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Full Length Research Paper

Evaluation of rangeland in arid and semi-arid grazing land of South East Ethiopia

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Rangelands have multiple uses in drier parts of Africa. However, rangelands in Ethiopia are seriously degrading and under increasing threat. A study was conducted to examine the condition of rangeland, vegetation composition, percentage of bare ground cover, biomass production and grazing capacity under different elevation belts (high and low) and along grazing gradients (heavy, medium and light grazing pressure) using an integrated approach of herbaceous, soil, and woody plants layers. A total of 44 grasses, 2 legumes, 2 sedges, 8 other herbaceous plant species and 45, woody species were identified. Less desirable grass species dominated on the heavily grazed sites while highly desirable grass species were most frequent on the light grazed areas. The mean density of woody species was highest ($P \leq 0.05$) in heavily (2 654 plants/ha) and in medium (2 668 plants/ha) than in light grazing sites (2 042 plants/ha). Rangelands in both elevation zones had suffered bush encroached and had low values for grass parameters. The total dry matter biomass (1332 kg/ha), dry matter of grass (1144 kg/ha), desirable (611 kg/ha), intermediate (269 kg/ha), least desirable grass dry matter (251 kg/ha) and grazing capacity (5.7TLU/ha) were highest ($P \leq 0.05$) in lightly grazed sites. The mean total range condition score in the heavily grazed site 25.1 (poor), medium 41.0(fair) and lightly grazed sites 51.9(good) showed the heavily and medium grazed rangelands were deteriorated and urgent action is needed. This emphasizes the importance of stocking rates and proper rangeland management.

Keywords: Rangeland condition, grazing pressure, bush encroachment, grazing capacity, Ethiopia

INTRODUCTION

Rangelands in Ethiopia are in danger of becoming seriously degrading owing to natural and human-induced factors (Coppock, 1994; Amaha, et al., 2006). This implies that rehabilitation is a matter of priorities and should follow by a detailed assessment of the state of health of the rangelands. Rangelands of Ethiopia consist of mainly native pastures (grass, forbs and woody plant species); they are main feed sources of grazers and browers (Gemedo-Dalle et al., 2006).

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These fodder plants usually are consumed by domestic and wildlife animals. Therefore, assessing the condition of vegetation utilised by grazing and browsing herbivores are essential for sustainable utilisation of rangeland ecosystem. The concept of rangeland condition is encompassing to indicate the state of health of the rangeland in terms of its ecological status, resistance to soil erosion and potential for producing forage for sustained optimum livestock production (Trollope et al., 1990).

Rayitu district is located in the lowlands of Bale, South East Ethiopia where pastoralism and agro-pastoralism are the main land use systems and livestock are the main assets of the community.

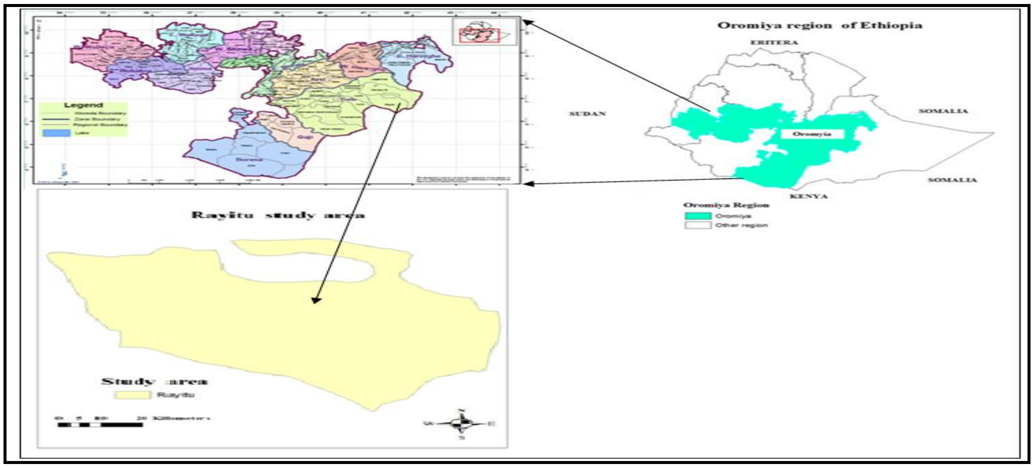

Figure 1: Map of the oromiya region of Rayitu district, South East Ethiopia

Pastoralists own different animal types including browsers (33%) and grazers (67%) irrespective of the condition of rangelands. As elsewhere in other dry land of Africa, pastoralists in the area depend heavily on woody plants as livestock feed. Other studies (e.g. Friedel, 1991) have shown that assessment of a rangeland composed of different vegetation components must incorporate three parameters of assessments (i.e., the herbaceous layer, the soil and the tree-shrub layer). However, previous studies in Ethiopia rangelands (e.g. Ayana and Baars 2000; Amsalu and Baars, 2002) have used grass and soil parameters in evaluating the condition of rangelands. Recent studies (e.g. Amaha, 2006; Gemedo-Dalle et al., 2006; Solomon et al.,2006b; Abule et al.,2007a) have indicated that use of species composition alone as an index of rangeland condition rating to be unsatisfactory. They have suggested that the inclusions of other parameters like woody parameters (e.g. its density, frequency, canopy cover, browsing effect and palatability), percentage of bare ground, and biomass yield as deemed necessary. The present study considered the above parameters in indexing of rangeland condition. So far many methods have been developed in assessing rangeland condition. However, the choice of the method or parameters to be used should depend on the local conditions (Jordaan et al., 1997). Furthermore, other studies (e.g. Warren, 2002) suggested that range condition cannot be simply rated based on its usefulness for a single priority of land use and the interpretation of assessments requires a multiplicity of perspectives. Hence, this study was intended to examine the hypothesis that inclusion of woody parameters in rangeland condition rating can be useful in evaluating rangelands.

In arid and semi-arid rangelands heavy grazing pressure and climatic factor such as elevation can influence forage production and shift composition (Amsalu and Barrs, 2002; Gemedo-Dalle et al.,2006), soil erosion and rangeland degradation (Kassahun et al.,2008b), increase bush density (Angassa and Oba, 2008). Such changes will influence the productivity, sustainable utilization and management of rangelands ecosystem.

In the past in the rangelands of Ethiopia some attempts have been made by many scholars to determine rangeland condition. However, compared with the vast rangeland areas of the country, there are only very limited studies; for example, in south Ethiopia (Ayana, 1999; Gemedo-Dalle et al., 2006; Solomon et al., 2006b) in middle Rift valley (Amsalu and Baars, 2002; Abule et al., 2007a), in East Ethiopia (Amaha, 2006)). Despite of all these studies, there is limited information regarding to rangeland condition in South East Ethiopia. Furthermore, evaluation of rangeland condition using the three component of assessments, use of benchmark method and use of wheel point methods have not yet explored, only the studies of Amaha (2006) and Abule et al. (2007a). Therefore, the objectives of this study were to evaluate vegetation compostion, rangeland condition, percent cover of bare ground, biomass production, and grazing capacity in different elevation belts and along grazing gradient in Rayitu rangelands.

