ABUNDANCE AND DIVERSITY OF NATIVE FORAGE SPECIES IN PASTORAL KARAMOJA SUB-REGION, UGANDA

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ABSTRACT Low input pastoral production systems rely exclusively on natural forage resources in space and time. Information on the abundance and diversity of such pastures is vital in improving livestock production and managing the biodiversity of grazing landscapes. This study documented grass and browse forage species utilised in pastoral Karamoja, and determined their relative abundance by district, season and grazing land cover. Up to 65 grass and 110 browse species were utilised in Karamoja Sub-region. *In situ* assessments revealed that *Chloris*, *Hyparrhennia*, *Sporobolus*, *Pennisetum*, *Aristida*, *Cynodon*, *Eragrostis*, *Setaria*, and *Panicum* grasses had higher relative abundance. *Triumfetta annua*, *Indigofera erecta*, *Acacia drepanolobium*, *Grewia holstii*, *Acacia kirkii*, *Acacia mellifera*, *Acacia tortolis*, *Maerua pseudopetalosa*, *Acacia oerfota*, and *Ocimmum canum* woody species were the most abundant. From the community assessment, *Hyparrhennia*, *Chloris, Panicum*, *Bracharia*, *Eragrostis*, and *Setaria* grasses and *Acacia mellifera*, *Cadaba farinose*, *Acacia oerfota*, *Acacia drepanolobium*, *Caparis tormentosa*, *Maerua pseudopetalosa* and *Hisbiscus micrantha* woody plants were identified as the most abundant among the grazing land cover. The grass and browse forage species varied by season, location, and land cover type. The study also found detailed local knowledge of grass and browse forage species in the community. This study has shown the existence of high diversity among grass and browse forage species with differentiated relative abundance across space and time. This, and the detailed communal cultural knowledge, form a basis for the improvement of livestock production as well as biodiversity conservation in Karamoja sub-region.

Key Words: Forage; Abundance; Species richness; Grasslands; Karamoja.

INTRODUCTION

Finely honed symbiotic relationships between local ecology, domesticated livestock, and people in resource-scarce and highly variable regions, often at the threshold of human survival, best describe pastoral livestock production (Nori et al., 2005). In Africa, it is a major land use practice in 66% of the land area, providing a range of benefits. Pastoral livestock production accounts for 10% of the global meat supply, supports 200 million pastoral households, and a large proportion of camels, cattle and small stock (FAO, 2001). Additionally, it provides a range of environmental benefits (Inter-Réseaux Développement Rural et de SOS Faim, 2012). In Uganda, livestock rearing is an important undertaking in the cattle corridor, a strip of land running from southwest to northeast of the country, that occupies 40% of the country's land area. Livestock contributes up to 14.4% of the agricultural Gross Domestic Product (FAO, 2005) and a 22.5% share of the GDP (MAAIF, 2011: 3). Livestock is at the heart of income generation in the pastoral communities of the cattle corridor. In Karamoja. it defines the socio-cultural facets, and is the main financial capital that defines wealth, status, and resilience to climate variability shocks (Grade et al., 2009; Stites & Akabwai, 2009).

In pastoral livestock production systems such as in Karamoja, livestock rely exclusively on natural pastures (Tolera et al., 2000; Bhasin, 2011) that are grazed in space and time by diverse livestock species (Beyene et al., 2013: 3, 25) and often in large herds (Pica-Ciamarra et al., 2011). Thus, the rangeland landscapes in these regions are the lifelines of livestock rearing that provide a spectra of forage, both herbage and browse (Tesfay & Tafere, 2004; Oba, 2012). Range utilisation by pastoralists is often open grazing, where the livestock is grazed on communal rangelands, and the communal resource base, range, water, and land, are shared resource properties (Abusuwar & Ahmed, 2010). This is aimed at adapting to large variations in forage production over wide areas, both within years and between years. It is also aimed at taking advantage of seasonal nutritive quality that is a vital facet in animal production, particularly in ensuring milk quality and length of lactation (Senock & Pieper, 1990). The quantity and quality of forage in arid and semi-arid areas fluctuate seasonally, with poor quality forage dominating the dry season (Tolera et al., 2000). This leads to the occurrence of poor livestock nutrition with a chain of negative consequences including low production and reproductive performance, slow growth rate, poor body condition and increased susceptibility to diseases and parasites (Tolera et al., 2000).

According to Bhasin (2011), high grazing pressure constrains the ability of palatable grasses and legumes to develop seeds as well as disperse seeds. Consequently, the undesirable, ungrazed plant species obtain ample opportunities to thrive and set seed. The unchecked growth of weeds leads to their dominance in most of the pastures. In the event of a perturbation such as a drought, fodder trees and shrubs are important in providing forage for herd reconstitution (Kowsar, 2008; Barrow, 1990; Barrow & Mlenge, 2003; Huho et al., 2011). Further, cattle foraging behavior has been observed to shift during dry seasons. For example, scraping tree barks, licking pods, and eating tree leaf litter are livestock response mechanisms in the event of a drought. Therefore, in herbage limiting conditions, browse may buffer imminent nutritional stress (Mnene et al., 1996). Moreover, the availability and/or absence of browse can determine the stock forms adopted by livestock keepers. Conner et al. (1993) observed that where browse makes up a large component of the forage base, it is possible to stock more goats than cattle because goats are more efficient in utilising browse than cattle. On the other hand, where the forage base is diverse, a combination of two or more types of grazing animals can utilise the forage more efficiently than a single species. The latter knowledge has been mastered and relied on by the pastoral communities to maximize productivity in heterogeneous landscapes.

