasture	Lowland shrubland	Ungrazed pasture	Hillside shrubland
Annual grasses						
Alopecurus creticus	71.65			151.27		
Aira caryophyllea	55.73					
Avena barbata		310.50	71.65	159.23	111.46	350.31
Avena clauda	119.42	230.89			47.77	
Bromus arvensis	55.73	485.66	63.69	318.47	127.38	310.50
Bromus hordeaceus	87.57					
Bromus sterilis		509.55	63.69	278.66		103.50
Bromus tectorum		461.78				
Cynosurus echinatus					135.34	230.89
Dasypyrum villosum		374.20	39.80	254.77		175.15
Gaudinia fragilis	39,80					39.80
Hordeum marinum	87.57					
Hordeum spotaneum					135.34	358.27
Phalaris paradoxa		318.47				
Phleum subulatum	79.61	103.50	15.92			
Polypogon monspeliensis	63.69					
Lagurus ovatus	39.80					135.34
Trachynia distachya		1249.99		183.12		143.31
Vulpia ciliata					15.92	31.84
Annual forbs						
Anagallis arvensis	135.34	214.96	222.92	246.81	31.84	135.34
Anthemis arvensis	31.84	15.92			7.96	
Arenaria leptoclados					95.54	1,289.80
Centaurium tenuiflorum	55.73	39.80		207.00	31.84	525.47
Chenopodium glaucum	95.54			159.23		7.96
Crepis foetida	143.31	15.92	55.73	39.80		
Crepis pulchra		39.80		310.50	119.42	
Crepis zacintha		47.77	1,122.60		15.92	31.84
Filago pyramidata						183.12
Fumaria densiflora					613.05	
Geranium dissectum	103.50					
Hedypnois cretica		15.92		79.61		
Kickxia elatine		79.61	31.84			
Lactuca saligna			31.84	47.77		
Mercurialis annua						23.88
Picnomon acarna		23.88	175.15			
Ranunculus ficaria					501.59	23.88
Silene gallica	207.00					
Solanum nigrum				191.08		
Sonchus oleraceus		15.92				
Stellaria media	573.24			111.46		
Torilis arvensis	238.85	47.77	1,202.22	230.89	453.81	
Turgenia latifolia					7.96	
Velezia quadridentata						31.84
Veronica arvensis	39.80	23.88	262.73			191.08
Perennial grasses						
Cyperus capitatus	23.88					
Dactylis glomerata	119.42	1138.53	71.65	509.55	445.85	764.32
Koeleria lobata				398.08		294.58
Lolium perenne		907.63	103.50	366.24	222.9	183.12

Species	Coastal pasture	Reseeded pasture	Artificial pasture	Lowland shrubland	Ungrazed pasture	Hillside shrubland
Poa pratensis	103.50	628.97	47.77	366.24	151.27	238.85
Perennial forbs						
Alchemilla mollis			23.88		23.88	
Anchusa azurea				191.08		
Bellis perennis		23.88			71.65	
Carlina corymbosa					55.73	
Centaurium erythraea					39.80	
Cichorium intybus				103.50		
Dianthus leptopetalus						15.92
Eryngium creticum		15.92				
Euphorbia sp.				79.61	39.80	
Foenicum vulgare					135.34	
Galium heldreichii	15.92	183.12	119.42	15.92	246.81	294.58
Linum nodiflorum		63.69		278.66		
Plantago lagopus					119.42	39.80
Plantago lanceolata				326.43	39.80	
Prunella laciniata				127.38		
Ranunculus repens				95.54	183.12	
Salvia verbenaca						7.96
Scolymus hispanicus			199.04	238.85		
Teucrium scordium						23.88
Verbascum sp.					39.80	
Legumes						
Astragalus hamosus	79.61					
Lotus corniculatus			318.47		47.77	
Medicago lupulina	15.92	31.84		23.88		
Medicago minima		39.80	39.80	31.84		79.61
Medicago rigudula		15.92				
Trifolium campestre				95.54	31.84	
Trifolium pratense		23.88	31.84	47.77		
Trifolium repens	55.73					
Trifolium resupinatum		15.92	31.84	47.77	15.92	
Trifolium stellatum						23.88
Trifolium tomentosum	15.92					23.88
Total	2,755	7,715	4,347	6,313	4,363	6,313

(Tab. 6: v). Between different types of seed banks, similarity ranged from 0.173 to 0.459 (Tab. 6: s). The degree of similarity in seed banks was moderately stronger than in vegetation. The weakest similarity was found in the vegetation of hillside shrubland and coastal pasture. The strongest similarity was observed in the seed bank and vegetation of reseeded and artificial pasture. In seed banks, the weakest similarity was observed between ungrazed and coastal pasture.