MATERIALS AND METHODS

Description of the study area

The study was conducted in grazing lands of Rayitu district, which is found in Bale zone of the Oromia Regional State, Ethiopia (Fig 1). It covers an area of about 6139 km2 of land. Its climate varies from hot to warm sub-moist plains (Sm1-1) sub-agro ecological zone. The rainfall pattern is bimodal (March-June and September-October) with mean annual rainfall about 450 mm. The production system in the district is pastoral (PADS 2004). In Rayitu district, woodland vegetation accounts for 75%, pastureland 20%, cropland 2% and settlement 3% (Phaulos et al. 1999). The district lies at an elevation of 500-1785 masl. Solonchaks, Fluvisols and Xerosols (FAO, 1976) are the main soil types of the district. The human population of the study district is estimated to be 43 914 (excluding 60% of nomadic people), with a grazing livestock population of 22 000-37 600 cattle, 31 000 goats, 10 900 sheep, 6 700 camels, 4 400 donkeys, 110 horses and 64 mules (Phaulos et al. 1999; CSA 2003). Livestock are the main assets of the community; it is customary among this society to own as many animals as possible, irrespective of the condition of the animal or availability of the pasture. The livestock are considered as a living bank for the pastoralists. This is partly because livestock are regarded as wealth and have prestige value, determining a man's social position (Phaulos et al. 1999).

Evaluation of the condition of the rangeland. The condition of the rangelands in the Rayitu grazing lands were estimated focusing on 3 factors, i.e., herbaceous layer (its species composition, basal cover, litter cover, age distribution of grass, number of seedlings of grass species); soil layer (related issues such as erosion and compaction); and woody layer (their density, hedging and canopy cover) (Friedel 1991). Moreover, percentage of bare ground cover was determined to strengthen the result of range condition rating.

The factors for grass and soil layers were considered based on the criteria developed for semi-arid rangelands in south and eastern Africa (Tainton 1981) and the analysis of rangeland condition was carried out following Baars et al. (1997) and adapted by some authors (Amsalu and Baars, 2002; Gemedo-Dalle et al. 2006). The factors for woody layer were considered and adapted based on the criteria developed for southeast Ethiopia (Kuchar 1995). The assessment factors sum up to a total of 65 points based on grass, soil and woody parameters. The overall rating was interpreted as excellent (53-65 points), good (40-52 points), fair (27-39 points), poor (14-26 points) and very poor (≤13 points) (Baars et al. 1997).

Assessment of rangeland condition

Field layout and site selection. To study the range condition, grazing sites of the area were identified based on available documents and maps pertinent to vegetation cover. This was followed by a discussion with the respective agricultural development office experts, and the elders of the community in the area about the nature and location of the grazing areas. Furthermore, the process was also supported by information obtained from the household survey. Accordingly, the grazing areas of the study area were stratified into two based on elevation, i.e., 765-1070 meter above sea level (masl) (bottom land) and >1070-1350 masl (upland). Within each elevation groups, the grazing areas were further stratified into heavily grazed site (communal grazing site), medium grazing (enclosure grazing site) and light grazing site (benchmark grazing site). Heavily grazing sites were communally owned, being grazed through-out the year at a high intensity of grazing. Medium grazing site, grazing lands classified as "enclosure "(or locally called Hogga) were privately used as grazing fields, protected and fenced with thorny bushes for dry season grazing and the intensity of grazing was medium. They were mainly found around homesteads and croplands. These grazing fields were stayed during the rainy season and were utilised during the dry season for lactating cows, calves and oxen and selected as medium grazed site. Lightly grazed sites, (benchmark sites) had been protected and less grazed area for a long time (10-15 years), had relatively low grazing intensity and was used for comparative purposes. A total of 15 upland grazing sites (8 heavily, 5 medium and 2 light) and 9 bottom land grazing sites (4 heavily, 3 medium and 2 light) were selected. On each grazing site, a sampling block (3 km x 1 km) of the land area, representative of the vegetation under consideration, was demarcated either in a continuous or a separated form. The demarcated area was further sub-divided into 3 equal plots of 1 km x 1 km for the purpose of stratification. In each of the sub-divided plots, a belt transect of 50 m x 4 m was laid out randomly to accommodate both vegetation layers, i.e., woody and herbaceous (Friedel 1991; Abule et al. 2007c).

Herbaceous floristic composition (1-10 points) and biomass. The species composition of the herbaceous layer along each belt transect (50mx4m) was determined, based on the frequency of occurrence, using a wheel point apparatus (Tidmarsh and Havenga 1955). At each site, 300 point observations were recorded and the readings were undertaken at 3 m intervals by revolving the wheel point. Although, the use of the wheel point method in rangeland condition assessment has not been practiced in Ethiopia, studies conducted by Hardy and Walker (1991) have shown that a sample size of 300 point observations are adequate for detailed scientific studies. At each observation point, the nearest herbaceous plant, within a radius of 300 mm, was recorded by species. Non-grass herbaceous species were recorded as forbs. If no herbaceous species occurred within the given radius, the point was recorded as "bare ground". Bare ground and species composition were determined based on percentages of occurrence of bare ground and individual species in relation to the total number of observation points.

The study was carried out during the main growing season (May) at the time when most grasses were flowering. Plants with full flowering heads and other