Understanding the dynamics and availability of native grasses and browse forage, their diversity, composition, and abundance is vital in maintaining sustainable livestock production in pastoral systems. Further, identification of forage species composition helps to identify livestock grazing patterns, because, in the event of heavier grazing by livestock, increasers (less palatable plants) and invader plants tend to be promoted while decreasers (palatable plants) are limited (Rollins et al., 1993: 63). Heitschmidt et al. (1995) pointed out that species composition was a primary determinant of the ecological condition of rangelands, and the kinds, size, and density of plants at a location influenced the quantity and quality of forage. For the semi-arid regions, where pastoralism is an important undertaking, additional information on forage resources derived from local ecological knowledge is vital (McAllister et al., 2006). Pastoral communities are known to have extensive bodies of local ecological knowledge on forage resources (Linstadter et al., 2013), including their environmental growth conditions, palatability, phenology, and availability (Thomas & Twyman, 2004).

Minimal vegetation and forage assessments have been conducted in Karamoja. The first well- documented vegetation survey was conducted by Wayland (1931) and subsequently by Thomas (1943) and Langdale-Brown (1959). No other major documentations were conducted until the 1995 National Biomass Survey that broadly classified vegetation landscapes in Uganda. Aleper et al. (2008) documented a few plant species, such as Acacia siberiana, of interest to elephants, while Nalule (2010) identified a few grasses of interest for cattle in general. Focusing on plants of ethnopharmacological relevance in Karamoja, Grade et al. (2009) has conducted the most extensive documentation of plants in the subregion. However, like others she did not provide a detailed account of their dynamics, but concentrated on the random identification of those with medicinal value. Therefore, the authors of this study identified forage (both grass and woody) species and documented their relative abundance and diversity by location, land cover type, and season in Karamoja Sub-region.

MATERIALS AND METHODS

Study Area

Karamoja lies in northeastern Uganda (Fig. 1) and is generally a land of plains rising from east to west punctuated by imposing mountains of Mt. Moroto, Mt. Zulia, Mt. Kadam, Mt. Iriiri and Mt. Labwor. A series of other erosional outcrop rocks occur, such as Kogwele, Kanamerinjor, Katipus, Morutit, Toror, Kapernakori in Kotido District; Koromwae, Turusuk, Nyanga, Theno, Arakas, Kolung, and Nakithilet in the Kotido-Kaabong axis. Karamoja borders Kenya on the east where Pokot and Turkana pastoral groups exist. On the other hand, the pastoral Toposa border Karamoja to the north in the Republic of South Sudan. To the west are the Districts of Kitgum, Pader, Lira, Amuria, Katakwi, and Kumi and Sironko, and Kapchorwa borders Karamoja in the south (Fig. 1). The area is generally semi-arid, with unpredictable rainfall ranging between 400–1,000 mm per year, although around the isolated highland areas, rainfall may exceed 1,000 mm per year (Anderson & Robinson, 2009; Mubiru, 2010). Karamoja's rainfall is lowest in the east extending the pastoral zone into the much drier conditions found in Moroto District, moderate in the central zone running north to south, leading to the prevalence of the agropastoral gradient covering Kotido District, and relatively higher in the west of the sub-region leading to the agricultural gradients. The gradients cover Napak and Abim Districts (Levine, 2010). Temperatures and evapotranspiration are high all year round and this leads to inadequacy of surface water (Avery, 2014: 30). The region has high interannual and intra-annual variability in rainfall (Fig. 2) with intermittent occurrence of drought (Mubiru, 2010: ix; Egeru et al., 2014a, 2014b). According to Anderson and Robinson (2009), average annual rainfall has decreased by about 15%, but the deficit is further

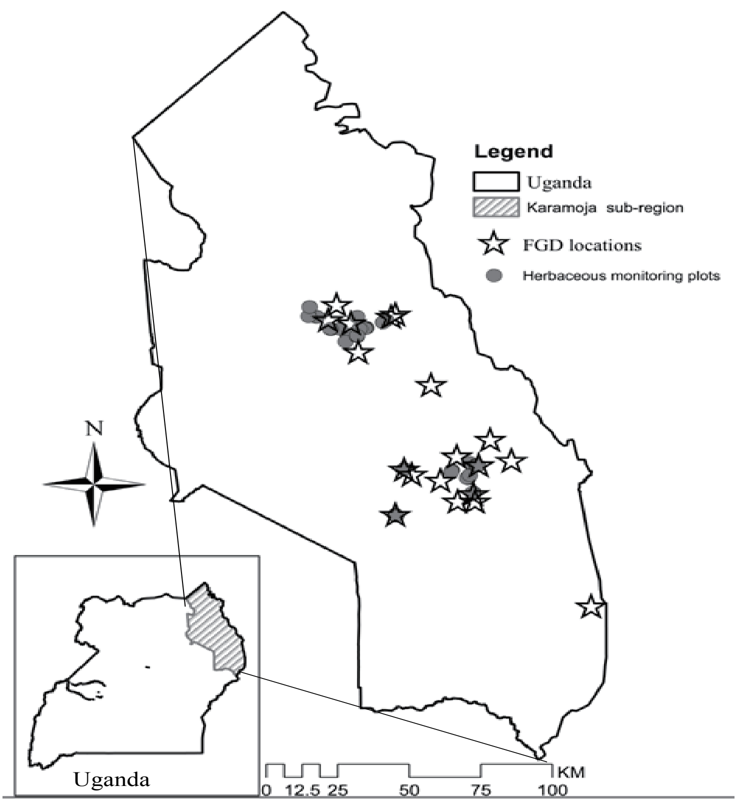

Fig. 1. Location of Karamoja Sub-region, Herbaceous monitoring sites and focus group discussions (FGD)

