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RANGELAND IMPROVEMENT AND MANAGEMENT STUDIES IN THE SOUTHEASTERN ANATOLIA REGION OF TURKEY

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The purpose of this study was to examine applied rangeland improvement and management studies carried out from 2004 to 2011 in six provinces of the Southeastern Anatolia Region of Turkey. The aims of the studies were to (1) protect and conserve rangeland soil and water resources, (2) improve and strengthen weakened rangeland vegetation, and (3) increase hay yields and grazing capacities of the rangelands. Additionally, one of the most important goals of these studies was to enhance the cultivation of forage crops in cultivated areas in order to decrease the adverse effects of overgrazing and to supply quality roughage for livestock. To achieve these objectives, different rangeland improvement methods and rangeland management strategies were applied in 40 different rangelands in the region. The results indicated that the average sufficient rangeland area per animal unit was 1.99 ha, whereas the value recorded prior to these studies was 4.80 ha.
Keywords: Rangeland improvement, rangeland management, plant species, forage crops, Southeastern Anatolia Region

INTRODUCTION

Rangelands or grasslands are wide and open areas where grasses and other herbaceous plants are dominant. They exist on every continent except for Antarctica (Sabancı, 2012). The major forms of vegetation are grasses, and there are few or no trees. Rangeland was defined by UNESCO as "land cover with herbaceous plants with less than 10 percent tree or shrub cover" (White, 1983; cited in Anonymous, 2013a). In the same source, wooded rangeland is defined as "vegetation with grasses and grass-like plants with 10–40 percent tree or shrub cover."

Rangelands have many benefits, such as the provision of forage for livestock, protection and conservation of soil and water resources, provision of wildlife habitat (both flora and fauna), and contribution to the attractiveness of the landscape (Carlier *et al*., 2005). In many countries of the world, pastoral rangelands are the primary and only resource on which both wild and domesticated herbivores depend. As the human population increases, rangelands are converted into cropland, resulting in overgrazing of the remaining rangelands (Carlier *et al*., 2009).

Rangelands cover a large proportion of the globe and are a very important source of livestock feed as well of livelihood for stock farmers and herders (Suttie and Reynolds, 2003; Upton, 2004). Worldwide, rangeland area is estimated at approximately 52.5 million square kilometers. This is equivalent to approximately 40.5 percent of Earth's land surface excluding Greenland and Antarctica (Anonymous, 2000; Cited by Ozturk *et al*., 2012). The rangeland in the world is dominated mainly by plant taxa belonging to the family Poaceae and is typically characterized by low productivity due to a shortage of water and nutrients (Naz *et al*., 2010; Knezevic *et al*., 2012). Almost 5 million square kilometers are in the high and medium land-use categories, and 30 million square kilometers are in the low and zero land-use categories (Reynolds and Frame, 2005).

Turkey, located at 35–43°N, 25–45°E, is the world's 37th-largest country in terms of area (783.562 km^2). It is one of the oldest continuously inhabited regions of the world (Anonymous, 1999; Anonymous, 2005; Thissen, 2007; Immerfall, 2011; Ozturk *et al*., 2012). Turkey is surrounded by the Black Sea to the north, the Mediterranean Sea to the South and the Aegean Sea to the west. Turkey is nearly 2000 km long, and its width is almost 800 km.

Rangelands covered a large area of Turkey in the 1950s. However, as a result of the implementation of poor agricultural policies, such as the conversion of rangeland to cropland and failure to prevent the encroachment of urbanization, Turkey's rangeland has been permanently decreased. According to Sabanci (2012), the rangeland area in Turkey decreased by approximately 37 million hectares between the 1950s and 2000s. Now, permanent meadow and pastures (14.6 million ha) cover nearly 19% of the total land area and 37.4% of the total utilized agricultural land in Turkey. The Southeastern Anatolia Region, one of the seven regions of Turkey, has 1.01 million ha of rangeland,

accounting for 6.92% of total rangeland of Turkey (Sayar *et al*., 2010).

Hay yield potential has been deteriorating in the majority of rangelands in Turkey. Among the reasons for the deterioration are unsuitable uses, such as early grazing, overgrazing, non-uniform grazing, etc. The grazing period in the natural rangelands of Turkey is estimated at approximately 240–270 days. In addition to this unusually long grazing period, intensive grazing has resulted in the decline and eventual disappearance of high-quality plant species in Turkey's rangelands (Sayar *et al*., 2010). The problem with degradation (or desertification) has occupied the imagination and attention of policy-makers for nearly a century, with little apparent progress toward a solution (Scholes, 2009). Accordingly, to address the deteriorating state of rangeland in Turkey, pasture law no. 4342 was enacted in 1998. The purpose of this legislation was to protect and conserve rangeland soil and water resources, improve and strengthen weakened rangeland vegetation, and increase the hay yield and grazing capacity of rangelands. To this end, official protocol between the General Directorate of Agricultural Research (TAGEM) and the General Directorate of Agricultural Production (TUGEM), both within the Turkish Ministry of Food and Agriculture, was signed in 2003. According to this protocol, 10 Agricultural Research Institutes under the auspices of the General Directorate of Agricultural Research were appointed to coordinate applied rangeland improvement and management studies in provinces, near them. The GAP International Agricultural Research and Training Centre, which is one of these institutes, has been commissioned for the coordination of rangeland improvement projects in the provinces of Batman, Diyarbakir, Mardin, Siirt, Sanlıurfa, and Sırnak under the supervision of professors from the Dicle and Harran Universities Faculties of Agriculture. The aim of this study is to present the applied rangeland improvement and management activities that have occurred in the Southeastern Anatolia Region, Turkey, in the last decade.