vegetative parts were collected and identified at the Herbarium of Haromaya University, Ethiopia. All identified grass species were classified into highly desirable, desirable and less desirable, based on the information obtained from pastoralists and the insights from the literature. Highly desirable species were decreasers and perennials with a high palatability based upon the pastoralists' perceptions, while desirable species were those that increased in abundance with moderate over-utilisation and perennials and were rated as average or high in terms of their palatability. The less desirable species included those species that increased in abundance with severe or extremely severe over-utilisation. This group included both perennial and annual species that were less palatable as perceived by pastoralists (Tainton 1999).
For herbaceous species composition points were allocated based on the contribution of grasses only. A maximum score of 10 points was given if the contribution of highly desirable grasses was 91-100%, 9 points if the highly desirable grasses contributed 81-90% etc. score of 3 and 4 points were given if highly desirable grasses made up 10-40%, as well as <30% and equal or > 30% increasers, respectively. Scores of 1 and 2 points were given if highly desirable grasses were less than 10%, as well as <50% and ≥50% intermediate desirable grasses, respectively. Dry matter (DM) biomass of the herbaceous species was determined in each belt transect by harvesting material from four 1 m x 1 m quadrats along each belt transect at ground level. The fresh material was weighed and hand-separated into grasses and forbs. The grass species were further separated into highly desirable, intermediate desirable and less desirable species. Dry matter percentage was determined by oven-drying at 68°C for 72 hours.
Basal area (0-10 points) and litter cover (0-10 points). Within each belt transect (50mx4m), the basal cover of living plants was estimated in a randomly laid out 1 m x 1 m quadrat that was partitioned into 8 equal parts, with 3 measurements per transect. Material was cut at ground level and superimposed on one segment of the quadrat. The highest score (10 points) was given if bases of the tufted species completely filled the segment (corresponding to 12% basal cover). Accordingly, classes of < 3%, 3-6%, 6-9%, 9-12% were distinguished. Lower scores (0 point) were given for basal cover with < 3%. The maximum score was given to creeping grasses such as Cynodon dactylon. The rating for litter cover within the same quadrat was given the maximum score (10 points) when it exceeded 40% and the minimum score when the litter cover was < 3%.
The number of seedlings (0-5 points) and age distribution (1-5 points). The number of seedlings and age categories of the grasses species were recorded from each belt transect using 3 areas equal to the size of an A4 sheet of paper (210mm x 297mm) chosen at random. The sheet was dropped from a height of 2 m above the ground. The numbers of seedlings were counted and the mean for the site calculated. The highest score (5 points) was given for more than 4 seedlings, while scores of 4, 3, 2, 1 and zero were given for the corresponding numbers, respectively. Similarly, when all age categories (young, medium and old plants) of the dominant species were present, the maximum score of 5 points was given. If there were only old plants, medium-aged or young plants, scores of 3, 2 or 1, respectively, were assigned. Young and medium-aged plants were defined as having approximately 20% and 50%, respectively, of the biomass of old and mature plants of the dominant species.
Soil erosion (0-5 points) and soil compaction (1-5 points). The extent of soil erosion and compaction along each belt transect was evaluated from 3 measurements of 1 m x 1 m quadrats by visual observations. The score for soil erosion was based on the amount of pedestals (higher parts of soils, kept together by plant roots, with eroded soil around the tuft), and in severe cases, the presence of pavements (terraces of soil, normally without basal cover, with a line of tufts between pavements). The highest score (5 points) was given for no sign of erosion; 4 points = slight sand mulch; 3 points = weak pedestals; 2 points = steep-sided pedestal; 1 = pavement; 0 = gullies. Soil compaction (1-5 points) was evaluated based on the level of capping or crust formation of the surface soil. The highest score (5 points) was given for a soil surface with no capping; 4 points = isolated capping; 3 = greater than 50% capping; 2 = greater than 75% capping; and 1 = almost 100% capping.
Sampling of woody vegetation layer. In each transect woody vegetation density, hedging, and canopy cover was recorded. All rooted live woody plants were counted and identified to determine wood species density. Identification and nomenclature of the woody species followed that indicated for herbaceous species. The scoring system was: 0 = >5000 plants/ha; 1= >4000-5000/ha; 2 = >3000-4000/ha; 3 = >2000-3000/ha; 4 = >1000-2000/ha; and 5 = >0-1000/ha. Furthermore, the canopy cover of plants in each belt transect was measured in percent using the line-intercept method with a tape measure. Canopy cover (1-5 points) was rated as described by Kuchar (1995). Scoring for woody cover was: 5 = <15% cover; 4 = 15-25%; 3 = 26-35%; 2 = 36-45%; 1 = >45% cover. Fortheremore, palatability of woody plants were determined and grouped into highly desirable, intermediate and less desirable species by interviewing the pastoralists. The hedging effects (0-5 points) for the woody vegetation were rated as described by Kuchar (1995) and are presented in Table1.
Grazing capacity determination: Determination of the grazing capacity was made from the grass DM yields,

Table 1: **Criteria for the scoring of woody plants in grazing land of the study area**

	Value	Total point	Descriptions
Hedging	3	5	if the highly palatable and palatable shrubs dominant in each belt transect and most of hedgeable plants were lightly to moderately hedged and few or no decadent plants were present in belt transect
	2	3	If palatable plants dominant in each belt transect and hedgeable plants moderately to heavily hedged and some shrubs decadent due to hedging were present in belt transect.
	1	2	if palatable and least palatable plants dominant in each belt transect and hedgeable plants heavily to very heavily hedged and if considerable numbers of decadents' shrubs were present and some may be dead due to hedging
	0	1	If least palatable and unpalatable shrubs dominant in belt transect and some normally unhedgeable shrubs were hedged moreover, hedgeable shrubs were very heavily hedged the crowns often reduced to nubbins. Many shrubs decadent and dead from hedging.
Canopy cover	3	1	>45 % cover
	2	2	36-45%cover
	1.5	3	26-35%
	1.0	4	15-25%
	0	5	<15%cover
Density		5	0-1000/ha
		4	> 1000-2000/ha
		3	>2000-3000/ha
		2	>3000- 4000/ha,
		1	>4000-5000/ha

using methods described by Minson and McDonald (1987) and the formula proposed by Moore et al. (1985):

$$Y = d[DM \times f]/r$$

Where Y is the grazing capacity (ha /LSU), d the number of days in a year (365), DM the total grass DM yield (kg/ha), f the utilisation factor, r the daily grass DM required per LSU or TLU. The grazing capacity was expressed using both hectare per Large Stock Unit (ha/LSU) and hectare per Tropical Livestock Unit (ha/TLU). LSU is an animal with a live weight of 450 kg. The animal will consume 10 kg of forage dry matter daily. In calculating grazing capacity based upon TLU, the assumption was that an animal will consume 2.5% of its body weight (Minson and McDonald, 1987), thus each TLU will consume 6.25 kg of forage DM daily. In both LSU and TLU, the utilisation factor used was 0.35.

Statistical analyses

For data analysis, the mean of the 3 measurements of rangeland condition parameters and composite sample of biomass from 4 quadrants of 1 m^2 from each belt transect of 50 m x 4 m were considered as an experimental unit. Before all the data were subjected to analysis, the experimental units were sorted by elevation and grazing gradient. Furthermore, range condition data were transformed using square root transformation. A total of 72 experimental units were used for the data analysis. For the woody vegetation, each belt (50 m x 4 m) transect from each sample site was considered as an experimental unit for data analysis. The grass, soil and woody species parameters were subjected to ANOVA using the GLM procedure of Statistical Analytical System (SAS) computer software (1987).

Furthermore, linear correlation were used to determine the relationship between woody density with grass species botanical composition, basal cover, soil erosion, total range condition rating, biomass production and bare ground cover. The least significant difference (5%) was used for comparison of means.

RESULTS

Herbaceous composition and bare ground cover

A total of 44 species of grasses, 2 species of legumes, 2 species of sedges and 8 species of other herbaceous plants were identified in the grazing area (Table 2). Grass species made up 79% of the total herbaceous vegetation, with 25% highly desirable, 25% intermediate

Table 2: Herbaceous species, life form and desirability in the different elevation categories and a grazing gradient in Rayitu rangelands. Values are the frequency of occurrence (%) in that elevation-grazing gradient combination.