Discussion

Reseeded pasture was rich with germinated seeds. Seeds of herbaceous species were produced in between *Paliurus spina-christi* plants, which had been growing for a long period of time and prevented grazing. After removing shrubs, reseeding with legumes and grass led to an increase in the number of seeds in the seed bank. Reseeded pasture has productive soils with the least amount of erosion due to a low slope. The species diversity of germinative seeds increased with increasing soil fertility (Staff *et al.*, 1987).

Shrublands were rich in germinating seeds; specifically, low shrubland displayed the highest species richness, diversity and uniformity. When compared to other types of shrublands, lowland shrubland experienced the least water stress and little to no erosion due to a lack of slopes. Animals were not able to access herbaceous vegetation between shrubs; thus, plants produced seeds even under heavy grazing. Seeds in low shrublands disperse by many mechanisms: small seeds dispersed by wind, animals and overflow (Harper, 1977; Grant, 1983).

In ungrazed pasture, less germination occurred compared to other types of shrubland. Similarly, Bakoğlu *et al.* (2009) reported more germination in grazed land com-

Tab. 4. Characteristics of aboveground vegetation (means, plants/m^2) of the grazing lands

Species	Coastal pasture	Reseeded pasture	Artificial pasture	Lowland shrubland	Ungrazed pastured	Hillside shrubland
Annual grasses						
Aegilops umbellulata		4.37	5.06	9.07		7.47
Alopecurus creticus	0.13					
Aira caryophyllea	5.53					
Avena barbata			1.68	7.35	6.45	18.05
Avena clauda	12.29	0.44			10.58	
Bromus arvensis	5.18	8.99	2.09	13.92	12.65	2.98
Bromus hordeceus	2.71					
Bromus sterilis		5.61	3.62	5.24		
Bromus tectorum		0.36				
Cynosurus echinatus			5.26		1.30	
Dasypyrum villosum		6.61	3.48			
Echinaria capitata			0.78			
Gaudinia fragilis	5.49					
Hordeum marinum	5.36					
Hordeum spotaneum		10.16	5.46	15.22	34.02	
Phalaris paradoxa		0.75				
Phleum subulatum	0.32	2.75	4.31			
Poa bulbosa	1.98	4.91	4.07			
Lagurus ovatus	6.87					
Taeniatherum caput-medusae		0.25				
Annual forbs						
Anagallis arvensis	3.92	4.05	2.15		0.65	3.37
Anthemis arvensis	6.75				1.08	
Arenaria leptoclados					1.33	2.17
Carduus pycnocephalus				1.85		
Centaurium teniflorum	1.88			0.70		1.12
Chenopodium glaucum	2.13			1.05		
Crepis foetida	2.20			0.21		
Crepis pulchra		0.04	0.08	1.99	0.97	
Crepis zacintha	0.19	0.08	0.12		0.90	1.63
Filago pyramidata						1.41
Fumaria densiflora					1.57	
Geranium dissectum	1.31	3.06	1.26			
Hedypnois cretica		3.07				
Lactuca saligna			2.39			
Picnomon acarna		2.53				
Silene gallica	1.35					
Stellaria media				0.21		
Torilis arvensis	1.89				1.80	
Turgenia latifolia					0.22	
Xeranthemum annum	3.58					
Velezia quadridentata				0.73		1.28
Veronica arvensis						2.02
Perennial grasses						
Briza sp.	2.32					
Chrysopogon gryllus	1.11					
Cyperus capitatus	2.80					
Dactylis glomerata	6.42	10.88	7.84	8.19	21.10	12.07
Koeleria lobata				18.00		20.62