MATERIALS AND METHODS

The studied rangelands: The studies were carried out between 2004 and 2011 in six provinces of the Southeastern Anatolia Region of Turkey.The provinces were Batman, Diyarbakır, Mardin, Siirt, Sanlıurfa and Sırnak, The 40 different rangelands studied and the village, district, and province names of their locations are indicated in Table 1. Additionally, Fig. 1 shows a map of the studied areas. Rangelands whose farmers voluntarily supported the activities of rangelands improvement were chosen.

Soil and climatic characteristics of the region: The analysis of rangelands soils showed that soils (0–30 cm) in the region generally had a clay loam texture, with a slightly alkaline pH (7.5–7.8). Although the soils studied were rich in calcium ($CaCO_3$ of 8–20%) and potassium (400–600 kg K ha^{-1}), they were poor in organic matter (0.5–3%) and useful phosphorus (25–45 kg P ha^{-1}). The climate in the region is characterized as semi-arid (humid winters and dry summers), with variable rainfall distribution between years. Long-term (42 years) temperature, rainfall, and humidity records from the South East Anatolia Region are summarized in Fig. 2. Mean annual precipitation is 530 mm based on the long-term average, of which approximately 80% occurs from November to May. Almost no precipitation falls during the period between June and September in all years. During this period, rising temperatures are associated with shorter vegetative growing periods in the region's rangelands. The highest mean temperature and lowest humidity in the region were recorded in July and August.

Figure 1. Map of the study area

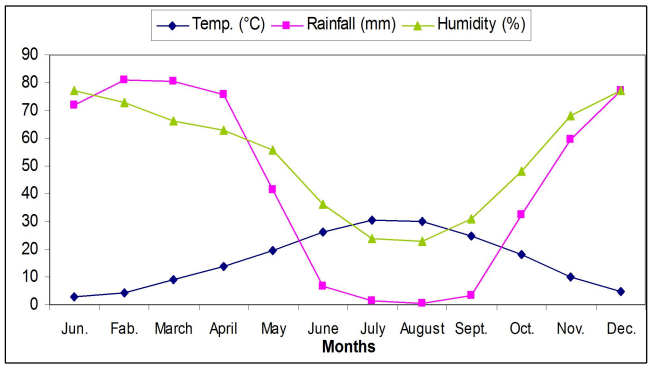

Figure 2. Long-term average monthly temperature, rainfall and humidity values of the Southeastern Anatolia Region of Turkey (The data based on General Directorate of Meteorology, Ankara)

Determination of the botanical composition of vegetation and rangeland improvement and management activities: Vegetation surveys on the rangelands were carried out using a modified wheel loop (MWL) method, and survey evaluations were made according to Griffin (1989). MWL

Table 1. Conducted Rangeland improvement and management studies in Southeastern Anatolia Region of Turkey.

