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Full Length Research Paper

Evaluation of woody vegetation in the rangeland of Southeast Ethiopia

Teshome Abate*[1], Abule Ebro[2] and Lisanework Nigatu[3]

[1*]Dilla University, School of Agriculture, Dilla, Ethiopia
[2]Adami Tulu Agriculture Research Center, Zeway, Ethiopia
[3] Haromaya University, Dire Dawa, Ethiopia

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Tree play crucial role in arid and semi arid rangeland and pastoralists depend heavily on woody plants for multiple uses. However, there is limited information regarding to woody plants in Rayitu rangeland of South East Ethiopia. The objectives of the study were to document traditional use of woody plants, assess woody plant structure and examine relationship between woody plants density with rangeland condition parameters, bare ground cover, and biomass production. A structured questionnaire (90 households), focused group discussions and field observations were used to gathered data. Data on woody plant composition, density, frequency, canopy cover, plant height, desirability and browsing effect was gathered from 72 belt transects (50mx4m) laid across three grazing types and two elevation zones. The most dominant use of woody plants was for construction (91%), followed by browse (68%) and medicinal purposes (25%). About 80% of the respondents replied the woody plant vegetation cover has declined. Drought (52.8%), deforestation for the expansion of farmland (39.2%) and construction purposes (26.8%) were the major causes. A total of 45 woody species were identified in the grazing area. The mean density of woody species (plants/ha) were (p <u><</u>0.05) highest in communal (2654) and in enclosure grazing sites (2668) than in benchmark (2042). Both the household and the field vegetation studies confirmed that communal and enclosure rangelands are encroached by bush. *Acacia tortilis, Acacia bussie* and *Commiphora erythraea* were the encroaching woody plants in grazing sites. Most of the woody species had the highest abundance in the height class > 2–5 m regardless of grazing type and altitude belt. Emphasis on conservation of desirable plants and control of bush encroachment through selective thinning are recommended.

Keywords: Woody species, bush encroachment, density, multipurpose plants, southeast Ethiopia.

INTRODUCTION

The multipurpose role of trees and shrubs as a source of feed for both domestic and game animals, firewood, implements, source of medicine, mulch and soil conservation in semi-arid regions has long been recognized by scholars in the past (Smit, 2002). Trees and shrubs are important sources of livestock diet in the drier parts of Africa (Scoones, 1995). These trees are often browsed or casually lopped by domestic animals and game (Abule et al., 2005). Due to the highly irregular nature of rainfall in the dry lands and virtual disappearance of nutritious grasses during the dry seasons, trees and shrubs are an essential part of the pastoral environment. Browse trees and shrubs often have a high crude protein and mineral content (Kibon and Ørskov, 1993; Kadzere, 1995) and thus important in supplementing low quality feeds like mature grasses. In Africa, at least 75% of the trees and shrubs serve as browse plants and many of these are legumes (Abule, 2003). The pastoral and agro-pastoral communities in the dry land areas of Africa have indigenous knowledge to utilise the woody plant for economic, cultural and environmental purpose (Solomon et al., 2006).

In Ethiopia, rural communities in general and pastoralists in particular depend on woody plants for

*Corresponding Author E-mail: teshome_abate@yahoo.com or teshomeabate@gmail.com; Tel:+25109032167; Fax: +2510463312674

wider range mainly for medicine, food, forage, local construction, making of household implement, firewood and shade (Gemedo-Dalle et al., 2006). On the other hand, bush encroachment is a common problem in many rangelands of Ethiopia and seen as indicator for rangeland degradation in semi arid savanna (Smit, 2002) and causes a reduction of herbaceous production, grazing capacities and undesirable shifts in species composition (Archer and Bassham, 1988). Understanding of the bush encroachment, its consequences and the planning of the control measures require quantitative data on the species composition, density and height distribution classes of the woody plants (Abule et al., 2005).

Rayitu rangeland is located in the lowlands of Bale, where pastoralism and agro-pastoralism are the main land use systems and livestock is the main asset of the community. The communities in these areas depend heavily on woody plants for multiple uses. However, the woody plants of the rangeland have not been assessed and there is no quantitative information regarding to traditional use of woody plants, woody plants structure, and bush encroachment status in the area. Furthermore, the study was intended to examine the hypothesis that does the assessment of rangeland woody plant vegetation concurs with the human perception of changes in cover and vegetation.

In the past in the rangelands of Ethiopia some attempts have been made to investigate the rich diversity of woody plants and the perception of pastoralist on woody plant utilization. However, compared with the vast rangeland areas of the country, there are only very limited studies; for example, woody plants assessments were studied in south Ethiopia (Coppock, 1994; Gemedo-Dalle et al., 2006; Solomon et al., 2006), in middle Awash Rift valley (Abule et al., 2005), in East Ethiopia (Amaha, 2006) and in North East Ethiopia (Diress, 1998). Despite of all these studies, there is limited information regarding to woody vegetation in South East Ethiopia. Therefore, the objectives of the study were to document the traditional use of woody plants, to assess woody plants structure and examine the relationship between woody plant density with rangeland condition parameters, total range condition score, biomass production and bare ground cover in the rangelands.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Rayitu district, which is found in Bale zone of the Oromia Regional State, Ethiopia (Figure 1). It covers an area of about 6139km^2 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). Of the total land area of the 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. Solancharks, fluvisols and xerosols 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).