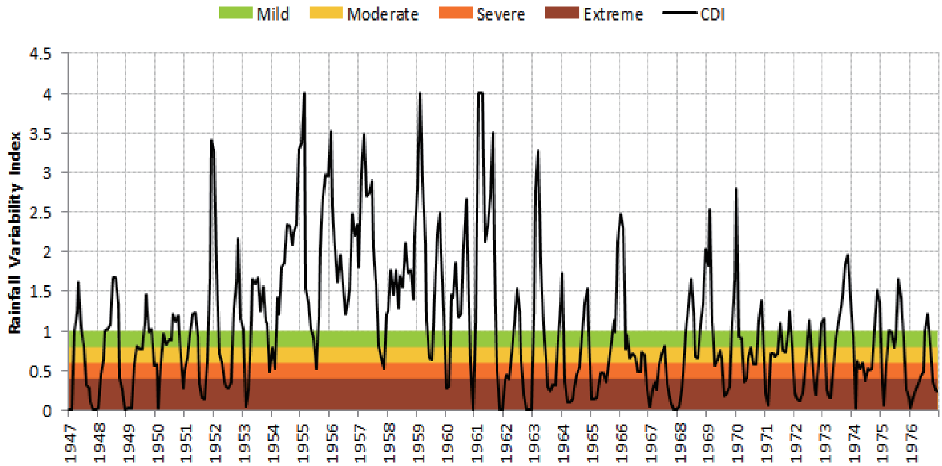

Fig. 2. Rainfall variability index for Namalu Station, Karamoja (1947–1976)
CDI: combined drought index

compounded by the way in which the rainfall arrives. The intensity and the duration between rainfall events has varied considerably. No longer can periods of reliable rainfall be assumed in one year out of three (Mubiru, 2010). This variability was similarly observed during the period of this study (2013) when there was a sudden cessation of rains before reaching its usual early peak period in the May–June period. Vegetation characterization conducted by Wayland (1931) and Langdale-Brown (1959) placed the sub-region into the dry season *Acacia-Combretum-Terminalia* vegetation type. The 2008 Livestock Census estimated the total number of cattle at 2.3 million (19.8% of the national herd) as well as a considerable population of goats, sheep and camels (UBOS, 2009: vi).

Field Documentation of Abundance and Diversity

Relative abundance and diversity of grass and browse (shrubs, herbs and forbs) were documented by way of an onsite field survey in 2013. Land cover (woodlands, grasslands, thickets and shrublands, Figs. 3 & 4) for the onsite survey were identified with the help of elders, herders, youths, and scouts. Monitoring plots were subsequently established in the identified land cover. However, in Napak District, we were unable to access woodlands identified in Apeitolim in Lokopo subcounty because the road had been cut-off during the 2012 wet season. Meanwhile, we were unable to establish monitoring sites for thickets and shrublands in Napak District, because those that were identified in Ngolerit were heavily grazed or affected by crop cultivation and did not meet the established criteria. Where monitoring sites were established, plots of 50 × 40 m^2 with four replications were randomly established in each of the identified areas. In all 50 × 40 m^2 plots, nested plots were diagonally established from where the assessment was conducted. Five nested plots of 5 × 5 m^2 were diagonally set up in the wood-

Fig. 3. Open grassland at Nakicumet Napak District

Fig. 4. Shrubs mixed with grasses in Lomejan Village in Kotido District

lands, ten plots of 5×5 m^2 in the thicket and shrublands, and twenty plots of 1×1 m^2 in the grasslands. Onsite identification of available grass and browse species was conducted in each of the plots. Grass and browse species that could not be readily identified were safely stored in a plant press and taken to Makerere University herbarium for further identification.

All plots were remotely mapped using a Garmin eTrex 10 high sensitivity Global Positionning System (GPS) device. The device is WAAS-enabled with a HotFix and GLONASS support, worldwide basemap and supports paperless geocaching. Utilising a GPS for plot marking was deemed necessary in order to avoid raising suspicion owing to the heightened tension on perceived land grabbing incidents in the sub-region, and secondly to allow grazing to continue without any form of bias from the herders and thirdly, maintain georeferenceable locations for the subsequent assessment exercises. The assessment was conducted in three phases in 2013: the first phase (January and February) concided with the traditional early regeneration and dry season, the second phase (June and July) coincided with the maturing and flowering stages of grasses in the wet season and is also the wet season, and the third phase (October and November) coincided with the standing dry hay (also representing the transitionary season, a period between the wet and the long dry season). The results of the third season have not been presented in this paper to allow for ease of comparison between dry and wet seasons.