Species	Coastal pasture	Reseeded pasture	Artificial pasture	Lowland shrubland	Ungrazed pastured	Hillside shrubland
Lolium perenne		45.20	55.68	14.77	16.86	10.45
Poa pratensis	8.33	10.72	9.65	15.90	19.87	16.86
Perennial forbs						
Centaurium erythraea					4.83	
Cirsium arvense	0.27		0.90	1.12		
Dianthus leptopetalus	6.09					
Eryngium creticum	0.12			2.77		
Galium heldreichii		0.51	0.18	1.74	1.40	2.09
Linum nodiflorum						2.61
Oenanthe sileifolia		1.00				
Plantago lagopus			1.18			3.91
Plantago lanceolata		1.61		5.97		
Ranunculus repens				0.44	3.52	
Rumex scutatus	4.87					
Salvia verbenaca	0.30			0.70		
Scolymus hispanicus						2.41
Scorzonera cana			0.75			
Thymus longicaulis						5.18
Verbascum sp.					5.57	
Legumes						
Astragalus hamosus	6.52				1.27	
Hippocrepis unisiliquosa				3.13		
Hymonocarpus circinnatus					1.61	
Lotus corniculatus			8.26			
Medicago lupulina	9.02	11.85		0.57		
Medicago minima		1.03	1.29	4.03		7.48
Medicago rigudula		3.18				
Onobrchis sp.				2.00		
Scorpiurus muricatus		1.49	1.45	3.16		
Trifolium campestre	1.92		0.78	2.25	4.91	
Trifolium pratense		0.31	4.76	0.82		
Trifolium repens	1.53					
Trifolium resupinatum	6.87	4.94	9.16	0.97	0.12	
Trifolium stellatum			3.14			10.57
Trifolium tomentosum	1.64					
Total	131,19	150,75	146,83	144,07	154,58	135,75

pared to ungrazed land. Grazing allows seeds to become buried in the soil (Altın *et al.*, 2005) and grazing animals cause a decrease in the number of seed predators (birds, rodents, etc.) (Gökkuş and Koç, 2001). Despite a higher seed production in ungrazed land, a lower germination rate was observed in *Hordeum spotaneum*, *Centaurium erythraea* due to less seed burial and more seed damage.

The number of seeds that germinated in artificial pasture was low. These lands also displayed the lowest species richness, diversity and uniformity. Artificial pasture

Tab. 5. Species richness, diversity, and uniformity in soil seed bank and vegetation (Soil seed bank/ aboveground vegetation)

Grazing lands	Species richness (*S*)	Simpson index (*D*)	Shannon index (*H'*)	Hurlbert's *PIE*	Pielou index (*J*)
Coastal pasture	28/36	0.924/0.934	2.968/3.053	0.903/0.955	0.958/0.961
Reseeded pasture	33/29	0.913/0.884	2.753/2.596	0.911/0.880	0.941/0.916
Artificial pasture	23/25	0.842/0.854	2.335/2.510	0.838/0.839	0.881/0.890
Lowland shrubland	34/29	0.958/0.908	2.306/2.718	0.957/0.899	0.987/0.940
Ungrazed pasture	33/24	0.929/0.886	2.968/2.373	0.929/0.880	0.958/0.929
Hillside shrubland	32/20	0.914/0.887	2.850/2.506	0.915/.0907	0.944/0.929

Tab. 6. Jaccard's similarity coefficient among different types of soil seed bank and vegetation

Grazing lands	Coastal pasture	Reseeded pasture	Artificial pasture	Lowland shrubland	Ungrazed pasture	Hillside shrubland
Coastal pasture	0.600*sv*	0.207*v*	0.150*v*	0.226*v*	0.220*v*	0.100*v*
Reseeded pasture	0.270*s*	0.512*sv*	0.410*v*	0.295*v*	0.261*v*	0.166*v*
Artificial pasture	0.219*s*	0.459*s*	0.411*sv*	0.350*v*	0.289*v*	0.216*v*
Lowland shrubland	0.240*s*	0.425*s*	0,390*s*	0.465*sv*	0.232*v*	0.225*v*
Ungrazed pasture	0.173*s*	0.294*s*	0.272*s*	0.288*s*	0.676*sv*	0.194*v*
Hillside shrubland	0.224s	0.250*s*	0.250*s*	0.245*s*	0.274*s*	0.444*sv*

v) Similarity among different types of vegetation; *s)* Similarity among different types of seed bank; *sv)* Similarity between seed bank and aboveground vegetation of the same type

originated as farmland and was transformed into pasture by reseeding; thus, these lands have a low number of seeds in the seed bank. In fact, annual forbs and weeds were most often germinated in artificial pasture. These results agree with the observations of Gokkus (1994), Walker *et al.* (2004) and Zhan *et al.* (2007), who found that annual forbs and grasses were abundant in abandoned farmlands. Perennials were not able to develop or produce seeds in farmlands due to seasonal plowing; thus, annuals and weeds produced seeds intensively.