An assessment of woody plant use and structure

Data were gathered using a single-visit formal survey method (ILCA, 1990). Prior to the actual survey, field visits and secondary information relevant to the study was gathered. Informal surveys and group discussions were made to gather information about the district and to get insights from community members who were directly or indirectly involved in the production system. Group discussions were held with elders, key informants and development agents. These discussions focused on household demography, woody plant use and status, bush encroachment and constraint of woody plants. The information gathered through the above process was summarized and used as a basis to design other data collection instruments. A structured questionnaire was designed to obtain data on woody plant use and bush encroachment. The questionnaire included both single response and multiple responses questions. Single response questions were those questionnaires where the sampled household would have a single response and multiple response questions were questions where the individual household might provide more than one answer for given question. In case of the latter, the percentage of responses (respondents) would be greater than 100%. A pretest of the questionnaire was made before the actual data collection, and appropriate modifications and corrections were made. Interviewers were recruited and trained in an attempt to improve the accuracy of answers to questions. From a total of 19 Pastoral Associations (PAs) in the district six PAs were selected based on accessibility, representativeness of grazing land and livestock potentials. From the selected PAs, a total of 90 households were chosen at random and interviews were conducted, with community leaders

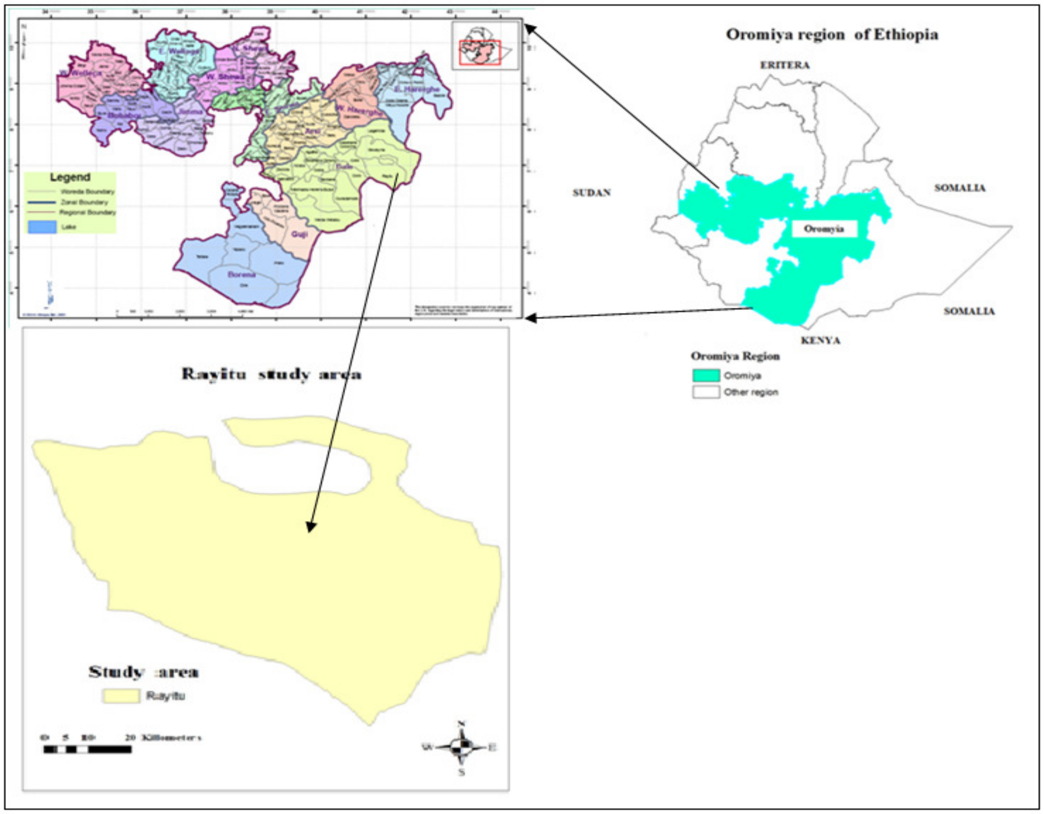

Figure 1. Map of the study area

as facilitators. Prior to the interview, the objectives of the survey were explained and discussed with the informants in order to ensure their cooperation.

To study the woody vegetation, grazing sites were identified based on available documents and maps pertinent to vegetation cover of the study areas. This was followed by a discussion with the respective agricultural development office experts, and the elders of the community in the study district 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) (low land) and >1070-1350 masl (high lands) Within each elevation group, the grazing areas were further stratified into communal, enclosure and benchmark. Communal grazing lands were communally owned, being grazed through-out the year at a high intensity of grazing. 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 not utilised during the rainy season and were used during the dry season for lactating cows, calves and oxen and selected as medium grazed site. Benchmark sites had been protected and less grazed areas for a long time (10-15 years) had relatively low grazing intensity and were used for comparative purposes. A total of 15 highland grazing sites (8 communal, 5 enclosure and 2 benchmark) and 9 lowlaand grazing sites (4 communal, 3 enclosure and 2 benchmark) were selected. On each grazing site, a sampling block of land, 3 km x 1 km (300ha) and representative of the vegetation under consideration was demarcated. 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 (1 km x 1 km), a belt transect of 50 m x 4 m was laid out randomly to accommodate both vegetation layers, *i.e.*, woody and herbaceous (Abule et al., 2007c). In each of the 50 m x 4 m belt transect, woody plant species composition, density, hedging, plant height, and canopy cover were recorded. All rooted live woody plants regardless of being single stemmed or multi-stemmed were counted and identified to determine wood species density per hectare and the rating is presented in Table 1. Most of the species were identified in the field. Unidentified species were collected and identified in the Haramya University.