Botanical name		Des	High			Low		
			Hg	Mg	Lg	Hg	Mg	Lg
Grass	Life form							
Aristida vestita	A	LD	1.0	10.8	2.6	0.7	0.0	0.0
Aristida adscensionis	A	LD	4.0	1.3	0.0	12.3	0.0	0.0
Bothriochloa insculpta	P	HD	0.0	0.0	1.1	0.0	1.0	0.3
Bothriochloa radicans	P	HD	0.0	0.1	0.3	0.0	0.0	11.0
Brachiaria brizantha	P	ID	0.1	0.1	0.4	0.0	0.0	0.0
Brachiaria dictyoneura	A	IH	0.4	0.5	0.1	0.2	1.0	0.0
Brachiaria xantholeuca	A	IH	0.6	0.7	0.9	0.3	1.0	1.3
Cenchrus ciliaris	P	HD	1.0	14.2	21.4	2.6	1.7	20.0
Chloris pycnothrix	P	ID	0.5	0.0	2.3	1.1	0.0	0.0
Chloris roxburghina	P	ID	0.5	0.3	1.2	0.0	1.7	0.0
Chloris virgata	A	ID	0.5	2.8	3.2	0.3	0.0	0.8
Coelachyrum poaflorum	A	LD	1.0	2.3	1.8	2.7	1.3	0.0
Chrysopogon serrulatus	P	HD	3.3	3.7	1.1	0.7	1.2	0.0
Cynodon dactylon	P	HD	2.1	1.1	11.5	0.4	2.0	6.0
Cynodon plectostachyus	A	HD	0.2	0.5	2.3	0.0	0.0	0.0
Dactyloctinium aegyptica	A	LD	0.7	0.0	0.0	1.1	0.3	0.5
Digitaria senegalensis	A	LD	2.0	1.7	1.5	0.0	0.3	1.5
Digitaria ternate	A	LD	0.9	0.7	0.8	1.3	0.7	0.5
Digitaria velutina	A	LD	1.3	0.9	0.7	0.3	0.8	0.5
Eragrostis cilianensis	A	LD	0.0	1.4	0.3	1.3	0.7	0.0
Eragrostis cylindiriflora	A	LD	0.2	0.3	0.3	0.2	0.3	0.8
Eragrostis superb	A	LD	0.0	0.8	1.1	2.3	1.3	0.0
Eragrostis ciliaris	A	LD	0.5	0.1	0.2	0.2	0.3	1.8
Eragrostis tenuifolia	A	ID	0.0	1.4	1.0	0.0	1.5	13.2
Heteropogon contortus	P	ID	0.5	0.3	1.9	0.0	0.7	0.8
Lepthotherium senegalense	P	LD	2.4	2.7	0.4	1.6	5.0	0.0
Lintonia nutans	A	ID	0.2	0.3	0.2	0.0	0.0	0.0

desirable and 50% less desirable with 56.8% annuals and 43.2% perennials. In heavily grazing lands, Aristida adscension, Sporobolus panicoides, Sporobolus pyramidalis and Tragus berteronianus were the frequent species, whereas Aristida vestita, Cenchrus ciliaris, S. pyramidalis and Tetrapogon cencriformis were frequent and/or most frequent species in the medium grazing sites. On light grazing sites, Bothriochloa radicans, Cenchrus ciliaris, Cynodon dactylon, Eragrostis tenuifolia, Panicum maximum and S. pyramidalis were frequent and/or most frequent species (Table 2).

Woody vegetation composition

Bare ground area varied between 12 and 23% (mean 18%) across the grazing sites (Table 2).

The correlation analysis showed that bare ground was negatively ($P \leq 0.05$) correlated with elevation, basal cover, total range condition, DM production of grass, and DM of total biomass. On the other hand positively related with soil erosion, and woody density in heavily and medium grazing sites (Table 3).

A similar result was observed in light grazing site except absence of soil erosion was negatively correlation with bare ground cover.

A total of 45 woody species were identified in the grazing area, belonging to 23 families (Table 4). Families Fabaceae (21%), Tiliaceae (16%) and Burseraceae (14%) contributed the largest proportion of

Table 2 continues

Microchloa caffra	P	LD	0.4	0.2	0.4	1.2	4.0	0.5
Microchloa kunthii	P	LD	1.0	0.4	0.2	1.9	3.3	0.0
Panicum coloratum	P	HD	0.0	0.0	0.5	0.3	0.5	0.3
Panicum deustum	A	ID	0.1	0.0	0.3	0.0	0.0	0.0
Panicum maximum	P	HD	0.1	0.3	10.1	0.9	2.0	1.0
Pennisetum stramineum	P	HD	1.2	0.5	0.0	0.0	0.0	0.0
Paspalum dilatatum	A	ID	0.0	0.0	0.0	0.0	0.0	2.0
Setaria incrassate	A	LD	1.0	1.3	0.5	1.2	0.7	0.5
Setaria verticillata	A	LD	0.0	1.5	0.0	1.1	1.5	0.8
Sorghum bicolor	P	LD	0.0	0.0	0.0	0.0	0.0	1.7
Sporobolus panicoides	A	LD	10.0	2.4	2.8	15.0	2.3	2.2
Sporobulus pyramidalis	A	LD	10.3	12.5	0.0	3.1	23.0	10.5
Tetrapogon cenchriformis	P	ID	2.2	2.5	2.0	0.0	11.0	0.0
Tetrapogon tenellus	P	HD	0.7	0.3	0.1	0.0	2.8	0.0
Themeda triandra	P	LD	0.3	0.0	0.0	0.3	0.0	0.0
Tragus berteronianus	A	LD	11.6	2.3	0.0	4.4	0.0	0.0
Tragus racemosus	A	LD	2.8	0.0	0.0	1.4	0.0	0.0
Legumes								
Crotolaria incana		F	0.1	0.7	0.6	0.0	0.0	0.0
Indigofera volkensii		F	0.4	1.1	1.4	0.3	0.0	0.3
Other herbaceous plants								
Achyranthes aspera		F	3.0	1.5	1.6	4.2	1.5	1.5
Belpharis persica		F	0.2	0.1	0.0	0.2	0.0	0.0
Bidens biternata		F	0.2	0.2	0.6	0.0	0.0	0.0
Hibiscus aponeurus		F	1.7	1.5	1.6	1.6	0.7	0.0
Ocimum basilicum		F	1.7	1.0	1.3	3.4	0.7	0.0
Sida ovata		F	2.6	1.0	2.0	3.6	1.2	2.0
Tephrosia ogelii		F	0.8	0.0	0.0	0.0	0.0	0.3
Tribulus terrestris		F	1.3	1.3	2.2	0.7	0.3	0.2
Sedge								
Commolina benghalensis		F	1.7	2.1	0.9	1.8	1.3	1.0
Cyprus obtusiflorus		F	0.4	0.0	0.0	0.0	0.0	0.0
Bare ground		B	20.1	16.4	12.3	23.4	20.3	16.0
			100.0	100.0	100.0	100.0	100.0	100.0

Des= Desirability; HD = Highly desirable; ID = Intermediately Desirable; LD = Less desirable; B = Bare ground; F = Forb; Hg = heavily grazed; Mg= Medium grazed; Lg = Lightly grazed; A = Annual; P = Perennial. Accordingly, the abundance of each plant, plant species was categorized as less frequent (frequency of occurrence of <10%), frequent (frequency of occurrence of 10-20%), and highly frequent (frequency of occurrence of >30%).

woody vegetation. Woody species comprises 22 % highly desirable, 41 % intermediate and 37 % less desirable, respectively. Acacia tortilis, Acacia bussie, Combertum collinum and Commiphora erythraea were common and/or dominant woody species in the heavily grazing areas, whereas A. bussei, Acacia mellifera, Acacia oerfota, Acacia senegal, A. tortilis and C. erythraea in the medium grazing and Acacia bussei, Acacia seyal, A. tortilis, C. collinum and Grewia penicillata in the light grazing sites were common and/or dominant species (Table 4).