Coastal pasture had the lowest number of germinated seeds and vegetation on these lands (Tab. 3). This may be due to the texture of coastal soils: buried seeds were able to resurface from the sandy soil and seeds left on the soil surface were eaten by insects such as ants and beetles and small mammals (Thompson, 1987). Similarly, Staff *et al.* (1987) found that less seeds were germinated from sandy loams. In coastal pasture, species richness was higher in vegetation than in the seed bank. This result indirectly suggests that asexual reproduction was the primary method of reproduction in coastal grassland. Similar results have been obtained in steppe ecosystems (Zhan *et al.*, 2007). Thus, the preservation of perennial vegetation may play a more significant role in grassland recovery than soil seed banks.

The most germinated species in all grazing lands were annuals. Research has shown that annuals are a major component of Mediterranean grasslands (Marcelo *et al.*, 2003). The grazing of Mediterranean grasslands can have a large impact on vegetation (Montalvo *et al.*, 1993; Seligman, 1996; Lavorel *et al.*, 1999; Sternberg *et al.*, 2000); however, the soil seed bank may buffer the impact of differences in inter-annual grazing (Russi *et al.*, 1992; Ortega *et al.*, 1997). It is generally assumed that Mediterranean annuals show adaptive responses to unpredictable environments by producing dormant seeds that persist during periods of limited resources (Shmida and Ellner, 1984; Thompson, 1992; Lavorel *et al.*, 1993; Perevolotsky and Seligman, 1998). Thus, a persistent soil seed bank acts as a long-term refuge for annual plant populations in variable environments typical of the Mediterranean region (Kigel, 1995).

With the exclusion of coastal pasture, seed banks of grazing land contained more species than aboveground vegetation. This is expected in heavily grazed pastures because plants are removed by grazing but seeds remain in the soil due to dormancy.

Many studies have been conducted on the similarity of seed banks and aboveground vegetation. Low similarities were observed between the seed bank and aboveground vegetation in most studies involving grasslands dominated by perennial grasses (Rabinowitz, 1981; Archibold, 1981; Schenkeveld and Verkaor, 1984; Thomson, 1986; Fischer, 1987; Millberg, 1995; Bakkler *et al.*, 1996). These discrepancies were explained by the minor contribution of dominant perennial grassland species to seed banks. In general, perennial grasses have low seed production because they alternate between sexual reproduction and vegetative forms and their seeds persist in the soil for short periods of time (Touzard *et al.*, 2002).

The strongest similarity between vegetation and seed bank was observed in coastal and ungrazed pastures. Annual grasses and forbs commonly grow in coastal pasture and water stress often occurs due to the presence of sandy soils. This leads to rapid seed production by annuals and results in increased similarity (Peco *et al.*, 1998). Plants in ungrazed pasture produce seeds in vast quantity. Since there is no grazing pressure, plants do not disappear from the vegetation. Due to the fact that seeds on the aboveground vegetation are buried in the soil, similarity between the soil seed bank and vegetation increases (Grime, 1979). The weakest similarity between vegetation was observed in hillside shrubland and coastal pasture. Sandy soil in coastal pasture results in unique plant species and the weakest similarity.

The strongest similarity was observed in seed banks and vegetation of reseeded and artificial pasture. These pastures are located close to each other and possess similar soils. Although the use of reseeded and artificial pastures is different, their characteristics are quite similar. This result indicates that soil properties have an effect on vegetation type.

Conclusions

The grazing lands of Southern Marmara are under heavy grazing pressure and shrublands play a crucial role in species richness and the number of seeds that germinate.

A decrease in grazing pressure and reseeding with desired plants will improve the conditions of grazing lands.

Acknowledgements

We wish to thank Dr. Ersin Karabacak (Canakkale Onseliz Mart University) for plant identification.

References

Altın M, Gokkus A, Koc A (2005). Range and Meadow Improvement and Development. T.C. The Ministry of Agriculture and Rural Affairs, Republic of Turkey.