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

Nomenclature of the plant species followed the Flora of Ethiopia (Hedberg and Edwards, 1989; 1995) and the Flora of Tropical East Africa (Cufodontis, 1953-1972). Within each belt transect, woody density (0-5point) was rated and presented in Table 1. 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 (Table 1). Plant heights were measured using calibrated aluminum poles. The heights of the woody plants were grouped into four classes (0-0.5m, >0.5m-2m, >2-5m and >5m) (Solomon et al., 2006) and their palatability was 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 Table 1. Furthermore, from each belt transect range condition parameters such as botanical composition of grass, basal cover, litter cover, number of seedling, age distribution of grass, soil erosion and soil compaction were gathered by adapting method developed for semi-arid rangelands in south and eastern Africa (Baars et al., 1997), herbaceous biomass yield and bare ground cover were also determined from each belt transect.

Statistical Analysis

The collected household data were summarized and analysed using Statistical Package for the Social Sciences (SPSS, Version 10, 1996). Descriptive statistics such as mean, percentage and standard deviation were used to present the results. Furthermore, the woody species parameters were subjected to ANOVA using the GLM procedure of Statistical Analytical System (SAS) computer software (1987). Mean comparison was made using Fisher’s LSD. Pearson correlation was used to determine the relationship between woody density with total range condition parameters, Dry mater biomass production and bare ground cover.

RESULT

Household demographic characteristics

The household survey showed an average family size of

Table 2. Household family size and education status in Rayitu district (n=90)

Age category (years)	Mean Family size	Percent
<15	4.91	52.3
16-64	3.10	33.1
>65	1.44	15.4
Level of education	Frequency	Percent
Uneducated	31	34.5
Basic education	21	23.3
Primary (1-6 grade)	36	40
Secondary (7-12 grade)	2	2.2
Farm activities before 30 years	Frequency	Percent
Livestock production	85	94.4
Crop production	-	-
Both	5	5.6
Current farming activities	Frequency	Percent
Livestock production	32	35.6
Crop production	1	1.1
Both	57	63.3
Cultivation started	Frequency	Percent
During *Haile sellassie* regime ***	12	13.3
During *Derg* regime**	76	73.4
After the down fall of *Derg* regime*	12	13.3
Reason for cultivation	Frequency	Percent
Income diversification	73	81.1
Human population pressure	44	48.9
Settlement	17	18.9
Decrease of livestock population	11	12.2

n= no of respondent

9.45 ± 5.94 (± SD). All respondents were males, as they were the head of the family and strong cultural practice prevented females responding on behalf of the family. The age range was 27–77years (mean 48 ± 9.56). About 34.5% of the respondents had no formal with only 2% being educated secondary school. In the past (30 years earlier), livestock production was practiced by 94% of households and the inhabitants were totally pastoralists (Table 2). Livestock and livestock products played a major role and the rangelands were used mainly for grazing. Currently, only 36% were purely livestock producers, with 63% combined livestock and crop production (agro-pastoralists). Most of the households (73%) commenced growing crops, did so during the period 1974–1991, with 13% doing so before that time. Reasons for adopting an agro-pastoral lifestyle included: the need to diversify household income (81%); human population pressure (49%); expansion of settlements (19%); a decline in livestock numbers per household (11%) and owing to drought (12%). Consequently, pastoralists started to cultivate small plots of land to grow cereal crops in situations which were marginal for cropping. About 94% of the respondents had increased the area of land devoted to cultivation at the expense of grazing area. Maize (*Zea mays*), sorghum (*Sorghum biocolor*) and teff (*Eragrostis tef*) were the major crops grown.

Use of woody plant and status

Pastoralists use woody plant species for a wide range of services mainly for construction purposes (91%), followed by use as livestock feed (68%), for medicinal purposes (25%) and to some extent for timber (14%), edible fruit (30%), fuel and charcoal making (17.8%), household equipment (13.3%), shelter (6%) and fragrance (3%). The role of woody plants in traditional uses is presented in Table 3, it depicts that about 85.1% of the total identified woody plants were utilized for different purposes and about 91.5% of plant have multiple uses; these include for house and fence construction (19 species), livestock feed (29 species), medicine for livestock and human (11 species), shelter and shade (8 species), fruit and food (12 species), making household utensils and farm implements (17 species), fuel and charcoal making (8 species), timber (1 specie), gums and resins (4 species), hygienic for fumigation of milk processing equipment and

Table 3. Woody trees and shrubs use based on pastoralists perception in Rayitu district