Province Name	No	District Name	Town or Village Name	Altitude (m)	The Rangeland Size (ha)	The Project Implementation Time	Before the studies sufficient rangeland area for per animal unit (ha)	After the studies sufficient rangeland area for per animal unit (ha)	Applied Improvement Methods
BATMAN	1	Merkez	Oymatas	510	382.20	2004-2008	3.40	1.03	F+W+M
	2	Merkez	Binatlı	717	1183.90	2007-2010	7.66	2.95	F+O+W+M
	3	Besiri	Asmadere	624	838.10	2007-2010	5.57	2.29	F+W+M
	4	Besiri	Bespınar	829	1397.20	2007-2010	6.13	2.43	F+W+M
DİYAR-BAKIR	5	Bismil	Ambar	548	432.90	2004-2008	3.22	1.09	F+O+W+M
	6	Baglar	Oglaklı	907	1584.20	2005-2008	4.71	1.87	F+O+W+M+R
	7	Bismil	Tepe	532	226.00	2005-2009	3.40	1.28	F+O+W+M
	8	Egil	Kalkan	782	1566.20	2005-2008	5.57	2.42	F+W+M
	9	Cınar	Bespınar	687	231.90	2005-2008	6.13	2.28	F+O+W+M
	10	Ergani	Akcakale	824	4294.70	2005-2008	5.10	2.29	F+W+M
	11	Silvan	Sulubag	713	161.50	2005-2008	4.38	1.72	F+W+M
	12	Lice	Duru	658	160.00	2005-2008	4.71	1.79	F+W+M
	13	Hazro	İncekavak	839	480.00	2005-2008	4.86	1.98	F+O+W+M
	14	Cermik	Agachan	923	326.00	2005-2008	4.50	1.81	F+W+M
	15	Cungus	Kelesevleri	1007	100.00	2005-2008	4.31	1.69	F+W+M
	16	Kayapınar	Karayakup	891	1428.10	2007-2010	4.94	2.13	F+W+M
	17	Cınar	Alatosun	1142	1674.70	2008-2012	4.60	2.30	F+O+W+M
	18	Yenisehir	Dikentepe	765	472.30	2009-2012	3.06	1.03	F+W+M
	19	Bismil	Uctepe	549	274.00	2010-2012	3.06	0.83	F+O+W+M
	20	Silvan	Basıbuyuk	748	110.80	2010-2012	4.78	2.05	F+O+W+M
	21	Sur	Tavuklu	646	57.90	2010-2012	5.10	1.37	F+O+W+M
MAR-DİN	22	Merkez	Dara	572	1194.30	2004-2008	6.82	2.58	F+O+W+M
	23	Derik	Uctepe	705	256.10	2005-2009	4.73	1.64	F+O+W+M+R
	24	Midyat	Dogancay	914	454.00	2009-2013	5.25	1.82	F+W+M
	25	Merkez	Avcılar	863	1273.80	2009-2013	5.63	1.88	F+O+W+M
SİİRT	26	Kurtalan	Koprubası	674	113.70	2004-2008	3.74	1.79	F+W+M
	27	Merkez	Akyamac	969	183.80	2004-2008	4.18	2.66	F+W+M
	28	Kurtalan	Gozpınar	678	107.00	2005-2008	3.89	2.29	F+O+W+M+R
	29	Pervari	Yukarıbalcılar	1580	1374.90	2007-2010	3.61	1.33	F+W+M
	30	Kurtalan	Cayırlı	828	331.90	2009-2012	3.52	1.29	F+W+M
	31	Pervari	Tuzcular	1455	336.40	2011-2014	2.92	1.17	F+W+M
SANLI-URFA	32	Merkez	Diphisarı	647	579.70	2004-2008	5.67	2.79	F+W+M
	33	Merkez	Kusluca	869	1224.50	2004-2008	5.89	2.75	F+W+M
	34	Merkez	Asagıickara	735	146.80	2004-2008	5.37	2.64	F+W+M
	35	Siverek	Karabahce	1496	5337.10	2007-2011	4.14	1.79	F+O+W+M+R
SIRNAK	36	İdil	Pınarbası	686	292.00	2005-2008	4.71	2.02	F+O+W+M+R
	37	Cizre	Katran	497	295.90	2006-2009	5.47	2.32	F+O+W+M+R
	38	İdil	Sırtkoy	627	1154.80	2007-2010	5.10	2.29	F+O+W+M+R
	39	İdil	Oymak	855	1386.80	2008-2011	6.12	3.27	F+O+W+M+R
	40	İdil	Ucok	831	1183.90	2008-2011	5.96	2.79	F+O+W+M+R
	Total /Average			**808**	**34610.00**		4.81	1.99	

*F, Fertilization; O, Overseeding; W, Weed Control; M, Management Strategies; R, Rocks Removing

apparatus has a wheel with a diameter in 1 m. Also, on the wheel have two rings, 1 cm diameter, on opposite sides of the wheel,_allowing us to read each meter on rangeland. When vegetation surveys were performed by using MWL, firstly, a straight measurement line, was determined for each special part of rangeland. Then, 100 points, coincides with inside of the rings, were read on the each line. In the readings, we recorded names of plant species encountered, numbers of without plant points and numbers of rocky points. Hereby, we determined the percentage of herbaceous plants area, the percentage of shrubs area, the percentage of without plant area and the percentage of rocky area on the rangelands. Generally for each 10 ha rangeland size a straight measurement line determined, and the process was repeated on the rangelands.

The rangeland vegetation surveys revealed that several rangeland improvement methods, such as fertilization, overseeding, and weed control, were applied. In these studies, when rangeland improvement activities were applied, the following literature was considered: on rangeland fertilization, Altın (1999) and Altın *et al*. (2005); on rangeland overseeding, Avcioglu (1999) and Altin *et a*l.

(2005); and on weed control, Gokkus (1999). Additionally, rangeland management activities were applied according to methods indicated by Bakır (1987), Bakır (1999), Ekiz (1999), and Altın *et al*. (2005).

Determination of grazing capacity(GC) and sufficient rangeland area per animal unit (SAPAU): Grazing capacities of rangelands were accounted both before studies and after the studies. Accordingly; animal unit (AU), size of the rangeland and available forage yield were used to calculate grazing capacity. In order to determine available forage yield of a rangeland, quadrate frames were randomly thrown on ungrazed parts of the rangelands. Afterwards, the forages coincide with into the frames mowed and weighted. Then, arithmetic average of the fresh forage yields accounted and converted into hectare. Available forage yield of the rangeland was taken as 50% of this yield. For determining dry matter yield of the rangeland, we took 500 g fresh forage sample and dried in oven-dried at 70 ºC for 48 hours and weighed, then dry weight percentage was calculated. Dry matter yield of the forage was calculated by multiplying the fresh forage yield with its dry weight percentages. When grazing capacity (GC) was assessed, the following formula was used (Bakır, 1999).