Archibold OW (1981). Burial viable propagules in native prairie and adjacent agricultural sites in central Saskatchewan. Can J Bot 59:701-706.

Bakker JP (1989). Nature Management by Grazing and Cutting. Kluwer Academic Publishers, Dordrecht.

Bakker JP, Bakker ES, Rosen E, Verweij GL, Bekker RM (1996). Soil seed bank composition along a gradient from dry avlar grassland to *Juniperus* shrubland. J Veg Sci 7:165-176.

Bakoglu A, Bagci E, Erkovan HI, Koc A, Kocak A (2009). Seed stocks of grazed and ungrazed rangelands on Palandoken Mountains of Eastern Anatolia. J of Food, Agriculture and Environment 7(3,4):674-678.

Bochet E, Rubio JL, Poesen J (1999). Modified topsoil islands within patchy Mediterranean in SE Spain. Catena 38:23-44.

Gökkuş A (1994). Secondary succession in the abandoned rangelands. Ataturk University Publication No: 787, Erzurum, p. 61.

Gokkus A, Koc A (2001). Range Management. Ataturk University, Agriculture Faculty Publication No . 228.

Grant JD (1983). The activities of earthworms and the fates of seeds, p. 107-122. In: Satchell JE (Ed.). Earthworm ecology. Chapman and Hall, London.

Grime JP (1979). Plant Strategies and Vegetation Processes. Chichester, John Wiley and Sons.

Grubb PJ (1977). The maintenance of species-richness in plant communities:the importance of the regeneration niche. Biol Rev 52:107-145.

Harper JL (1977). Population Biology of Plants. Academic press, London, p. 892.

Jaccard P (1912). The distribution of the flora of the alpine zone. New Phytology 11:37-50.

Jutila HM (1998). Seed banks of grazed and ungrazed Baltic seashore meadows. J of Vegetation Sci 9:395-408.

Kigel J (1995). Seed germination in arid and semiarid regions, p. 645-699. In: Kigel J, Galili G (Eds.). Seed Dvelopment and Germination. Marcel Dekker, NY, USA.

Lavorel S, Debussche M, Lebreton JD, Lepart J (1993). Seosanal patterns in the seed bank of Mediterranean old-fields. Oikos 67:114-128.

Lavorel S, Rochette C, Lebreton JD (1999). Functional groups for response to disturbance in Mediterranean old-fields. Oikos 84:480-498.

Leck MA, Parker YT, Simpson RL (1989). Ecology of Soil Seed Banks. Academic Press, New York.

Marcelo S, Mario G, Avi P, Jaime K (2003). Effects of grazing on soil seed bank dynamics: An approach with functional groups. J of Vegetation Sci 14:375-386.

Mayor MD, Bo'o RM, Pela'ez DV, Elia OR (2003). Seasonal variation of the soil seed bank of grasses in central Argentina as related to grazing and shrub cover. J of Arid Environments 53:467-477.

Milberg P (1995). Soil seed bank after eighteen years of succession from grassland to forest. Oikos 72:3-13.

Montalvo J, Casado MA, Levassor C, Pineda FD (1993). Species-diversity patterns in Mediterranean grasslands. J Veg Sci 4:213-222.

Navie SC, Cowley RA, Rogers RW (1996). The relationship between distance from water and the soil seed bank in a grazed semi-arid subtropical rangeland. Australian Journal of Botany 44:421-431.

O'Connor TG, Pickett GA (1992). The influence of grazing on seed production and seed banks of some African savanna grasslands. J of Applied Ecology 29:247-260.

Ortega M, Levassor C, Peco B (1997). Seasonal dynamics of Mediterranean pasture seed banks along environmental gradients. Biogeography 24:177-195.

Ozaslan-Parlak A, Gokkus A, Hakyemez BH, Baytekin H (2011). Forage yield and quality of kermes oak and herbaceous species throughout a year in Mediterranean zone of western Turkey. International Journal of Food, Agriculture and Environment 9(1):510-515.

Papachiristou TG, Nastis AS, Mathur R, Hutchings MR (2003). Effect of physical and chemical plant defences on herbivory: implications for Mediterranean shrubland management. Basic Appl Ecollogy 4:395-403.

Papachristou TG (1994). Foraging behaviour and nutrition of goats grazing on shrublands of Greece. In: Gordon LJ and Rubino R (Eds.). Grazing Behaviour of Goats and Sheep, Cahiers Options Mediterranean 5:83-90.