Botanical name	Local name	Con	For	Med	Tim	FC	Hu	Wf	Sh	Fra	Hyg	En	Bf
Acacia brevispica	*Harmuco*	X											
Acacia bussie	Hallo	X	ID			X	X		X				X
Acacia mellifera	*Bilala*	X		X		X							X
Acacia nilotica	*Burquqqee*	X				X							X
Acacia oerfota	*Ajo*	X	HD						X		X		X
Acacia Senegal	*Saphensa*	X	ID					X					X
Acacia seyal	*Wachuu*	X	ID					X	X				X
Acacia tortilis	*Tedechaa*	X	ID			X	X		X				X
Acokanthera schimperi	*Qaraaruu*						X						
Asparagus falcatus	*Saritti*												
Balanites aegyptiaca	*Badena*		ID				X	X		X			
Becium filamentesum	*Gurbii harre*												
Boscia mossambicensis	*Qalqalchaa*		ID								X		
Boswellia neglecta	*Dakara*		HD	X		X		X		X			
Calotropis procera	*Kobo*			X									
Cassia singueana	*Cheketa*		ID	X									
Chenopodium opulifolium	*Anenewa*			X									
chionothrix tomentosa	*Hadda*		ID										
Combretum collinum	*Herreerri*	X	ID				X						
Combertum molle	*Ruukessa*	X	ID			X	X						
Combretum hereroense	*Keenno*	X	HD								X		
Commiphora kua	*Unsii*		HD	X			X			X			X
Commiphora boranensis	*Ileemssa*		ID	X									
Commiphora erythraea	*Agarsu*	X	ID	X	X	X	X					X	X
Commiphora myrrha	*Kumbi*	X	ID							X			
Commiphora schimperi	*Hamechaa*						X	X					
Delonix elata	*Shukume*		HD			X		X					
Dichrostachys cinerea	*Jirrimee*												
Erythrina abyssinica	*Likimee*		HD				X		X			X	X
Euclea divinorum	*Mii'eechaa*	X		X									
Ficus syhomorus	*Odaa*						X	X	X			X	
Grewia arborea	*Qoqoroo*	X	ID				X	X					X
Grewia flavescens	*hunfururaa*	X											
Grewia lilicina							X						
Grewia penicillata	*Ogomdii*		ID				X	X					
Grewia tembensis	*Qachalle*	X	HD				X	X					
Grewia tenax	*Shukumaa*	X	ID	X			X	X					X
Grewia velutina	*Harorressa*		ID										
Phyllanthus sepialis	*Dhiggrii*												
Psiadia incana	*Chillee*		HD										
Rhus natalensis	*Dabobechaa*		HD				X		X		X		
Salvadora persica	*Addee*		ID								X		
Sida ovate	*Harcumman*		ID										X
Solanum incanum	*Hidda*												
Vepris glomerata	*Karuu*	X	HD										
Ziziphus mucronata	*Qurquraa*			X			X		X				
Lantana rhodesiensis	*Midhaan dubraa*												

Con= House and fence construction; For= Fodder; Med=Medicinal plant; Tim =timber; FC = Firewood and charcoal making; Hu = Household utensil and farm implements; Wf= Wild edible fruit and gum; Sh = shade and shelter; Fra= Fragrant; Hyg = Hygienic/perfurming; EI= environment indicator; Bf= Bee forage; HD = highly desirable ; ID = intermediate desirable human teeth brushing (5 species), environmental indictors (3 species) like indicators for sources of well during drought and soil fertility and bee forage (13 species). Some of the most important browse species mentioned by pastoralists were: *Acacia bussie, A. senegal, Combretum collinum, Commiphora erythraea, C. kua, Delonix elata, Grewia tembensis, Psiadia incana,* and *Rhus natalensis*. The communities ranked use of browse plant second next to natural pasture as livestock feed resources in both dry (73%) and wet (32%) season. Furthermore, the communities used browse plant as alternative feed sources and supplementary feeding for coping up feed shortages and drought period. As indicated in Table 3, some trees and shrubs were commonly used as traditional medicine for livestock and human, they used part of leaf, bark, exude and root. *Acacia tortilis,* and *Ficus sycomorus* were mentioned for their use as shelter and shade for livestock and human beings. The fruits of *G. penicillata, G. tembensis, G. tenax, Z. mucronata*, and the exudates of A. *senegal* were listed as the most important woody plants species, which provide fruit during herding, long journey and drought period. *Boswell neglect, C. kua* and *C. myrrha* were identified for resins. *F. sycomorus* was also important as a shade tree during traditional rituals and meetings. Some plant species used for hygienic purpose for teeth brushing include *S. persica, Sida ovata,* and *A. oerfota*. *Boscia mossambicensis* and *Combretum hereroense* were commonly used tree and shrub species for cleaning up and smoking of milking utensils, beside of this, some tree species were also used as indicators of potential locations for wells during drought. Respondents perceived that F. *sycomorus* probably required large amounts of moisture and usually grew near underground streams, where the water table was shallow. *C. erythraea,* which is deciduous, was used as an indicator for onset of rain by the community.

Change in woody plant abundance

Eighty percent of the respondents replied that the status of woody plant cover has decreased as compared with those 30 years ago. The communities ranked drought (52.8%) as mainly, followed by deforestation for the expansion of farmland (39.2%) and construction purposes (26.8%), fuel and charcoal production (80%), browsing (4.4%) and human population pressure (3.3%) were the main causes for the reductions of abundance of woody plants. There were very little efforts made by government, non-government institutions and the community to plant and rehabilitate the forest that was cleared in the area. Above 97.8% of respondents replied that there was no tree seedling nursery site in the district. Like any other rural parts of Ethiopia, fuel wood was the major source of household energy. However, only dry and dead wood was used for fuel and community did not have the habit of cutting a living tree for fuel source. Charcoal making and marketing was rare in the area due to government control, prohibition of marketing charcoal, and poor accessibility to markets place.