GC = [Rangeland size (ha) x Available dry matter yield of the rangeland (kg ha^{-1})] / [Dry matter intake per AU (kg day^{-1}) x Grazing period (day)]

In these studies animal unit (AU) was accepted as a mature, non-lactating bovine (middle-third of pregnancy) weighing 500 kg and fed at a maintenance level for zero gain. Also; when animal unit of different animal species (AU) was calculated, a native cow, sheep and goat were accepted as follows respectively; 0.5 AU, 0.1 AU and 0.08 AU. Dry matter intake per animal unit (AU) was accepted as 12.5 kg per day. Available dry matter yield of the rangeland was taken as half of the actual yield of the rangeland. Average grazing period before the studies and after studies were taken into account as 245 days and 165 days respectively. Sufficient rangeland area per animal unit (SAPAU) was calculated by dividing the rangeland area into the rangeland grazing capacity (GC). For each of the studied rangeland; SAPAU was calculated both before the studies and after the studies.

RESULTS AND DISCUSSION

The studied rangelands: Information related to rangeland improvement and management activities at province, district, town or village, and rangeland scales is given in Table 1, which shows that most rangeland improvement activities were in Diyarbakir Province, with 17 projects across 13581 ha. The other provinces were represented as follows: Sanliurfa, four projects and 7288 ha; Batman, four projects across 3801 ha; Sirnak, five projects and 4313 ha; Mardin, four projects and 3178 ha; and Siirt, six projects and 2447 ha. The totals for the six provinces in the region showed 40 rangeland improvement and management projects, with 34610 ha of rangeland area improved from 2004 to 2011. Among the rangelands, the highest altitude was recorded in the rangeland of Yukarıcılar/Siirt (1580 m), and the lowest altitude was recorded in the rangeland of Katran/Sırnak (497 m). The average altitude of the studied rangelands was 808 m (Table 1).

The most productive period for these rangelands was between April and May. In these spring months, if sufficient rain fell, the herbage yield of rangelands increased significantly. Similarly, Schonbach *et al.* (2012) reported that variability in precipitation among years affected the mass and production of herbage in rangelands. Namely, the mass and production of herbage increased linearly with increasing annual precipitation. The vegetation surveys revealed that the prevalence of high-quality plant species in the region's rangelands was generally low (20–25%), and the quality of the rangeland was usually poor prior to improvement. Accordingly, prior to these studies, the amount of obtained available annual dry matter yield varied between 400 and 1100 kg ha^{-1} among the rangelands. However, the dry matter yield in most of the rangelands was under the 600 kg ha^{-1}. This low productivity can be attributed to rangeland degradation as a result of a combination of adverse abiotic and management factors (Pasho *et al.,* 2011). In particular, the low productivity can be attributed to the region's extremely dry and hot summers. However, following these studies, the amount of obtained available annual dry matter yield varied from 700 to 2000 kg ha^{-1} across the studied rangelands.

The found valuable plant species on the rangelands: From the results on rangelands vegetation surveys; encountered plant species are listed in Table 2 and Table 3. Which shows that when high quality legume and grass species are examined from Table 2, it was observed that the majority of encountered legumes in rangeland of the region were annual plant species. Species of *Trifolium*, *Medicago* and *Vicia* genus were dominant in the rangelands of the region. Especially, *Trifolium campestre*, *Trifolium haussknechtii*, *Trifolium nigrescens* were commonly found in the rangelands. Also, the majority encountered species of *Medicago* genus were *Medicago orbicularis, Medicago polymorpha* and *Medicago rigidula.* Moreover; *Onobrychis armena* was mostly found among the perennial legumes species in the region rangelands. Similarly, Tessema *et al.* (2010) reported that most of the identified herbaceous legumes in rangelands were annual *Trifolium* species. Moreover; they observed that these plants were highly palatable to ruminants, cow, sheep, goat. Unlike the legumes, the majority valuable grass species encountered in the rangelands were perennial. Commonly encountered grass species were *Cynodon dactylon, Festuca ovina, Hordeum bulbosum* and *Poa bulbosa. Cynodon* dactylon was the most

Table 2. Encountered important legumes and grasses species during vegetation surveys in the region rangelands

Valuable Legume species		Valuable grass species
Astragalus cicer L.	*Trifolium pilulare* Boiss.	*Alopecurus textilis* Boiss.
Hedysarum syriacum Boiss.	*Trifolium pratense* L.	*Avena fatua* L.
Lathyrus cicera L.	*Trifolium purpureum* Lois.	*Chrysopogon (Andropogon) gryllus* (L.) Trin.
Lathyrus sativus L.	*Trifolium repens* L.	*Cynodon dactylon* L.
Lotus corniculatus L.	*Trifolium resupinatum* L.	*Dactylis glomerata* L.
Medicago minima (L.) Bart.	*Trifolium scabrum* L.	*Festuca ovina* L.
Medicago orbicularis (L.) Bart.	*Trifolium speciosum* L.	*Hordeum bulbosum* L.
Medicago polymorpha L.	*Trifolium spumosum* L.	*Lolium perenne* L.
Medicago rigidula (L.) All.	*Trifolium spumosum* L.	*Phalaris aquatica* L.
Medicago sativa L.	*Trifolium stellatum* L.	*Phleum montanum* K. Koch.
Medicago truncatula Gaertn.	*Trifolium tomentosum L.,*	*Phleum pratense* L.
Onobrychis armena Boiss.	*Trifolium vesiculosum* Savi.	*Poa bulbosa* L.
Onobrychis caput-galli L.	*Trigonella coelesyriaca* Boiss.	*Poa pratensis* L.
Onobrychis galegifolia Boiss.	*Vicia cracca* L. subsp. *Cracca*	*Stipa lagascae* L.
Pisum arvense L.	*Vicia dasycarpa* Ten.	
Trifolium angustifolium L.	*Vicia ervilla* (L.) Wild.	
Trifolium arvense L.	*Vicia grandiflora* Scop.	
Trifolium aureum Poll.	*Vicia hybrida* L.	
Trifolium campestre Schreb.	*Vicia narbonensis* L.	
Trifolium fragiferum L.	*Vicia sativa* L.	
Trifolium haussknechtii Boiss.	*Vicia sativa* L. supsp. *nigra* Ehrh.	
Trifolium hirtum All.	*Vicia sericocarpa* Fenzl.	
Trifolium nigrescens Viv.	*Vicia villosa* Roth.	
Trifolium physodes Stev.		