Condition of rangeland, biomass production and grazing capacity in relation to elevation

Species composition rating and basal cover were significantly ($P \leq 0.05$) higher at upper land than bottom land elevation ranges (Table 5). On the other hand, soil erosion, soil compaction, and the numbers of grass seedlings were significantly ($P \leq 0.05$) higher at bottom

Table 3: Relationships between bare ground cover and elevation, botanical composition of grass, basal cover, absence of soil erosion, absence of soil compaction, total range condition, woody density, canopy cover and total biomass in Rayitu rangelands.

	Elv	Bcg	Bc	Se	Sc	Trs	Wd	Cc	Tb	Br
Br (r)	-0.44*	-0.61*	-0.65	-0.57*	-0.54*	-0.65	0.18	0.19	-0.55	-

R = Correlation coefficient; * = correlation is significant at the 0.05 level (2-tailed); Ele = elevation; Bcg = botanical composition of grass; Bc = basal cover; Se = soil erosion; Sc = soil compaction; Trs = total range condition score; Wd = woody density; Cc = canopy cover; Tb = total biomass; Br = bare ground cover.

Table 4: Woody vegetation composition and desirability in different elevation zones and grazing gradient of Rayitu rangelands based on density expressed in terms of percentage.

			High			Low		
Botanical name	Local name	Des	Hg	Mg	Lg	Hg	Mg	Lg
Acacia brevispica	Fabaceae	LD	0.6	0.6	3.7	0.0	0.0	0.6
Acacia bussie	Fabaceae	ID	11.1	3.7	10.4	15.5	20.0	11.1
Acacia mellifera	Fabaceae	LD	6.2	15.8	4.4	4.1	0.0	6.2
Acacia nilotica	Fabaceae	LD	2.2	0.0	2.2	1.3	5.0	2.2
Acacia oerfota	Fabaceae	HD	0.6	10.1	0.0	0.0	2.9	0.6
Acacia Senegal	Fabaceae	ID	6.9	11.2	5.8	3.5		6.9
Acacia seyal	Fabaceae	ID	2.2	6.8	0.0	1.0	5.8	2.2
Acacia tortilis	Fabaceae	ID	10.1	5.9	2.9	2.8	12.1	10.1
Acokanthera schimperi	Apocynaceae	LD	0.5	0.0	0.0	1.0	2.1	0.5
Asparagus falcatus	Asparagaceae	LD	1.7	0.0	5.1	0.0	0.0	1.7
Balanites aegyptiaca	Balanitaceae	ID	0.6	0.0	0.0	0.0	1.3	0.6
Becium filamentesum	Lamiaceae	LD	0.8	1.4	0.0	2.2	0.0	0.8
Boscia mossambicensis	Capparidaceae	ID	4.1	1.5	3.7	1.9	0.0	4.1
Boswellia neglecta	Burseraceae	HD	1.1	0.3	0.0	0.0	1.7	1.1
Calotropis procera	Ascelpiadaceae	LD	1.6	0.0	0.0	1.0	0.0	1.6
Cassia singueana	Caesalpiniaceae	ID	0.0	0.0	0.0	0.6	0.0	0.0
Chenopodium opulifolium	Chenopodiaceae	LD	0.0	0.8	4.4	3.5	0.0	0.0
Chionothrix tomentosa	Amaranthaceae	ID	0.3	0.0	2.9	0.6	0.0	0.3
Combretum collinum	Lamiaceae	ID	5.1	5.4	10.5	12.3	6.7	5.1
Combretum molle	Combretaceae	ID	2.5	1.1	0.0	0.3	0.4	2.5
Combretum hereroense	Combretaceae	HD	2.8	3.9	0.0	1.9	0.0	2.8

elevations. However, the difference in range condition and biomass parameters between elevations was generally low. There was no significant ($P \geq 0.05$) variation in litter cover, woody density, hedging, canopy cover, total range condition score between the two elevation zones. The mean density of woody plants was 2 539 plants/ha. Total dry matter (DM) biomass, DM of grass, DM of highly desirable grass and DM of least desirable grass were significantly ($P<0.05$) higher in the upland elevation zone. The grazing capacity based upon ha /LSU and ha /TLU[1] were higher at upper than bottom elevation ranges which implies that more land is required to sustain a LSU or TLU at bottom grazing sites than at upper, which may reflect their grass DM production (Table 5).

Condition of rangeland, biomass production and grazing capacity along grazing gradient

Analysis of variance showed that there was a significant difference ($P \leq 0.05$) among the grazing pressure in species composition, basal cover, litter cover, number of grass seedlings and age distribution of grasses (Table 5). These parameters were higher in the light grazing sites followed by the medium, with the lowest values in heavly grazing sites. On the other hand, the

Table 4 continues

Commiphora kua	Burseraceae	HD	0.6	2.5	0.0	3.5	3.8	0.62
Commiphora boranensis	Burseraceae	ID	0.5	0.0	0.0	0.0	0.0	0.5
Commiphora erythraea	Burseraceae	ID	10.0	12.6	5.1	22.1	17.9	10.0
Commiphora myrrha	Burseraceae	ID	4.8	2.8	6.6	2.5	8.8	4.8
Commiphora schimperi	Burseraceae	LD	2.8	0.8	0.7	1.6	0.0	2.8
Delonix elata	Fabaceae	HD	2.2	1.1	0.0	0.3	0.0	2.2
Dichrostachys cinerea		LD	0.0	0.3	4.4	3.2	4.6	0.0
Erythrina abyssinica	Fabaceae	HD	1.7	1.4	0.0	0.0	0.0	1.7
Euclea divinorum	Ebenaceae	LD	1.7	0.3	0.0	2.8	5.0	1.7
Grewia arborea	Tiliaceae	ID	0.0	0.0	0.0	3.8	0.0	0.0
Grewia flavescens	Tiliaceae	LD	0.6	0.6	3.7	0.0	0.0	1.3
Grewia lilicina	Tiliaceae	LD	11.1	3.7	10.4	15.5	20.0	0.0
Grewia penicillata	Tiliaceae	ID	6.2	15.8	4.4	4.1	0.0	0.3
Grewia tembensis	Tiliaceae	HD	2.2	0.0	2.2	1.3	5.0	1.4
Grewia tenax	Tiliaceae	ID	0.6	10.1	0.0	0.0	2.9	2.1
Grewia velutina	Tiliaceae	ID	6.9	11.2	5.8	3.5	1.3	0.5
Phyllanthus sepialis	Euphorbiaceae	LD	2.2	6.8	0.0	1.0	5.8	1.0
Psiadia incana	Asteraceae	HD	10.1	5.9	2.9	2.8	12.1	0.8
Rhus natalensis	Anacardiaceae	HD	0.5	0.0	0.0	1.0	2.1	2.8
Salvadora persica	Salvadoraceae	ID	1.7	0.0	5.1	0.0	0.0	0.0
Solanum incanum	Solanaceae	LD	0.6	0.0	0.0	0.0	1.3	3.6
Vepris glomerata	Rutaceae	HD	0.8	1.4	0.0	2.2	0.0	0.0
Ziziphus mucronata	Rhamnaceae	LD	4.1	1.5	3.7	1.9	0.0	0.5
Lantana rhodesiensis	Verbenaceae	LD	1.1	0.3	0.0	0.0	1.7	0.3