Bush encroachment

About eighty six percent of the respondents replied that compared to past 30 years, their grazing land was covered with bushes and shrubs. About 83% of the sampled households perceived bush encroachment as an indicator of rangeland degradation. It is also commonly seen as indicator of rangeland degradation in semi-arid savanna (Coppock, 1994). The present study revealed that drought (55.6%) and overgrazing (45%), uncontrolled livestock movement (44%) and ban on the use of fire (9%), to be the triggering factors for bush encroachment in the area as perceived by the pastoralists. However, 17.8% of the respondents failed to give any kind of reason. According to the respondents, decrease in the production of the grass layer (84.4%), difficulty in herding (54.4%), wildlife attack (50%) were the major problem associated with abundance of trees and shrubs in the rangelands. *Acacia bussie* and *Commiphora* species were the major encroaching species in the rangelands as indicated by the pastoralists

Woody plant composition

A total of 45 woody species were identified in the grazing area, belonging to 23 families (Table 4). *Fabaceae* (21%), *Tiliaceae* (16%) and *Burseraceae* (14%) were families that contributed the largest proportion of woody plant. In both elevation zones, the highest number of species was recorded on communal land, followed by the enclosure and the benchmark sites. About 41 and 35 different woody plant species were identified in the upper and lower altitudinal zones. Based on the subjective opinion of pastoralists, among the identified woody species, highly desirable, intermediate and less desirable accounted for 22, 41 and 37%, respectively. *Acacia tortilis, A. bussie, C. collinum* and *C. erythraea* were common and/or dominant woody species in the communal grazing areas, whereas *A. bussei, A. mellifera, A. oerfota, A. senegal, A. tortilis* and *C. erythraea* in the enclosure grazing lands and *A. bussei, A. seyal, A. tortilis, C. collinum* and *G. penicillata* in the benchmark grazing area were common and/or dominant species (Table 4).

Height classes of woody plant

The plant height structure is presented in Table 5 and showed that in communal and enclosure grazing sites

Table 4. Woody plant composition and desirability in different elevation categories and grazing type of Rayitu rangelands based on frequency of occurrence expressed in terms of percentage.

			High			Low		
Botanical name	**Family**	**Des**	**Com**	**Enc**	**Ben**	**Com**	**Enc**	**Ben**
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	1.3	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
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	Fabaceae	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 = intermediate desirable; LD = less desirable; Com= communal grazing lands; Enc= enclosure grazing lands; Ben = benchmark grazing lands

Table 5. Height class distribution (plant/ha) of trees and shrubs in the study area

Grazing type	Height classes (meter)					
	0-0.5 m	> 0.5-2 m	> 2-5 m	>5 m	Lsd	N
District	129.86d	819.44b	1257.64a	322.92c	133.33	72
Communal	106.94d	781.94b	1368.06a	345.83c	188.34	36
Enclosure	179.17c	831.03b	1320.8a	337.5c	257.11	24
Benchmark	100.00b	908.30a	800.00a	225.0b	250.83	12
Altitude						
High land	154.44c	950.00b	1227.78a	236.67c	180.37	45
Low land	88.89c	601.85b	1307.41a	466.67b	191.19	27

Means with a different superscript letter in a raw are significantly different (P<0.05); M= meter;
Lsd= Least significant differences

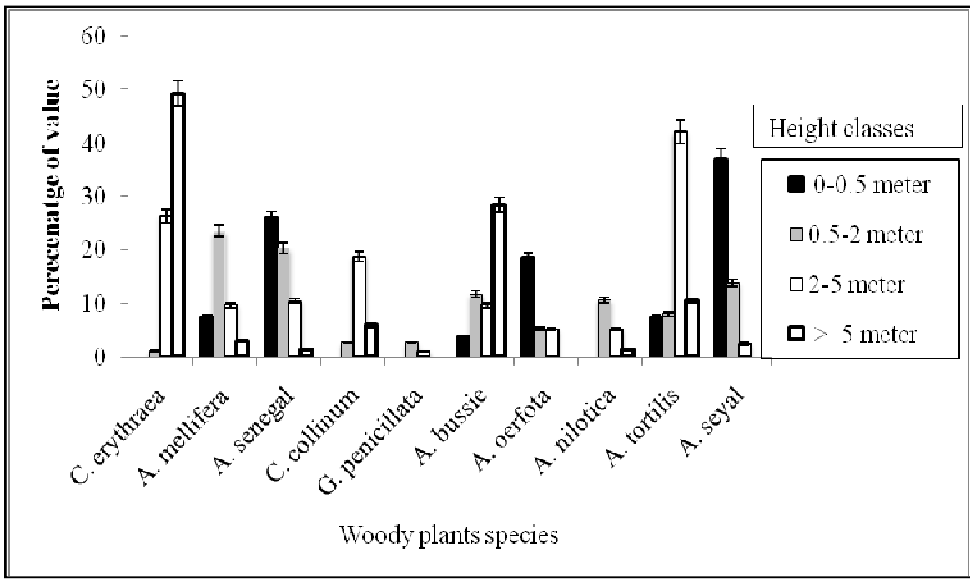

Figure 2. Height class distribution (%) of the dominant trees and shrubs in the rangelands