Table 3. Encountered weed species during vegetation surveys in the region rangelands

Achillea biebersteinii Afan.	*Centaurea hyalolepis* Boiss.	*Onosma bulbotrichum* DC.
Achillea pseudoaleppica Hub.	*Centaurium erythraea Rafn subsp. turcicum*	*Onosma rascheyanum* Boiss.
Aegilops markgrafii (Greuter) Hammer	*Chenopodium album* L.	*Papaver bracteatum* Lindl.
Aegilops ovata L.	*Chenopodium botrys* L.	*Papaver glaucum* Boiss. & Hausskn.
Aegilops umbellulata Zhukovsky	*Cirsium arvense* (L.) Scop.	*Phlomis bruguieri* Desf.
Alcea digitata (Boiss.) Alef.	*Convolvulus arvensis* L.	*Phlomis kotschyana* Hub.-Mor.
Alhagi mannifera Desv.	*Convolvulus dorycnium* L.	*Picnomon acarna* (L.) Cass.
Alkanna kotschyana DC.	*Convolvulus reticulatus* Choisy.	*Picris kotschyi* Boiss.
Anchusa arvensis (L.) M.Bieb.	*Crepis foetida* L.	*Pilosella hoppeana* (Schultes) C.H. & F.W. Schultz
Anchusa strigosa Labill.	*Crepis sancta* (L.) Babcock	*Plantago lagopus* L.
Anthemis cretica L.	*Crepis setosa* Hall.	*Plantago major* L.
Anthemis tricornis Eig.	*Cuscuta babylonica* Aucher ex Choisy	*Poligonum cognatum* Meissn.
Anthemis triumfetti (L.) All.	*Dianthus crinitus* Sm.	*Rumex acetosella* L.
Aristolochia bottae Jaub.	*Eryngium billardieri* Delar.	*Rumex scutatus* L.
Arum detruncatum C.A. Mey. ex Schott	*Euphorbia arvalis* Boiss.et.Helder.	*Salvia cryptantha* Montbret.
Astragalus adustus Bunge	*Euphorbia denticulata* Lam.	*Salvia montbretii* Bentham
Astragalus asterias Stev. ex Ledeb	*Euphorbia macroclada* Boiss.	*Salvia multicaulis* Vahl.
Astragalus canescens DC.	*Euphorbia orientalis* L.	*Salvia palestina* Bentham.
Astragalus cephalotes Banks & Sol.	*Galium aparine* L.	*Scale montanum* L.
Astragalus deinacanthus Boiss.	*Galium verum* L.	*Scorzonera cana* (C.A. Mey.) Hoff m var. *cana*
Astragalus hamosus L.	*Gentiana olivieri* Griseb.	*Scorzonera mollis* M. Bieb.
Astragalus macrocephalus Wild.	*Geranium cicutarium* L.	*Silybum marianum* (L.) Gaertn.
Astragalus microcephalus Wild.	*Geranium tuberosum* L.	*Sinapis arvensis* L.
Bromus japonicus Thunp.	*Gladiolus kotschyanus* Boiss.	*Sonchus asper* (L.) Hill.
Bromus scoparius L.	*Glaucium grandiflorum* Boiss. & Huet	*Stipa ehrenbergiana* Trin. & Rupr.
Bromus tectorum L.	*Glycyrrhiza glabra* L.	*Tanacetum abrotanifolium* (L.) Druce
Campanula postii (Boiss.) Engler	*Gundelia tournefortii* L. var. armata	*Tanacetum aucheranum* (DC.) Schultz Bip.
Capsella bursa - pastoris L.	*Hordeum murinum* L.	*Tamarix smyrnensis* Bunge.
Cardaria draba (L.) Desv. subsp. chalepensis	*Isatis cochlearis* Boiss.	*Taraxacum aleppicum* Dahlst.
Carduus nutans L.	*Lamium* sp.	*Taraxacum phaleratum* G. Hagl. ex Rech.
Carduus pycnocephalus L.	*Lepidium perfoliatum* L.	*Taraxacum scaturiginosum* G. Hagl.
Centaurea iberica Trev. ex Sprengel	*Linum pubescens* Banks & Sol.	*Torilis leptophylla* (L.) Reichenb. fil.
Carthamus persicus Willd.	*Linum strictum* L.	*Xanthium spinosum* L.
Centaurea carduiformis DC.	*Malva neglecta* Wallr.	*Xanthium strumarium* L.
Centaurea coronofolia Lam.	*Ononis viscosa* L.	*Xeranthemum annuum L.*