Forage Abundance as Perceived by the Community

Perceived abundance and richness-diversity of grass and browse forage species were documented with an ethnobotanical approach using focus group discussions (FGDs). Fifteen FGDs were conducted with elders, youths, scouts and herders. All participants were male adults between 19–75 years. In Kotido District, FGDs were held in Regen, Lobel, Nakapelimoru, Kayelein and Panyangara. In Moroto District, they were conducted in parts of Kobebe, Rupa, Nadunget, Mogose and Katikekile. In Napak District, they were conducted in Lopei, Nakicumet, Lotome, Lokopo and Kangole, some of which are reflected in Figure 1 above. Participants were asked to identify grass and browse forage species available among their grazing land cover using local names. They were then tasked to identify those availabile during the dry season and/or the wet season. Each participant was then provided with 10 small stones (each stone representing 10%) and was asked to proportionately pile stones to a particular forage species based on its perceived abundance during wet and dry seasons relative to other species among the grazing land cover. Further, participants were asked to provide a brief description of location characteristics of the identified species. Then, after the FGD assessment process, a select team of participants (identified by the FGD participants as more knowledgeable) worked with a botanist to match the identified grass and browse forage species with botanical names. The grass and browe forage plants that could not readily be identified were taken to Makerere University herbarium for identification. However, some grass and browse species identified by the community could not readily be obtained for identification as they were remotely located. It is these species that are missing the botanical names and in quotation marks below and in Tables 14 and 15.

DATA ANALYSIS

Data was descriptively analysed for relative abundance and species richness-diversity. Shannon's index of diversity was used to measure diversity. Analysis was conducted in the palaeontological analysis software (PAST) of Hammer et al. (2005).
Shannon's index is computed using the following equation

$$H = -\sum_{j=1}^{S} p_i \ln p_i$$

H: Shannon's diversity index
S: total number of species in the community (richness)
p_i: proportion of S made up of the ith species

RESULTS

Relative Abundance of Grass and Browse Species in Grasslands

In situ surveys revealed a total of 33 grass species in the grasslands during the wet season (Table 1). Overall, *Hyparrhennia rufa* (13.9%), *Sporobolous stapfianus* (12.2%), *Chloris pychnothrix* (9.8%) and *Pennisetum unisetum* (9.4%) had the highest abundance during the wet season. *Pennisetum unisetum* (26.3%), *Sporobolus sphacealata* (18.4%), *Aristida adscensiones* (15.1%) and *Hyparrhenia rufa* (13.2%) were the most observed grass species in Kotido District during the wet season (Table 1). In Moroto District, *Sporobolus stapfianus* (24.7%), *Chloris lamproparia* (22.7%), *Chloris pychnothrix* (17.3%) and *Aristida adscensiones*

Table 1. Relative abundance of grass species in grasslands during the wet season

Karamoja Sub-regional	%	Napak District	%	Moroto District	%	Kotido District	%
Hyparrhenia rufa	13.9	*H. rufa*	23.9	*S. stapfianus*	24.7	*P. unisetum*	26.3
Sporobolus stapfianus	12.2	*S. sphacealata*	18.1	*C. lamproparia*	22.7	*S. sphacealata*	18.4
Chloris pychnothrix	9.8	*C. pychnothrix*	10.2	*C. pychnothrix*	17.3	*A. adscensiones*	15.1
Pennisetum unisetum	9.4	*P. patens*	8.8	*A. adscensiones*	12.0	*H. rufa*	13.2
Aristida adscensiones	8.5	*S. stapfianus*	6.2	*C. dactylon*	5.3	*S. stapfianus*	8.6
Setaria sphacealata	8.1	*S. primidalis*	6.2	*B. jubata*	4.0	*H. filpendula*	3.3
Chloris lamproparia	6.4	*C. dactylon*	4.4	*C. nlemfuensis*	4.0	*H. diplandra*	3.3
Sporobolus sphacealata	5.3	*C. nlemfuensis*	4.4	*P. unisetum*	2.7	*M. repens*	3.3
Perotis pateus	3.8	*B. polystachion*	4.0	*S. sphacealata*	1.3	*S. festivus*	2.6
Cynodon dactylon	3.6	*Pennisetum unisetum*	2.7	*S. primidalis*	1.3	*C. pychnothrix*	2.0
Sporobolus primidalis	3.4	*Pennisetum* spp.	2.2	*S. prunilla*	0.7	*B. scalaris*	1.3
Cynodon nlemfuensis	3.0	*L. simplex*	2.2	*S. kagerensis*	0.7	*S. primidalis*	1.3
Bacharia polystachion	1.7	*A. adscensiones*	1.3	*D. nlemfuensis*	0.7	*C. dactylon*	0.7
Bracharia jubata	1.3	*B. platynota*	1.3	*D. aegyptium*	0.7	*P. maximum*	0.7
Hyparrhenia filpendula	1.3	*H. filpendula*	0.9	*S. pellucidus*	0.7		
Mellinus repens	1.1	*E. haploclada*	0.9	*P. scrobiculatum*	0.7		
Pennisetum spp.	0.9	*S. kagerensis*	0.4	*D. nuda*	0.7		
Hyparrhenia diplandra	0.9	*P. maximum*	0.4				
Loudeta simplex	0.9	*Crotalaria* spp.	0.4				
Sporobolus festivus	0.8	*B. jubata*	0.4				
Bracharia platynota	0.6	*P. scrobiculatum*	0.4				
Setaria kagerensis	0.4						
Bracharia scalaris	0.4						
Paspalum scrobiculatum	0.4						
Eichnocloa haploclada	0.4						
Setaria prunilla	0.2						
Panicum maximum	0.2						
Crotalaria spp.	0.2						
Dactylon nlemfuensis	0.2						
Dactylon aegyptium	0.2						
Sprobolus pellucidus	0.2						
Digitaria nuda	0.2						
Panicum maximum	0.2						

(12%) were the most observed species. On the other hand, *Hyparrhenia rufa* (23.9%), *Setaria sphacealata* (18.1%), *Chloris pychnothrix* (10.2%) and *Perotis pateus* (8.8%) registered higher abundance in Napak District during the wet season (Table 1).