plants in the 2-5 m height class was the most abundant (p≤ 0.05), followed by the 0.5-2 m height stratum, while minimum plants were found in the 0-0.5 m category. In benchmark grazing sites large proportions (P≤ 0.05) of individual woody plants were found in height class interval of > 0.5-2 m and > 2-5 m while the lowest were found in 0.0-0.5 m and > 5m height stratum. Altitude significantly (p≤ 0.05) affected plant height distribution, in both altitudinal belts the plants density in the height class range of > 2-5 m was significantly highest (P≤ 0.05) followed by the 0.5-2 m height stratum, while minimum plants were found in the 0-0.5 m group. The largest proportions (87.23%) of woody vegetation in the rangelands were found in the height class less than 5 meter which at least theoretically can be considered within the browsing heights for different animal species (Table 5). The height of 1.5 m represents the mean browsing height for the goats, 2 m and 5 m represent the mean browse height for Kudu and giraffe, respectively (Tainion, 1999). A considerable number of the individual (949.30 plants/ha/) tree and shrub species in the grazing sites belonged to the lower height classes (i.e. < 2 m); only few individuals (322.92plants/ha) attained heights of > 5 meter. When pooling all height structure in the grazing sites, the plants in the 2-5 m height class was the most abundant (p≤ 0.05), followed by the 0.5-2 m height stratum, while minimum plants were found in the 0-0.5 m category. The distribution of the most common/dominant tree and shrub by height class is presented in Figure 2. *Acacia seyal* (37.04%) was the most abundant in < 0.5 m height class, followed by *A. senegal* (25.93%) and *A. oerfota* (18.52%) whereas *A. mellifera* (7.41%), *A. tortilis* (7.41%) and *A. bussie* (3.70%) were the lowest. While no plant of C. *erythraea, C. collinum, G. penicillata* and *A.*

Table 6. The effect of altitude and grazing type and its interaction on woody density, canopy cover and hedging effect (mean± SE) in the study area

Grazing types	Wd Plant/ha	Cc m	Hed	N
Communal	2654.2±109.66 [a]	38.72±2.51 [a]	1.92±0.77 [b]	36
Enclosure	2668.8 ±125.80 [a]	33.83 ±3.29[a]	2.83 ±0.19[a]	24
Benchmark	2041.7±98.06 [b]	26.41±3.08 [b]	2.83 ±0.17[a]	12
Lsd	347	9.39	0.46	
Altitude				
High land	2612.2±98 [a]	35.58±2.32 [a]	2.31 ±0.15[a]	45
Low land	2464.8 ±116[a]	34.15±2.90 [a]	2.48 ±0.14[a]	27
LSD	NS	NS	NS	
Interaction of Grazing types X Altitude	NS	Ns	*	

Means with a different superscript letter in a column are significantly different (p< 0.05); Wd= Woody density; Cc=Canopy cover; Hed = Hedging effect; m= meter; Lsd= Least significant differences; SE= Standard error; N=sample site

Table 7. Relationships between woody density and grazing type, botanical composition of grass, basal cover, soil erosion, total range condition, canopy cover, grass DM yield, forb DM yield, total DM biomass and percentage of bare ground cover in rangelands of study area

		Gt	Bcg	Bc	Se	Trsl	Cc	Gr	Fb	Bb	Br
Wd	com (r) N=36	0.01	-0.001	-0.27	0.03	-0.35*	0.38 *	-0.23	0.22	0.11	0.08
	Enc(r) N=24	0.01	-0.63*	-0.10	0.03	-0.24	0.78*	-0.04	0.29	0.12	0.11
	Ben (r) N=12	0.69	0.41	0.61*	0.08	0.05	0.29	0.76*	-0.14	0.75*	-0.48

r = Correlation coefficient; * = correlation is significant at the 0.05 level (2-tailed); Gt= grazing type; Com = communal grazing sites; Enc= enclosure grazing site; Ben = benchmark grazing sites; N= grazing site; Wd = woody density; Bcg = botanical composition of grass; Bc = basal cover; Se = soil erosion; Trs = total range condition score Cc = canopy cover; Gr= grass yield; Fb= Forb yield; Tb = total biomass yield ; Br = percentage of bare ground cover

nilotica were recorded in below 0.5 meter height class. For the height class > 0.5-2 m, *A. mellifera* (23.53%) and *A. senegal* (20.32%) were the maximum followed by *A. seyal* (13.90%), *A. bussie* (11.76%) and *A. nilotica* (10.70%) while C*. erythraea, C. collinum,* and *G. penicillata* were the lowest. Plants in the > 2-5 m class *A. tortilis (*42.11%) was the dominant followed by C. *erythraea* (26.39%) and *C. collinum* (18.75%) whereas, *A. seyal* (2.43%) and *G. penicillata* (1.04%) were the lowest. For the height class above 5 m, *C. erythraea* (49.25%) and *A. bussie* (28.36%) was the dominant followed by *A. tortilis* (10.45%). While no mature tree of *G. penicillata, A. oerfota* and *A. seyal* were recorded in the height classes above 5 m.