Des= desirability; HD = highly desirable ; ID = interemidate desirable; LD = less desirable ; B = bare ground; F = forb; Hg=Heavily grazed; Mg= Medium grazed; Lg = Lightly grazed

soil was more eroded and compacted (P≤0.05) in the heavily grazing sites than in the other two grazing site. The density of woody vegetation (no/ha) was significantly (P≤0.05) affected by grazing intensity, i.e., density of woody species was higher in heavily grazing sites (2 654 plants/ha) and medium sites (2 668 plants/ha) than in the light grazing sites (2 042 plants/ha). Similarly, canopy cover was higher in heavily and medium grazing sites than in the light grazing sites. Heavily grazing sites had higher hedging effect (P≤0.05) than medium and light grazing sites.

Based on the total range condition scores, heavily grazing sites were classified as being in poor, medium grazing as fair, and light grazing as good condition, respectively. Total DM, grass DM, DM of highly desirable, intermediate and least desirable grasses were significantly higher (P≤0.05) in the light grazing sites followed by medium and heavily grazing sites.

On the other hand, significantly (P≤0.05) lower DM of forbs was observed in light grazing sites than in the other grazing sites.

Relationship between woody density and range condition and biomass parameters

The correlation result is presented in Table 6 and shows that woody plant density was negatively (p≤ 0.05) correlated with total range condition score in heavily grazing sites (r = -0.35, n=36). The relationship between woody density and botanical composition of grass in medium grazing sites was significant (p≤ 0.05) (r = -0.63, n=24). Similarly, negative relationships between woody density with botanical composition of grass, basal cover, and total range condition score and grass yield was observed in heavily and medium grazing sites (Table 6). The relationship between woody plant density and soil erosion and percentage of bare ground cover was positive. On the other hand, the relationship between density of woody plant and canopy cover was significantly positively correlated with (p≤ 0.05) heavily grazing sites (r = 0.38; n=36) and medium grazing sites (r =0.78; n=24). The relationship between density of woody plant and soil erosion was positive in heavily and medium grazing sites. In light grazing sites,

Table 5: Range condition score, biomass production (kg/ha) and grazing capacity (ha/LSU) along grazing gradient, and elevation in Rayitu rangeland.

	Grazing gradient				Elevation		
Parameters	Heavily	Medium	Lightly	LSD	High	Low	LSD
GSc	2.9c	5.1b	6.5a	0.42	4.4 a	4.1b	0.32
Bc	1.9c	4.6b	7.3a	0.30	3.8a	3.5b	0.23
Lc	0.7c	3.4b	4.8a	0.33	2.3a	2.2a	-
Ad	2.2c	3.8b	4.6a	0.34	3.2a	3.0a	-
Se	2.3c	4.0b	4.8a	0.26	3.1b	3.4a	0.20
Sc	2.2c	3.7b	5.0a	0.31	3.0b	3.5a	0.24
Ngs	0.2c	2.2b	3.8a	0.29	1.3b	1.7a	0.22
Wds	2.8b	2.8b	3.3a	0.38	2.8b	3.1a	0.29
Ccs	3.4a	3.0b	2.5b	0.78	3.1a	3.1a	-
Hed	1.9b	2.8b	2.8a	0.46	2.3a	2.5a	-
Trs	25.1c	41.0b	51.9a	1.14	34.7a	35a	-
Rc	Poor	Fair	Good		Fair	Fair	
Wd	2654a	2669a	2042b	347	2612.2a	2465a	-
Cc	38.7a	33.8a	26.4b	9.39	35.6a	34.2a	-
Grass	119.6c	350.3b	1144.0a	58.43	409.5a	296.8b	44.57
HD	21.4c	102.3b	611.0a	77.82	173.6a	101.7b	59.36
ID	38.6c	98.8b	269.3a	50.90	91.2a	107.1a	NS
LD	58.7c	145.4b	251.4a	56.93	140a	86.0b	43.42
Forb	371.7a	344.8b	188.6b	25.00	340.9a	317.8a	NS
TB	491.3c	695.1b	1332.0a	83.13	750.4a	614.6b	63.41
TLS	87.2	28.8	9.1		25.4	35.1	7.2
TLU	54.9	18.6	5.7		15.9	22.9	
N	36	24	12		45	27	

Means with different letters in a row are significantly different ($P \leq 0.05$) (5%). Gsc = Grass species composition score; Bc= Basal cover; Lc = Litter cover; Se = Soil erosion; Sc = Soil compaction; Ad = Age distribution of grasses; Ngs = Number of grass seedlings; Wds = Woody density score; Ccs = Canopy cover score; Hed = Hedging; Trs = Total range condition score; Rc= Range condition; Wd = Woody density; Cc = Canopy cover; HD = Highly desirable; ID = Intermediately Desirable; LD = Less desirable; LSD = Least significant differences; N=sample site **;** NS= non significant; TLS= Large Stock Unit ; TLU= Tropical Livestock Unit; GgX Elv= Interaction of grazing gradient and elevation

a positive significant ($p \leq 0.05$) relation was observed between woody density with basal cover (r = 0.61; n=12), grass yield (r= 0.76; n=12) and total biomass yield (r=0.75; n= 12). On the other hand, negative correlation was recorded between woody density with forbs biomass and bare ground percentage (Table 6).

DISCUSSION

Herbaceous, woody vegetation composition and bare ground cover

This study has provided information on current range condition, herbaceous and wood vegetation composition, DM biomass production and grazing capacity in the arid and semi-arid rangeland of southern Ethiopia, which will be invaluable in locating of range management plan. In the heavily grazed sites the composition of less desirable grass species was higher than intermediate and highly desirable grasses species. The local communities related this condition with drought and overgrazing of the rangelands, and they further suggested that the trend of annual grasses and forbs species such as Tribulus terrestris, Achyranthes aspera, Bidens biternata and Hibiscus aponeurus has increasing over the past 3-4 decades. This may indicate an increase in deterioration of the rangelands, which may call upon intervening the control of the expansion of forbs. According to pastoralists, the proportion of some desirable perennial grasses such as C. ciliaris, C.dactylon, P. maximum and Lepthotherium senegalense have decreased in abundance. These species are important and known as the key forage species in grazing lands. Many of the grass species identified in the heavily grazed sites were annuals and undesirable species. Some of the less desirable grass species which found in heavily grazed areas can be