During the dry season, the number of observed grass species in the grasslands dropped to 17 in total. This represented a 48.5% decline. At the same time, there was a shift in relative abundance of grass species, for example, *Aristida adscensiones* (21.8%), *Hyparrhenia diplandra* (16.1%), *Pennisetum* sp. (15.3%) and *Chrloris pychnothrix* 13.2% (Table 2). Further, there was variation within the district sites with only twelve species observed in Kotido District, including *Hyparrhennia diplandra* (35.6%), *Pennisetum* sp. (33.9%), and *Hyparrhenia rufa* (16.1%) that increased in abundance. Grasses such as *Sporobolus sphacealata*, *Aritisda adscensiones*, *Mellinus repens*, *Sprobolus festivus* and *Bracharia scalaris* that had previously been cited during the wet season could not be observed during the dry season in the monitoring sites of Kotido District.

In Moroto district, there was a 58.8% decline in the number of species observed with *Aritisda adscensiones* (46.2%), *Cynodon nlemfuensis* (24.2%), and *Chloris pychnothrix* (22.0%) recording high abundance during the dry season. Grasses, such as *Chloris lampropria*, *Bracharia jubata*, *Pennisetum unisetum*, *Setaria sphacealata*, *Sporobolus primidalis*, *Setaria prunilla*, *Setaria kagerensis*, *Dactylon aegyptum*, *Sprobolus pellucidus* and *Digitaria nuda* previously observed in the

Table 2. Relative abundance of grass species in grasslands during the dry season.

Sub-region	%	Kotido District	%	Napak District	%	Moroto District	%
A. adescensiones	21.8	*H. diplandra*	35.6	*A.adescensiones*	25.9	*A. adescensiones*	46.2
H. diplandra	16.1	*Pennisetum* spp.	33.9	*H. rufa*	24.7	*C. nlemfuensis*	24.2
Pennisetum spp.	15.3	*H. rufa*	16.1	*T. berteronianus*	18.5	*C. pychnothrix*	22.0
C. pychnothrix	13.2	*C. pychnothrix*	4.6	*C. pychnothrix*	14.2	*S. stapfianus*	4.4
Tragus berteronianus	7.8	*M. repens*	2.9	*P. pateus*	8.0	*E. tenuifolia*	1.1
H. rufa	7.3	*B. scalaris*	2.3	*S. stapfianus*	3.1	*C. dactylon*	1.1
C. nlemfuensis	5.7	*C. dactylon*	1.1	*C. dactylon*	3.1	*Cyperus* spp.	1.1
P. pateus	3.4	*S. stapfianus*	1.1	*H. filipendula*	1.9		
S. stapfianus	2.9	*H. filipendula*	0.6	*S. sphaecelata*	0.6		
C. dactylon	1.6	*S. festivus*	0.6				
M. repens	1.3	*E. tenuifolia*	0.6				
H. filipendula	1.0	*S. sphaecelata*	0.6				
B. scalaris	1.0						
Eragrostis tenuifolia	0.5						
S. sphaecelata	0.5						
S. festivus	0.3						
Cyperus spp.	0.3						

Table 3. Relative abundance of browse in the grasslands during the wet season

Sub-region	%	Moroto District	%	Napak District	%	Kotido District	%
Triumfetta anua	16.4	*I. erecta*	18.9	*T. anua*	26.5	*T. anua*	13.2
Indigofera erecta	15.1	*T. anua*	13.7	*I. erecta*	22.6	*O. canum*	12.9
Asparagus flagellasis	9.6	*A. flagellasis*	12.0	*I. kituensis*	7.7	*V. membranacea*	12.1
Ocimum canum	7.3	*C. farinosa*	8.0	*D. tortuosum*	7.1	*A. flagellasis*	11.2
Solanum incanum	6.4	*G. holstii*	6.3	*C. farinosa*	7.1	*I. erecta*	9.7
Vigna membranacea	6.3	*M. pseudopetalosa*	5.7	*A. hirtum*	5.2	*C. serpens*	9.1
Cyphosteua Serpens	4.6	*S. incanum*	5.1	*S. incanum*	4.5	*S. incanum*	7.6
Aspillia mossanubicensis	4.0	*A. hirtum*	4.6	*Acacia brevispica*	3.9	*A. mossanubicensis*	6.5
Maerua pseudopetalosa	3.9	*G. villosa*	2.9	*A. mossanubicensis*	3.2	*L. nepetifolia*	5.9
Cadaba farinosa	3.7	*S. edulis*	2.9	*I. dichroa*	2.6	*A. subpetiolalum*	5.9
Leonotis nepetifolia	3.3	*O. canum*	2.9	*A. flagellasis*	2.6	*M. pseudopetalosa*	3.8
Anthericum subpetiolalum	3.1	*A. gigantea*	1.7	*M. pseudopetalosa*	1.9	*D. tortuosum*	0.9
Abutilon hirtum	2.4	*C. arachnoidea*	1.7	*C. tormentosa*	1.3	*C. tormentosa*	0.6
Desmodium tortuosum	2.1	*C. diffusa*	1.7	*L. capensis*	0.6	*T. minuta*	0.3
Ipomea kituensis	1.9	*S. cuneifolia*	1.7	*G. holstii*	0.6	*B. spikeata*	0.3
Grewia holstii	1.8	*V. campea*	1.7	*A. gigantea*	0.6		
Acacia brevispica	0.9	*C. tormentosa*	1.1	*C. arachnoidea*	0.6		
Gweria villosa	0.7	*L. martiniensis*	1.1	*V. membranacea*	0.6		
Scilla edulis	0.7	*T. minuta*	1.1	*A. subpetiolalum*	0.6		
Ipomea dichroa	0.6	*L. nepetifolia*	1.1				
Asystasia gigantea	0.6	*U. lobata*	1.1				
Caparis tormentosa	0.6	*I. kituensis*	0.6				
Cyanotis arachnoidea	0.6	*D. burgessiae*	0.6				
Sida cuneifolia	0.4	*T. asiatica*	0.6				
Vernonia campea	0.4	*C. pubecens*	0.6				
Tagetes minuta	0.4	*A. rwenzorinsis*	0.6				
Leucas martiniensis	0.3						
Urena lobata	0.3						
Caparis tormentosa	0.3						
Lactua capensis	0.1						
Dombeya burgessiae	0.1						
Todalia asiatica	0.1						
Centrosema pubecens	0.1						
Aloe rwenzorinsis	0.1						
Borkea spikeata	0.1						