Woody plant density, canopy cover and browsing effect

There was no significant ($p \geq 0.05$) variation in woody density, hedging and canopy cover among altitude zone (Table 6). However, the density of woody plants and canopy cover was significantly ($p \leq 0.05$) affected by grazing types, i.e. a higher density of woody species was observed in communal grazing sites (2,654.2±211.77 plant/ha) and enclosure site (2668.8±142.73 plant/ha) than in the benchmark sites (2041.7±113.77 plant/ha). Hedging or browsing effect was significantly ($p \leq 0.05$) affected by the grazing type. Communal sites had higher hedging effect ($p \leq 0.05$) than enclosures and benchmark sites. Except, hedging effect, the other parameters were not significantly ($p \geq 0.05$) affected by interaction effect of elevation and grazing type (Table 6).

Relationship between woody plant density with range condition and biomass variables

The correlation result is presented in Table 7 and depicted that woody plant density was negatively ($p \leq 0.05$) correlated with total range condition score in communal grazing sites (r = -0.35, n=36). The relationship between woody density and botanical composition of grass in enclosure grazing sites was significant ($p \leq 0.05$) ($r = -0.63$, $n=24$). Similarly, negative relationships between woody density with botanical composition of grass, basal cover, total range condition score and grass yield was observed in communal and enclosure grazing sites (Table 7). 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 ($p \leq 0.05$) communal ($r = 0.38$; $n=36$) and enclosure grazing sites ($r = 0.78$; $n=24$). The relationship between density of woody plant and soil erosion was positive in communal and enclosure grazing sites. In benchmark grazing sites, 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 7).

DISCUSSION

Household demographic characteristics

The average family size in the study district (9.45) was higher than what was reported for Afar and Kereyu pastoralists of Ethiopia 6.74 by Abule et al. (2005) and 7.3 reported Admasu, (2006), but lower than that the 13 reported for the Borana pastoralists of south-east Ethiopia (Alemayehu, 1998). The higher family size might be associated with the cultural practice of polygamy by most pastoralists of the area. The low level of education observed in the survey is common to many pastoral areas of Ethiopia (Abule et al., 2005) and might impede efforts to achieve technology transfer to the local communities. Thus calls for introduction of pastoralists' lifestyle based education system. The development of agro-pastoralist similar to that in other pastoral areas in Ethiopia (Angassa and Oba, 2008), reflecting a change from the traditional pastoral lifestyle.

Use of woody plant and its status

The importance of woody plants to households in the study area was indicated by the broad range of uses to which they were put. While construction represented the most widespread use, the importance of trees and shrubs as forage sources for livestock was the second and this was in contrast with the report of Gemedo-Dalle et al., (2006), Solomon et al., (2006) indicated that woody plant utilization as forage was the primary. The high degree of dependence of the pastoralists on woody plants for forage reflects livestock is the main production system in the area. The use of plants for medicinal purpose was their major benefit for most indigenous rural people (Rossato et al., 1999), but this was their third-ranked role for Rayitu pastoralists. In general, herbal medicines are very important in Ethiopia because most imported orthodox medicines are expensive and unavailable for most communities. Pastoralists, in particular, depend heavily on these traditional herbal medicines because they live in remote areas where health centres are limited. In addition to their current uses, these plants may play potential role for the development of drugs in the future. Wild edible plants were 25.5% of the total identified species in this study. About 8 plants (66.67%) of the edible woody plants were similar with report of Gemedo-Dalle et al., (2005) and the remaining species were not included in their list (e.g. *B. neglecta* and *C. schimperi*). Grewia species were the most important contributing about 25% of edible plants.Some of the woody plants (e.g. *B. aegyptica*, *G. tembensis* and *R. natalensis)* were reported as edible wild plants elsewhere in Africa (Mueller et al., 2005). With the current trend of recurrent drought and poor animal productivity in pastoral areas of Ethiopia, wild edible plant may contribute to food security and may have potential as food crops in future. Since the population relies so heavily on woody species, it is not surprising that over-utilization can result in the loss of woody vegetation cover (Amaha, 2006) and alter the ecosystem. The causes for the reduction of abundance of woody plants in this study were similar to those reported by Diress et al., (1998) study made in arid and semiarid rangelands of North East Ethiopia. While improved livestock production must be achieved to sustain the pastoral production system in semi-arid ecosystems of the Rayitu rangelands. The sustainable use and conservation of woody plant resources need to be addressed by development programs, since pastoralists depend heavily on woody plants with their multiple uses. Hence, communities must be involved in the planning, design and implementation of development projects in integrated and participatory ways.

Woody plant composition, density and canopy cover

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 *S. incanum* and *L. rhodesiensis* and Z*. mucronata* 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 variation observed in woody plant composition in grazing type and altitude belt of study area agrees with the findings that altitude with its influence on temperature and precipitation primary influence on the vegetation composition of an area (Getachew et al., 2008). The variation in some of woody plant composition in grazing type can be attributed due 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 enclosure and benchmark grazing sites. It indicated earlier that pastoralists depend on woody plants; these over utilization practice results in alteration of woody composition. Furthermore, the high spatial distribution of woody plant in composition in the communal grazing land can be associated with ban on use of periodic fire and free movement of livestock. In the communal grazing sites when animals move from place to place in search of feed and water, livestock could serve as an agent for the dispersal of seeds of different plant species and this may promote the increase of woody plants composition.