Table 6: Relationships between woody density and some range condition parameters along grazing gradients in Rayitu rangelands

		Elv	Bcg	Bc	Se	Trsl	Cc	Gr	Fb	Bb	Br
WD	Hg (r) N=36	0.01	-0.001	0.27	0.03	-0.35*	0.38 *	-0.23	0.22	0.11	0.08
	Mg r) N=24	0.01	-0.63*	0.10	0.03	-0.24	0.78*	-0.04	0.29	0.12	0.11
	Lg (r) N=12	0.69	0.41	0.61*	0.08	0.05	0.29	0.76*	-0.14	0.75*	-0.458

r = Correlation coefficient; * = correlation is significant at the 0.05 level (2-tailed); Hg=Heavily grazed; Mg= Medium grazed; Lg = Lightly grazed ;N= grazing site; Elv = Elevation; Bcg = botanical composition of grass; Bc = basal cover; Se = soil erosion; Sc = soil compaction; Trs = total range condition score; Wd = woody density; Cc = canopy cover; Gr= grass yield; Fb= Forb yield; Tb = total biomass; Br = bare ground cover.

used as indicators of poor rangeland condition. For example, species like S. pyramidalis (Solomon et al., 2006b), A. adscension (Amaha, 2006), D. ternate, T. berteronianus (Abule et al.,2007a) were reported to occur on disturbed areas. This study can indicate desirable perennial grasses on the heavily grazed sites were replaced with annual grasses and forbs which supports study made by Gemedo-Dalle et al., (2006), Abule et al. (2007a) in Ethiopia rangelands.

The increase the abundance of annual plants in heavily grazed sites can be related to the sprouting of plant immediately after rainfall. Yates et al. (2000) supported this view and concluded that heavy grazing pressure and low rainfall promoted the growth of annual grasses. The identified grass species compositions on light grazed sites were more desirable perennial grasses. Nevertheless, the number of species composition was lower than that of heavily and medium grazed sites. The proportion of some highly desirable species such as C.ciliaris, C. dactylon was abundant on medium and light grazed sites. Cynodon dactylon is important forage species in the rangeland is in agreement with the report of Coppock (1994) and Ayana and Baars (2000). In contrast to our studies, Other studies (Amsalu and Baars, 2002; Abule et al. 2007a) have reported that C. dactylon is increasers plant and dominant species in overgrazed rangeland. This implies that classification of grass species based on desirability cannot be consistent, particularly in arid and semi-arid rangeland ecosystem including the study area where livestock feed scarcity and recurrent drought was a common problem. In such ecosystem even less desirable species may be heavily grazed and become relatively desirable. This may suggesting that classification of grass in reaction to grazing require detailed understanding of the local condition.

Cenchrus ciliaris was important forage species in the medium and light grazed sites. Ecologically this species is the most important key species in the semi-arid rangelands of Ethiopia and is a good indicator of the health status of rangelands (Gemedo-Dalle et al., 2006; Solomon et al., 2006b). Sporobolus pyramidalis was a dominant species in all grazing sites; this implies that this species is the single invading plant in the area which is in agreement with result of Solomon et al, (2006b) study made in southern Ethiopia. Other species, such as B. radicans was found in abundant in light grazed sites and based on opinion of pastoralists B. radicans is an undesirable grass with poor grazing value which is in agreement with result of Solomon et al. (2006b). However, this is contrast with the report of Ayana and Baars (2000) who indicated that B. radicans is desirable grass with good grazing value for calf. Tetrapogon cencriformis was less desirable plant and dominating on the medium grazing sites. Nevertheless, other studies (e.g. Amaha, 2006; Solomom et al., 2006b) conducted in Somalie and Borena rangeland of Ethiopia reported that T. cencriformis is not dominant. In this study, elevation through their effect on precipitation and temperature has primarily influenced the distribution of grass composition and similar conclusion was also made by Getachew et al. (2008) from their study in north Ethiopia.

The woody species identified in the grazing sites of the study area were more or less similar to those identified in the arid and semi-arid rangelands of southern Ethiopia (Gemedo-Dalle et al., 2006). Some of the woody species identified in the study area such as Solanum incanum, Ziziphus mucronata and Lantana rhodesiensis species give an indication of the condition of the rangelands. According to Abule et al. (2007b) Solanum species are indicators of deterioration in the condition of the rangeland. The observed variation in woody vegetation composition along grazing gradient and elevation may agree with the findings that altitude influenced the vegetation composition of an area (Getachew et al., 2008). Variation in woody composition along grazing gradient can be attributed to human disturbance such as deforestation for expansion of farmland, construction purpose and bush management influence of the pastoralists such as selectively clearing of unwanted woody vegetation from medium and light grazing sites. The high spatial distribution of woody vegetation in composition on the heavily grazed sites can be associated with drought, ban on use of periodic fire and free movement of livestock. In the heavily grazed sites when animals move from place to place in search of feed and water they could serve as an agent for the dispersal of seeds of different plant species and this may promote the increase of woody plants composition. On the other hand, the high percentage of highly and intermediate desirable woody plant species plays crucial role in livestock feed supply especially in the dry season and drought period. Furthermore, it helps to integrate more browsing (e.g. goat and camel) and grazing animals.

Bare ground is a good indication of over-utilisation and degree of the degradation of the vegetation. The high percentage of bare ground cover in heavily grazing site indicates that the deteriorating condition of the rangeland has negative implication on DM yield. The observed negative relationship between bare ground with basal cover, botanical composition of grass, absence soil erosion, total range condition score, DM biomass of grass, and total DM biomass in this study was similar with other reports (e.g. Gemedo-Dalle et al., 2006) of arid and semi-arid climate. The presence of a negative significant relation between the bare ground and absence of soil erosion indicates that bareness may contribute to the compaction of the soil due to the exposure of the soil to wind and water erosion.

Condition of rangeland, biomass production and carrying capacity

The low values for grass species composition, basal cover, litter cover, number of grass seedlings and age distribution in heavily grazed sites vis-a-vis the medium and light grazed sites reflect the impact of recurrent drought and grazing pressure in heavily grazed sites. In arid and semi-arid rangelands, these parameters depend on a number of factors such as gazing pressure, drought and rainfall (e.g. Van der Westhizen et al., 2001). Overgrazing and prolonged drought might lead to a reduction in herbaceous species composition and diversity, which could aggravate the rangeland deterioration. As reported by other investigators (Yates et al., 2000) heavy grazing pressure may reduce plant species composition and basal cover. On the other hand, the highest species composition, basal cover, age distribution and number of grass seedlings exhibited in light grazed sites reflected the benefits of lower grazing, trampling pressures, and management interventions by pastoralists as reported by Amaha (2006) from the rangeland of South east Ethiopia. Basal cover of grass was generally low in the heavily grazed sites as compared with medium and light grazed site with a mean score of 2.9. Different factors could lead to a low basal cover, based on the household result, overgrazing, drought and bush encroachment were the most likely determinants and these factors were interrelated and complex require long term studies. Nevertheless, the most important factors indicated by others studies are poor range condition and overgrazing (Solomon et al.,2006b), drought (Gemedo-Dalle et al.,2006), poor grazing practices (Snyman and Fouche, 1993) and high tree densities (Smit, 2002). The eroded and compacted soil in the heavily grazed sites owing the low basal cover, higher bare ground cover and could lead to its compactness and loss of the soil.