Table 4. Relative abundance of browse in the grasslands during the dry season

Sub-region	%	Moroto District	%	Napak District	%	Kotido District	%
T. anua	27.0	*Desmondium* spp.	23.5	*T. annua*	23.2	*T. anua*	36.3
Desmondium spp.	22.6	*T. anua*	16.2	*Indigofera* spp.	18.8	*Desmondium* spp.	22.6
G. holstii	7.7	*G. holstii*	15.4	*Desmondium* spp.	15.9	*Indigofera* spp.	11.0
M. pseudopetalosa	6.2	*Urena* spp.	8.1	*C. farinosa*	11.6	*M. pseudopetalosa*	10.3
Indigofera spp.	5.3	*A. oerfota*	6.6	*M. pseudopetalosa*	7.2	*A. gigantia*	4.8
S. incanum	3.3	*Clotalaria* spp.	5.1	*G. holstii*	7.2	*A. flagellaris*	4.1
A. flagellaris	3.3	*A. flagellaris*	3.7	*S. incanum*	2.9	*Aspilia* spp.	4.1
Urena spp.	3.3	*S. incanum*	2.9	*Vernonia*	2.9	*S. incanum*	3.4
Acacia oerfota	2.7	*Vernonia* spp.	2.9	*Acacia* spp.	2.9	*C. tormentosa*	1.4
C. farinosa	2.4	*O. canum*	2.9	*Sida* spp.	2.9	*S. rigrum*	0.7
A. gigantia	2.1	*Sida* spp.	2.2	*O. canum*	1.4	*E. candlebrum*	0.7
Clotalaria spp.	2.1	*Aloe* spp.	2.2	*Aloe* spp.	1.4	*L. martinicensis*	0.7
Aspilia spp.	1.8	*Indigofera* spp.	1.5	*A. oerfota*	1.4		
Vernonia campanea	1.8	*M. pseudopetalosa*	0.7				
Sida spp.	1.5	*C. tormentosa*	0.7				
O. canum	1.5	*L. martinicensis*	0.7				
Aloe spp.	1.2	*L. nepetifolia*	0.7				
C. tormentosa	0.9	*Ipomea* spp.	0.7				
Acacia spp.	0.9	*Acacia* spp.	0.7				
L. martinicensis	0.6	*F. abysinica*	0.7				
Solanum rigrum	0.3	*Senecio* spp.	0.7				
Euphorba candlebrum	0.3	*M. tagettes*	0.7				
L. nepetifolia	0.3						
Ipomea spp.	0.3						
Festuca abysinica	0.3						
Senecio spp.	0.3						
M. tagettes	0.3						

wet season were not observed in the same monitoring sites in the dry season. Of the 21 grass species observed in the wet season in Napak, only 9 grass species were observed in the dry season (Table 2). representing a 57.1% decline. *Aritisda adscensiones* (25.9%), *Hyparrhenia rufa* (24.7%), *Tragus berteronianus* (18.5%), and *Chrloris pychnothrix* (14.2%) were highly abundant during the dry season in Napak district. Grass species, such as *Bracharia platynota*, *Hyparrhenia* *filipendula*, *Eichnocloa haploclada*, *Loudeta simplex*, *Panicum maximum*, *Crotalaria* sp., *Paspalum scrobiculatum*, *Cynodon nlemfuensis*, *Bracaharia polystachion* and *Sporobolus primidalis* previously observed in the wet season were not observed in the dry season.

A considerable number of woody plant species were observed in the grasslands of Karamoja during both wet and dry seasons. Table 3 gives the list of observed woody browse plants in the sub-region and in the respective districts of Kotido, Moroto and Napak during the wet season. A range of other woody trees, such as *Acacia drepanolobium* (26.2%), *Lanea humilis* (21.5%), *Balanite aegyptica* (18.5%), *Acacia kirkii* (15.3%), *Acicia nilotica* (7.6%), *Acacia oreberiana* (3.1%), *Acacia xanthopholea* (1.5%) and *Commphora Africana* (1.5%), were observed with variable levels of abundance in the grasslands during the wet season. Generally, *Acacia drepanolobium*, *Acacia kirkii* and *Acacia nilotica* were the woody species with high abundance in the grasslands of Karamoja during the wet and dry seasons.