commonly found grass species in the Tigris riverside rangelands, treeless flat and fertile plains. One of the most striking point was that in these rangelands beside *Cynodon dactylon*; mostly found legume species were *Lotus corniculatus* and *Trifolium nigrescens*. Furthermore; *Hordeum bulbosum* was found almost in all the rangelands of the region. This species is one of the native perennial grass species of the region. *Hordeum bulbosum* produced a great deal amount of forage yield, and its forage quality was good as well. In addition; its rhizomes was extremely resistant to grazing animals. Moreover; owing to its palatability, this grass species was consumed eagerly by the

livestock. Therefore, this species was attracted the attention of the farmers and shepherds of the region. Due to the outstanding features of this species; we recommend that breeding studies should be done on this species in order to improve cultivars that are suitable in overseeding of rangelands, which have inadequate amount of high quality grass species. Meanwhile, except for legumes and grass species; encountered important forage species were *Poterium sanguisorba* minor, from *Rosaceae* family and *Thymus* sp., belonging to *Lamiaceae* familiy.

Rangeland fertilization: To increase potential forage yields and to enhance the healthy growth of plants in rangelands, any nutritional elements that are lacking should be added to rangelands soils with fertilizer, with the results of the soil analysis taken into account. In these studies, rangeland fertilization was performed according to Altın (1999) and Altın *et al*. (2005). Rangeland soil analysis revealed that the rangeland soils were rich in potassium, so potassium fertilization was not applied to the rangelands. However, phosphorous (P_2O_5) and nitrogen (N) fertilizers were applied. Phosphorus fertilizer was applied every 1–3 years during the late fall, and nitrogen fertilizer was applied annually. Half of the nitrogen fertilizer was applied in the fall, and the other half in early spring. The amount of phosphorus fertilizer applied to rangelands varied between 50 and 70 kg ha^{-1}, and the amount of nitrogen fertilizer per rangeland varied between 70 and 100 kg ha^{-1}. Once the type and amount of fertilizer had been determined, the plant species ratio for botanical composition, rangeland topography, regional rainfall conditions, and soil characteristics were taken into consideration. Many researchers have reported that it is possible to increase the forage yields of rangelands significantly using proper fertilization (Rubio *et al*., 1996; Hatipoglu *et al*., 2005; Koc *et al*., 2005; Aydın and Uzun, 2005; Mut *et al*., 2010) if sufficient moisture is present in the soil. The best results for rangelands in the Eastern Anatolia Region were obtained by Altın (1975), Gokkus (1984), Koc *et al.* (1994), Guven *et al.* (2005), and Cakal *et al*. (2007) by applying 50 kg ha^{-1} phosphorous (P_2O_5) and 100 kg ha^{-1} nitrogen (N) fertilization.

Rangeland overseeding: When the rangeland vegetation surveys revealed an insufficient number of quality plant species in the rangelands, overseeding was performed with good-quality plant species seeds. When rangeland overseeding was part of the studies, the principles indicated by Avcıoglu (1999) and Altın *et al*. (2005) were also taken into consideration. The most commonly used perennial grass species in overseeding were orchard grass (*Dactylis glomerata* L.), smooth bromegrass (*Bromus inermis* Leysser), and tall fescue (*Festuca arundinacea* Schreber), and the common perennial legume species were alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* L.), and bird's-foot trefoil (*Lotus corniculatus* L.). Small burnet (*Poterium sanguisorba* minor scop.) from the *Rosacea* family was used in overseeding mixtures as well. Overseeding mixtures containing at least one species from legume and grass species were applied in late autumn. Since the mixtures have a higher yield and quality than the sole perennial forages (Sayar *et al*., 2014).

One of the biggest handicaps in improvement of rangelands in Turkey is that there is no developed perennial legume or grass cultivars that can be used in overseeding of the rangelands. Thus; developing the cultivars, suitable for use in overseeding of rangelands, is of great importance in Turkey. Due to absent of the suitable varieties; the legume and grass cultivars used in rangelands overseeding are imported from abroad. These cultivars have usually been developed for use either as recreation space plant or as forage crops plant. Therefore; the rangeland overseeding has often not provided the desired success. However, when compared with other species, it can be said that the success rate of small burnet (*Poterium sanguisorba* minor Scop.) in overseeding is higher than that of the other species.

Weed control on the rangelands: Weeds in the rangelands can reduce the quantity and the life span of desirable forage plants. These unwanted plants can be more aggressive than desired forage species and compete with them for light, water, and nutrients. According to Roschinsky *et al*. (2011) when existence of these plants increase in a rangeland, this is evidence of an ongoing decline of rangeland quality. In addition; weeds also decrease the quality and palatability of the desired forage species for grazing livestock. Moreover, they prevent animals from grazing on rangelands comfortably. One of the most adverse effects of them is that some of the weed species are potentially poisonous to grazing animals on the rangelands.