An increase in the woody plant density beyond a critical density limit normally refers as bush encroached. A shrub covers of 40% and/or 2,400 woody plants/ha has been considered as a borderline between non-encroached and encroached condition (Roquest et al. 2001) and with 2,500 tree equivalents/ha indicating encroached condition (Richter et al. 2001). According to Gemedo-Dalle et al. (2006), when the woody plant density exceeds 2,400 plants/ha, the area is moving towards bush encroached. Thus, it can be said that heavily grazed sites and medium sites were bush encroached while the light grazed sites are not bush encroached. Smit (2002) sug¬gests that the causal factors for bush encroach¬ment are complex and have been a contentious issue in rangeland ecology. Pastoralists in the study area reported that drought, overgrazing, livestock movement and absence of fire were major factors triggering woody encroachment, in agreement with reports by Herrmann and Hutchinson (2005) for the Sahelian belt of Africa, Twine (2005) for South Africa, Angassa and Oba (2008) for the Borana zone of southern Ethiopia. There is also ample evidence in the literature that bush encroachment causes a decline in rangeland condition and the respondents from study area supported this view (Abate et al., 2010). Based on frequency value, density and perception of pastoralists A. bussie, A. tortilis and C. erythraea species were the major encroaching species in the grazing sites. The encroachment by species of Acacia has been reported by many scholars in different parts of Africa for example in Ethiopia (Gemedo-Dalle et al. 2006; Abule et al. 2007b; Angassa and Oba, 2008), in South Africa (Chanda et al. 2003), in Botswana (Moleele and Mainah, 2003), in Tanzania (Prins and Van der Jeugd ,1992), in Uganda (Mugasi et al., 2000). The control of bush encroachment will require a proper understanding of invasive species, the extent, the underlying cause, and the population dynamics of the invasive species.

The low DM yields of forage on heavily grazing sites as compared with other grazing types corresponded with the reports of Schlesinger et al. (1990), and Gemedo-Dalle et al. (2006) that rangelands in poor condition had low forage production with less desirable forage than range in good condition. This study has recognized high DM yield of forbs in heavily grazing sites than other grazing types. This may be evidence for poor range condition of heavily grazing sites as reported by Amsalu and Baars (2002) in middle rift valley of Ethiopia.

The observed value of grazing capacity in area showed that rangelands in poor condition had low grazing capacity than range in good condition. The mean grazing capacities of the study area showed that more land is required to sustain a LSU or TLU without damaging the rangeland ecosystem. Furthermore, the determination of grazing capacity in our study may be signify the extent of challenge in the grazing sites.

The overall range condition score observed in this study concluded as heavily grazed site was poor (25 points), medium was fair (41 points) and light grazed sites as good condition (51.9 out of 53-65 points). However, the difference in total range condition score between elevations was insignificant and classified generally as fair condition. The variation along grazing gradient reflects poor range condition had low DM yield with less desirable forage than good range condition. This implies that poor rangeland condition of heavily grazed sites and medium sites will exert a negative impact on rangeland ecosystem and livelihood of pastoralists. The challenges observed in rangelands are complex and multi-dimensional due to internal and external drivers. To date many rangelands based life style has been under increasing threat (Reid et al., 2004) and the challenges have emerged over many years, the solutions will also require time to implement. Thus, it is essential that deterioration of rangelands be halted and the current condition of communal rangeland be improved through rehabilitation and conserva¬tion. Rehabilitating the existing rangelands requires the development of a range¬land management strategy involving pastoralists and other stakeholders, with all participants fully committed to a successful outcome. Furthermore, rangeland intervention should be integrated with other activities like livelihood income diversification, drought risk management and improving the education level of the community to reduce in livestock population and adoption of pastoralists based technologies. The pastoral communities in the study area as elsewhere in other parts of east Africa have a detailed knowledge of their grazing resources (Oba and Kotile, 2001). Development interventions that neglecting pastoralists knowledge in Ethiopia and in other parts of arid and semi-arid rangelands of Africa had not been successful (Scoones, 1995). Therefore, communities must be involved in the planning, and implementing of rangeland development intervention. Moreover, to avoid the negative outcomes of rangeland deterioration, participatory approaches that involve all stakeholders should be essentials.

Relationship between woody plant density with range condition and biomass parameters

A negative correlation between total woody plants and grass botanical composition, grass DM yield and total range condition rating observed in the heavily and medium grazing lands was similar with report of Gemedo-Dalle et al. (2006) study made in the Southern Ethiopia. The positive relationship found between woody density and basal cover, grass DM yield and total biomass yield in the light grazing sites indicates that woody plants may not affect below a certain threshold density level. The observed positive correlation between density of woody plants and canopy cover conforms the findings of Gemedo-Dalle et al. (2006). This implies that, beyond a certain threshold density, woody plants may suppress the grass layer because of severe competition for available water, nutrients and a severe reduction in light reaching the grasses. This correlation analysis shows the apparent influence of woody plants density on some grass parameters, range condition, biomass production and bare ground cover. This leads to speculation that woody plants density influences the productivity of rangeland ecosystem is substantial. Furthermore, this study can suggest that when evaluating the condition of rangelands ecosystem composed from various components, incorporating woody parameters in assessments techniques should be essentials.

CONCLUSIONS

The rangelands in the study area are used both for grazing and browsing animals in such type of grazing land; the three layers in rangeland rating are essential. Heavily grazing sites support lower species composition, basal cover, total DM production, grass DM production, and grazing capacity per unit area, while the other grazing sites exhibit higher values of woody plant density, canopy cover, percentage of bare ground cover, soil compaction and erosion. This study also concludes that heavily grazing and medium grazing sites were bush encroached while the light grazed site was not bush encroached. Acacia bussie, A. tortilis and C. erythraea species were the main encroaching species in the grazing sites. Heavily grazed site were poor while medium grazing site was fair whereas lightly grazed sites was good. The heavily and medium grazed rangelands were deteriorated and urgent action is needed. Nevertheless, the medium grazing sites were in transitional state from poor to fair condition while the light grazed sites need maintenance of their present condition. Higher elevation sites carry higher total DM production, DM of grass, DM of highly desirable, DM of less desirable grass production and grazing capacity per unit area than the lower elevation sites. In overall, the higher and lower elevation sites were fair condition and need improvement interventions. This emphasizes the importance of stocking rates and proper rangeland management. To sustain the pastoral production systems in the area, the grazing sites need rehabilitation, conservation and proper management. This would involve resting of heavily and medium grazed sites, selective thinning of woody plants, and establish¬ment of community-based grazing reserve in some key sites. To this end, pastoralists and all stockholders involving in rangeland utilization and conservation need to collectively develop a land-management strategy to ensure the recovery of degraded areas and halt any further degradation.

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