During the dry season, *Triumfetta anua* (27.0%) and *Indigoferra erecta* (5.3%) had high abundance. An increased presence of *Desmodium* sp. (22.6%), *Grewia holstii* (7.7%), and *Maerua pseudopetalosa* (6.2%) was observed during the dry season in the sub-region (Tables 3 & 4). Further, forbs, such as *Asaparagus flagellasis* and *Ocimum canum*, considerably declined in relative abundance during the dry season (Table 4). Some of the woody plants, such as *Urena* sp., *Sida* sp., *Vernonia*, *Cadaba farinosa*, *Leonotis nepetifolia*, and *Festuca abyssinica*, that were previously observed during the wet season could not be observed during the dry season in Kotido District. Variations were similarly observed in Moroto and Napak Districts (Table 4).

Relative Abundance of Grasses and Browse Species in Woodlands

In the woodlands, a total of 26 grass species were recorded during the wet season (Table 5). *Panicum maximum* (14.7%), *Cynodon dactylon* (14.7%), *Microloa hunthii* (9.2%), *Hyparrhenia rufa* (7.3%) and *Sporobolus pyrimidalis* (6.4%) were highly abundant at sub-regional level in the woodlands during the wet season (Table 5). *Panicum maximum* (18.5%), *Microcloa hunthii* (15.4%), *Hyparrhenia rufa* (12.3%) and *Sporobolus pyrimidalis* (10.8%) had higher abundance in Moroto District. On the other hand, *Cynodon dactylon* (27.3%), *Echincloa* sp. (11.4%), *Panicum maximum* (9.1%) and *Chloris pychnothrix* (9.1%) recorded high abundance in Kotido District.

Results from the dry season showed that 18 grass species were observed. This was 30.7% fewer than that observed during the wet season (Table 6). Further, results showed that *Hyparrhenia filipendula* (14.1%), *Setaria* sp. (13.0%), *Cynodon dactylon* (13.0%), *Chloris pychnothrix* (13.0%) and *Hyparrhenia rufa* (9.8%) had higher relative abundance in the woodlands in the sub-region. As seen in the wet season, variation in abundance of grass species existed in the dry season. *Setaria* sp. (22.6%), *Hyparrhenia rufa* (17%), *Hyparrhenia filipendula* (11.3%) and *Chloris pychnothrix* (9.4%) were the most abundant grasses in Moroto District. On the other hand, *Cynodon dactylon* (27.3%), *Echnocloa* sp. (20.5%),

Table 5. Relative abundance of grass species in the woodlands during the wet season

Sub-region	%	Moroto District	%	Kotido District	%
P. maximum	14.7	*P. maximum*	18.5	*C. dactylon*	27.3
C. dactylon	14.7	*M. hunthii*	15.4	*E. pyrimidalis*	11.4
Microcloa hunthii	9.2	*H. rufa*	12.3	*P. maximum*	9.1
H. rufa	7.3	*S. pyrimidalis*	10.8	*C. pychnothrix*	9.1
S. pyrimidalis	6.4	*C. dactylon*	6.2	*S. stapfianus*	6.8
E. cillaris	4.6	*E. racemosa*	6.2	*E. cillaris*	6.8
E. pyrimidalis	4.6	*H. newtonii*	6.2	*A. adscensiones*	6.8
C. pychnothrix	3.7	*S. kagerensis*	4.6	*S. pilferus*	4.5
A. adscensiones	3.7	*P. unisetum*	4.6	*E. haplocada*	4.5
Eragrostis racemosa	3.7	*E. cillaris*	3.1	*S. festivus*	2.3
Hyparrhenia newtonii	3.7	*C. nardus*	3.1	*B. jubata*	2.3
S. stapfianus	2.8	*S. festivus*	1.5	*H. schimperi*	2.3
Echnocloa haplocada	2.8	*E. haplocada*	1.5	*E. temufolia*	2.3
Setaria kagerensis	2.8	*A. adscensiones*	1.5	*H. conlortus*	2.3
Pennisetum unisetum	2.8	*S. punulla*	1.5	*P. annua*	2.3
S. festivus	1.8	*Pennisetum* spp.	1.5		
Sporobolus pilferus	1.8	*M. repens*	1.5		
Cymbopogon nardus	1.8				
B. jubata	0.9				
Harpachwe schimperi	0.9				
Setaria punulla	0.9				
E. tenufolia	0.9				
Pennisetum spp.	0.9				
Heteropogon conlortus	0.9				
Poa annua	0.9				
M. repens	0.9				

Chloris pychnothrix (15.9%), *Sporobolus stapfianus* (6.8%) and *Aristides* sp. (6.8%) had higher relative abundance in Kotido District woodlands (Table 6).