Peco B, Ortega M, Levassor C (1998). Similarity between seed bank and vegetation in Mediterranean grassland: a predictive model. J Veg Sci 9:815-828.

Perevolotsky A, Seligman NG (1998). Role of grazing in Mediterranean rangeland ecosystems-Inversion of a paradigm. BioScience 48:1007-1017.

Pielou EC (1975). Ecology Diversity. New York: John Wiley and Sons Inc.

Rabinowitz D (1981). Buried viable seed in a North American tall-grass prairie: The resemblance of their abundance and composition to dispersing seeds. Oikos 36:191-195.

Raunkiaer C (1934). The Life Forms of Plants and Statistical Plant Geography. Oxford Univ. Press, London.

Roberts HA (1981). Seed banks in soils. Advanced Applied

Biology 6:1-55.

Russi L, Cocks PS, Roberts EH (1992). Seed bank dynamics in a Mediterranean grassland. J Appl Ecol 29:763-771.

Schenkeveld AJ, Verkaar HJ (1984). The ecology of short-lived forbs in chalk grasslands: distribution of germinative seeds and its significance for seedling emergence. J Biogeogr 11:251-260.

Seligman NG (1996). Management of Mediterranean grasslands, p. 359-392. In: Hodgson J, Illius AW (Eds.). The Ecology and Management of Grazing Systems. CAB International, Wallingford, UK.

Shannon CE, Weaver W (1949). The mathematical theory of communication. Illinois University Press.

Shmida A, Ellner S (1984). Coexistence of plant species with similar niches. Vegetatio 58:29-55.

Staaf H, Jonsson M, Olsen LG (1987). Buried germinative seeds in mature beech forests with different herbaceous vegetation and soil types. Holarctic Ecology 10:268-277.

Sternberg M, Gutman M, Perevolotsky A, Kigel J (2003). Effects of grazing on soil seed bank dynamics: an approach with functional groups. J of Vegetation Sci 14:375-386.

Sternberg M, Gutman M, Perevolotsky A, Ungar ED, Kigel J (2000). Vegetation response to grazing management in a Mediterranean herbaceous community: a functional group approach. J Appl Ecol 37:224-237.

Tallowin JRB (1996). Effects of inorganic fertilizers on flower-rich hay meadows: a review using a case study on the Somerset Levels, UK. Grassland and Forage Abstracts 66:147-152.

Thompson K (1986). Small-scale heterogeneity in the seed bank of an acidic grassland. J Ecol 74:733-738.

Thompson K (1987). Seeds and Seed banks, p. 23-34. In: Rorison IH, Grime JP, Hunt R, Hendry GAF, Lewis DH (Eds.). Frontiers of Comparative Plant Ecology. New Phytologist 106 (Suppl.).

Thompson K (1992). The functional ecology of seed banks, p. 231-258. In: Fener M (Ed.). Seeds. The Ecology of Regeneration in Plant Communities. CAB International, Wallingford, UK.

Tölü C, Yurtman İY, Baytekin H, Savaş T (2007). Grazing preferences of three goat genotypes grazed on wheat forage and natural shrubland. The V Symposium of Agriculture, Veterinary, Forestry and Biotechnology, 18-20 Oct. Travnik/ Vlasic-Bosnia and Herzegovina.

Türkeş M, Sümer UM, Demir İ (2002). Re-evaluation of trends and changes in mean, maximum and minimum temperatures of Turkey for the period 1929-1999. International Journal of Climatology 22:947-977.

Walker KJ, Stevens DA, Stevens PA, Mountford JO, Manchester S, Pywell RF (2004). The restoration and re-creation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. Biological Conservation 119:1-18.

Wisheu IC, Keddy PA (1991). Seed banks of a rare wetland plant community: distribution patterns and effects of human-induced disturbance. J Vegetation Sci 2:181-188.

Yılmaz KT (1996). Natural Plants of Mediterrenean. Çukurova University Faculty of Agriculture Publication No. 141, p. 179.

Yılmaz O (1993). Maquis. Ankara University, Agriculture Faculty Publication No. 1326, p. 60.

Zhan X, Li L, Cheng W (2007). Restoration of Stipa krylovii steppes in Inner Mongolia of China: Assess seed banks and vegetation composition. J of Arid Environments 68:298-307.