In these studies, the principles reported by Gokkus (1999) were adopted in the weed control of the rangelands. Accordingly, among the used weed control methods repeated mowing, burning, clippings, and hand weeding can be accounted. In the struggle against weed species, the most important point for us was that the weeds eliminated before spilling their seeds. Encountered weed species during vegetation surveys in the region rangelands are listed in Table 3. Mostly encountered weed species were *Aegilops ovata* L., *Alhagi mannifera* Desv. *Arum detruncatum* C.A. Mey. ex Schott., *Astragalus microcephalus* Wild., *Astragalus hamosus* L., *Bromus tectorum* L., *Carduus pycnocephalus* L., *Centaurea carduiformis* DC., *Centaurea coronofolia* Lam., *Cirsium arvense* (L.) Scop,. *Euphorbia macroclada* Boiss., *Euphorbia arvalis* Boiss.etHelder, *Geranium collinum* Steph., *Glycyrrhiza glabra* L. *Gundelia tournefortii* L., *Hordeum murinum* L., *Silybum marianum* (L.) Gaertn., *Taraxacum scaturiginosum*.

Especially in the near Tigris riverside, Uctepe, Ambar, Tepe/Diyarbakır rangelands *Glycyrrhiza glabra* and *Alhagi mannifera* had a great density, and the intensity of these species was a great obstacle for the grazing livestock on the

rangelands comfortably. Therefore; in order to eliminate the species from the rangelands a great deal of effort was spent by using different weed control methods, such as burning and different mechanical struggle methods. On the one hand, one of the most important point emphasized by the farmers is that when the livestock consumed large quantities of *Astragalus hamosus*, it causes their poisoning. On the other hand; in some mountainous rangelands *Astragalus microcephalus*, and *Astragalus macrocephalus*, eaten particularly by goats, were found in great amounts, and almost no other plant species was found on these rangelands except for the species. Hence; not applied any weed struggle methods against these species because of avoiding to exposing of soil erosion the rangelands.

The rangeland management activities

Grazing periods: The starting of grazing time is of great importance to rangelands both for forage production and healthy vegetation. Early spring grazing on rangelands causes physiological damage to the plants that store food reserves in the winter dormant period. Furthermore, due to early grazing in early spring, the amount of grass needed to benefit the animal would be much lower than necessary, since the plants are consumed by animals when they are very small. Another adverse effect of early spring grazing on rangelands is that animals grazing on rangeland generate a pressure on rangeland land because of their weight. This causes the compression of rangeland land and prevents soil aeration. In addition; late fall grazing has an adverse effect on rangelands as well, but not as much as early spring grazing. Owing to late fall grazing, the plants do not accumulate adequate reserve nutrients, which are consumed by the plant in the winter to survive; this reduces the efficiency of the plants in the next grazing season.

Terzioglu and Yalvac (2003) aimed at determining the starting of grazing time for natural pastures in Van; in their research they used Bakır's (1987) method, determining the start of grazing time for a pasture by taking into account plant height. For short, medium and tall plants, the plant heights were determined as10 cm, 15 cm, 20 cm, respectively, for the start of grazing time. At the end of their study, they reported that the most appropriate start of grazing time for natural rangelands of Van was May 10th. In order to determine start of grazing time, Koc and Gokkus (1995) conducted an investigation taking into account the status of the plants' phenological status, in natural rangelands of Erzurum. By the end of their study, they reported that the most appropriate start of grazing time for natural rangelands in Erzurum was May 15th. In addition, the researchers gave some practical knowledge in their research, which could be used to determine start of grazing time in Erzurum, and they expressed that the time of opening of the leaves of poplar trees (*Populus nigra* var. *Pyramidalis*) coincided with the start of grazing time in Erzurum. In the applied studies, the start of grazing time was determined by taking into account the phenological status of the rangeland plants. In these studies; the start of grazing time for the rangelands was changed between March 25 to April 5, depending on rangeland altitude and climatic conditions.

In the studies; when the end of the grazing time was determined, the late autumn frosts were taken into account. The end of the grazing time was adequate to allow the plants to generate enough store spare nutrients for winter. In the studies, the end of the grazing time was varied from September 15 to October 1 depending on rangeland altitude and climatic conditions. Accordingly; in the rangelands, although before the studies grazing period was 240-270 days, that is between March 1 to November 15, with the-studies, the period was adjusted to 150-170 days, which is between March 25 to September 15. According to the findings by Sabancı (2012) grazing period should be 150 days in East Anatolia Region rangelands, and 200 days in coastal regions rangelands of Turkey.

Grazing planning: Producers manage livestock and vegetation in order to achieve production objectives, not to maintain biodiversity (O'Connor *et al.,* 2010). Due to uncontrolled grazing, the range area has degraded and supports mainly unpalatable vegetation (Avcioglu *et al.*, 2010; Chaudhry *et al.,* 2010). However; uniform grazing on rangelands is of great importance, not only in terms of making use of all sides of the rangeland profitably, but also in terms of making use of the rangeland ecologically and sustainably, without damaging vegetation. In addition to the plant species generating seedlings, they maintain their generations thanks to resting or rotating grazing. In the applied rangeland improvement projects, to ensure uniform grazing, resting grazing was used. Thus, every rangeland land was divided into three equal parts. Each of the rangeland parts was grazed for 15 days, and then it was rested for 30 days.