The variation observed in woody plants height structure in the area could be many and difficult to justify explicitly from this study alone. In the study area, the tree and shrub species have used for different purpose (Table 3) such utilization together with human disturbance for instance vegetation deforestation for construction and expansion of cultivation land and bush management influence of pastoralists such as selective clearing of woody plant from benchmark grazing site could contribute for alteration of height structure of plants . Besides, some tree and shrub species in communal and enclosure grazing sites, once they were defoliated or pruned by livestock, could have poor regeneration capacity under the present conditions of the environment (i.e. drought, low and erratic precipitation) experienced in the study area. In some cases individuals of small tree and shrub species left in the communal and enclosure grazing land could be attributed to their morphologically inferior quality which may alter the height structure. On the other hand, the high percentage of highly and intermediate palatable woody plant species and the existing of large proportion of woody plants within browsing height of livestock were opportunities for the area from livestock production point of view. Thus, integrate more browsing (e.g. goat and camel) and grazing animals can help for efficient utilization of the exits feed resource and maintaining ecological balance like control of bush encroachment (Smit, 2002). The concept of rangeland multiple uses can be applied with proper resources planning and management. The grazing area is poor in herbaceous cover and therefore the browse resources plays a key role in livestock feed supply especially in the dry season and drought period. However, further studies in quantification of browse biomass production and browsing capacities potentials is required.

An increase in the woody plant density beyond a critical density limit normally refers as bush encroachment. A shrub cover of 40% and/or 2 400 woody plants/hectare has been considered as a borderline between non-encroached and encroached condition (Roquest et al., 2001) with 2 500 tree equivalents/hectare indicating highly encroached condition (Richter et al., 2001). According to Gemedo-Dalle et al., (2006), when the woody plant density exceeds 2 400 plants/hectare, the area is moving towards bush encroachment. Accordingly, it can be said that communal grazing sites and enclosure site are under bush encroachment while the benchmark grazing sites are not bush encroached. Smit (2002) suggests that the causal factors for bush encroachment are complex and have been a contentious issue in rangeland ecology. Pastoralists in the this study consider drought, overgrazing, livestock movement and absence of fire as major factors triggering woody encroachment, this is in agreement with reports by Abule et al., (2007b) for the Awash Rift Valley of Ethiopia, Herrmann and Hutchinson (2005) for the Sahelian belt of Africa, and Twine (2005) for South Africa. In semi-arid ecosystems, these issues are some of the major factors that cause conversion of grasslands to woodlands. 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 (Teshome, 2007). Based on frequency value, density and perception of pastoralists, *A. bussie, A. tortilis* and *C. erythraea* species are the major encroaching species in the grazing sites. The encroachment by species of *Acacia* has reported by many investigators in different part of Africa for example in Ethiopia (Gemedo-Dalle et al., 2006) in South Africa (Chanda et al., 2003). The control of bush encroachment will further require a proper understanding of invasive species, the degree of encroachment, the mechanisms leading to their increase and the population dynamics of the invasive species, which would be used to develop a long-term community-based control program.

Relationship between woody plant density with range condition and biomass parameters

A negative correlation between total woody plants and grass botanical composition, grass yield and total range condition rating observed in the communal and enclosure grazing lands was similar with report of Gemedo-Dalle et al., (2006) that woody plants in the Borana lowlands of Ethiopia are negatively correlated with grass composition and rangeland condition score. The positive relationship found between woody density and basal cover, grass yield and total biomass yield in benchmark grazing sites indicate that woody plants may not affect the botanical composition of grasses, grass yield and biomass production 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 the competition for available water, nutrients and a severe reduction in light reaching the grasses. This correlation analysis demonstrates the apparent influence of woody plants density on the botanical composition, basal cover of grass, soil parameters, total range condition rating, biomass production and bare ground cover. The speculation that woody plants density influence the productivity of rangeland ecosystem is therefore substantial and from this we can suggest that including woody layer parameters such as woody density in rangeland condition assessment in rangeland ecosystem composed of different vegetation components (i.e. herbaceous and woody vegetation) like study area is crucial.

CONCLUSION

Pastoralists in the study area acknowledge the vital role of trees and shrubs since they provide a range of products and services in their daily life. Therefore, it is essential to conserve and manage desirable tree and shrubs for sustainable and rational use of species. To this end, the indigenous knowledge of pastoralists about plant-livestock management and their environment should be incorporated in the planning and implementation of developmental interventions. The present findings conclude that both the household and the field vegetation studies confirme that the rangeland is encroached by bushes and shrubs. *Acacia bussie, A. tortilis* and *C. erythraea* species are the major encroaching species in the grazing sites. Most of the woody species had the highest abundance in the height class > 2–5 m regardless of grazing type and altitude belts .Therefore, carefully designed community based and participatory approaches are recommended to control bush encroachment. Furthermore, the bush control measure should start from key areas where mature tree populations have invaded and should not be indiscriminate but selective. The grazing area is poor in herbaceous cover, therefore, integrating more browsing animals (e.g. goat and camel) and grazing animals can play a key role for efficient utilization of the available resource and maintaining ecological balance like control of bush encroachment. Furthermore, including woody parameters like woody density in rangeland condition assessment is crucial.

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