Livestock, cow, sheep and goat, may walk from three to five kilometers for water (depending on topography). Their travelling distance has a significant influence on production, weight gaining and milk. The greater the distance to water, the more energy and time needed to satisfy the livestock's requirements (Anonymous, 2013b). Therefore; supplying basic needs, water sources is of great importance. In these studies, some vital structures were established in rangelands, both in helping uniform grazing and ensuring that livestock's requirements were in place. Among the structures are making of artesian wells and water bowls, shade for both animal resting and protection from sun, itching poles, salt shakers, additional feeders and ponds.

Carrying capacity and sufficient rangeland area per animal unit (SAPAU): One of the biggest reasons for the degeneration of rangelands, caused by loss of productivity in rangelands, is undoubtedly overgrazing. Furthermore; overgrazing and soil trampling result in impoverishment of species composition, reduction in vegetative cover and

exposure to soil erosion (Thornes, 2007; Unal *et al*, 2011). Carrying capacity could be used as a useful parameter to access the production potential of a rangeland (Chaudhry *et al.,* 2010). According to our observations in these studies; degeneration effects of overgrazing is much greater than non-uniform grazing on the rangelands. The calculated SAPAU values are listed in Table 1. It was observed that when a rangeland has lower SAPAU value, it is more productive. In the study; before the improvement and management studies; the highest SAPAU value was recorded from the rangeland of Binatlı/Batman (7.66 ha), while, the lowest value was recorded from the rangeland of Tuzcular/Siirt (2.92 ha). After the studies; although the highest SAPAU value was determined from the rangeland of Oymak/Sırnak (3.27 ha), the lowest value was calculated in the rangeland of Uctepe/Diyarbakır (0.83 ha) (Table 1). Accordingly; it was observed that before the improvement and management studies the rangeland of Tuzcular/Siirt was much more productive than the rangeland of Binatlı/Batman. Similarly; after the studies the rangeland of Uctepe/Diyarbakır was much more productive than the rangeland of Oymak/Sırnak. According to Kendir (1999) sufficient rangeland area for per animal unit is 4.32 ha for a natural rangeland of Central Anatolia Region. This finding is consistent with our findings, as seen from the before studies column in the Table 1.

Cultivation of forage crops: Overgrazing on the rangelands can be prevented by growing suitable forage crops species on the existing crop rotation systems (Karadag and Buyukburc, 2003). In the scope of the projects, forage crops were grown on arable lands so that quality roughage could be provided to use during the prohibited grazing periods on the rangelands. To accustom and attract the attention of farmers on the cultivation of forage crops, seed costs of forage crops were met from the project budgets. The forage plant species grown in scope of the projects were as follows: alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* L.), common vetch (*Vicia sativa* L.), Hungarian vetch (*Vicia pannonica* Crantz), Bitter vetch (*Vicia ervilia* (L.) Wild.), grass pea (*Lathyrus sativus* L.) and corn silage (*Zea mays* L.). Also, annual legume species, the vetch species, and annual grass species, barley, oats and triticale, were cultivated as a mixture, containing 1/3 legume species and 2/3 grass species. Also, grass mowing machines, silage machines and baling machines were supplied with the projects budgets.

Other activities on the rangelands: In some occasions rockiness was source of big problems in the rangelands. As a result of the rockiness area in some parts of the rangelands covering more than half of total rangeland area, there was not enough space for the growth of the plants. For this reason, rocks were removed from the rangeland area. In scope of the studies the rocks, which are removable, were cleaned using various types of equipment. Afterwards, rangeland areas with removed rocks were treated with overseeding. The rocks collected from rangeland surface were used as material to surround the territory of the rangelands. Moreover; rangelands were surrounded with wire cages where it was considered necessary in order to provide controlled grazing. Also, the rangelands roads and gates were built and repaired.

Lack of education has long been considered one of the major causes of the perceived mismanagement of communal rangelands (Ellis and Swift, 1988; Behnke and Abel, 1996; Smet and Ward, 2005). In order to ensure expected benefits from rangeland improvement and management studies, interest and the knowledge level of farmers and shepherds are of great importance. Therefore; we focused on training activities related to rangeland improvement and management rules and forage crop cultivation. Furthermore, we encouraged the establishment of rangeland management association in the villages in order to ensure a sustainable development in occasion of the rangeland. And rangeland management associations were established in most of the rangelands. As a result of more support gotten from farmers in the applied improvement and management projects, success were obtained from the projects. For this reason, great importance should be given to the training activities in order to constitute conscious farmers and shepherds, who are not only loving rangelands, but also, protecting them.

Conclusions: Applied rangeland improvement and management studies carried out from 2004 to 2011 in six provinces of the Southeastern Anatolia Region of Turkey have been discussed in this study. The applied rangeland improvement and management studies were conducted in 40 villages and towns of the region. Total size of studied rangelands area was 34610 ha. As a result of the applied rangeland improvement and management studies, important developments have been observed in grazing capacity of rangelands. The average sufficient rangeland area per animal unit was recorded as 1.99 ha, whereas the value recorded prior to these studies was 4.80 ha.

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