In terms of woody plant species in the woodlands, a total of 47 species were observed during the wet season (Table 7). At the sub-regional level, *Grewia holstii* (9%), *Acalypha bipartita* (6.7%), *Grewia vilosa* (6%) and *Fluegea virosa* (6%) had higher relative abundance in the woodlands during the wet season (Table 7). However, in Kotido District, *Flueggea virosa* (10.4%), *Aloe rwenzorensis* (9%), *Triumfetta anua* (7.5%), *Abutilon hirtum* (7.5%) and *Ocimum canum* (7.5%) were most abundant. On the other hand, *Grewia holstii* (14.9%), *Acalypha bipartita* (9%), *Hibiscus tiliaceus* (9%) and *Grewia villosa* (7.5%) had higher relative abun-

Table 6. Relative abundance of grass species in the woodlands during the dry season

Sub-region	%	Moroto District	%	Kotido District	%
H. filipendula	14.1	*Setaria* spp.	22.6	*C. dactylon*	27.3
Setaria spp.	13.0	*H. rufa*	17.0	*Echnocloa* spp.	20.5
C. dactylon	13.0	*H. filipendula*	11.3	*C. pychnothrix*	15.9
C. pychnothrix	13.0	*H. filipendula*	11.3	*S. stapfianus*	6.8
H. rufa	9.8	*C. pychnothrix*	9.4	*Aristides* spp.	6.8
Eichnocloa spp.	9.8	*E. racemosa*	5.7	*E. ciliaris*	4.5
E. racemosa	3.3	*E. tenuifolia*	1.9	*E. haploclada*	4.5
E. haploclada	3.3	*E. haploclada*	1.9	*B. scalaris*	2.3
S. stapfianus	3.3	*A. adescensiones*	1.9	*E. tenuifolia*	2.3
Aristides spp.	3.3	*E. ciliaris*	1.9	*P. maximum*	2.3
E. tenuifolia	2.2	*S. stapfianus*	1.9	*H. filipendula*	2.3
E. ciliaris	2.2	*S. pilferus*	1.9	*C. rotundus*	2.3
B. scalaris	1.1	*Aristides* spp.	1.9	*S. pilferus*	2.3
P. maximum	1.1	*C. dactylon*	1.9		
Cyperus rotundus	1.1				
A. adescensiones	1.1				
S. pilferus	1.1				

dance in the woodlands of Moroto District (Table 7). The relative abundance of other woody forage species in the woodlands of Karamoja is presented in Table 7. Additionally, there was a presence of woody trees, including *Lannea humilis* (28.7%), *Acacia campylacantha* (11.4%), *Gmelina arborea* (9.2%), and *Balanite aegptica* (9.2%) that provided browse to livestock. The relative abundance of

Table 7. Relative abundance of browse in woodlands during the wet season

Sub-region	%	Moroto District	%	Kotido District	%
G. holstii	9.0	*G. holstii*	14.9	*F. virosa*	10.4
Acalypha bipartite	6.7	*A. bipartita*	9.0	*A. rwenzorensis*	9.0
Grewia vilosa	6.0	*H. tiliaceus*	9.0	*T. anua*	7.5
Fluegea virosa	6.0	*G. vilosa*	7.5	*O. canum*	7.5
A. rwenzorensis	5.2	*S. edulis*	6.0	*A. hirtum*	7.5
A. hirtum	5.2	*C. farinosa*	6.0	*R. cumminis*	6.0
T. anua	4.5	*V. apiculata*	4.5	*G. vilosa*	4.5
Hibiscus tiliaceus	4.5	*A. mossambicensis*	4.5	*A. bipartita*	4.5
O. canum	3.7	*P. murex*	3.0	*T. orientalis*	4.5
C. farinosa	3.7	*C. vitellinum*	3.0	*D. tortluosum*	4.5
S. edulis	3.0	*A. flagellaris*	3.0	*G. holstii*	3.0

Vangueria apiculata	3.0	*A. hirtum*	3.0	*D. rotundifolia*	3.0
Ricinus cumminis	3.0	*C. pubescens*	1.5	*V. poskeana*	3.0
A. mossambicensis	2.2	*T. anua*	1.5	*S. robusta*	3.0
Vernonia poskeana	2.2	*S. lobata*	1.5	*C. floribunda*	1.5
Trema orientalis	2.2	*Leonotis* spp.	1.5	*V. apiculata*	1.5
D. tortluosum	2.2	*A. rwenzorensis*	1.5	*S. icanum*	1.5
Pedalium murex	1.5	*M. pseudopetalosa*	1.5	*A. hispidium*	1.5
Dombeya rotundifolia	1.5	*U. lobata*	1.5	*H. patula*	1.5
Crassocephalum vitellinum	1.5	*H. obtlisa*	1.5	*C. obtusifolia*	1.5
A. flagellaris	1.5	*C. edulis*	1.5	*M. pseudopetalosa*	1.5
M. pseudopetalosa	1.5	*Crotalaria* spp.	1.5	*C. farinosa*	1.5
A. brevispica	1.5	*J. flavis*	1.5	*A. aspera*	1.5
Seseveria robusta	1.5	*Sida rombifolia*	1.5	*S. codifolia*	1.5
Cenbrosema pubescens	0.7	*Erlangea* spp.	1.5	*V. petersii*	1.5
Conyza floribunda	0.7	*C. difusa*	1.5	*A. brevispica*	1.5
S. icanum	0.7	*F. virosa*	1.5	*A. oerfota*	1.5
A. hispidium	0.7	*V. poskeana*	1.5	*C. serpens*	1.5
Huellia patula	0.7	*A. brevispica*	1.5	*L. marhmausie*	1.5
C. obtusifolia	0.7	*G. superba*	1.5		
Sida lobata	0.7				
Leonotis spp.	0.7				
Urena lobata	0.7				
Hypoxis obtlisa	0.7				
C. edulis	0.7				
A. aspera	0.7				
Crotalaria sp	0.7				
Justicia flavis	0.7				
S. codifolia	0.7				
Sida rombifolia	0.7				
Erlangea spp.	0.7				
C. difusa	0.7				
Vernonia petersii	0.7				
A. oerfota	0.7				
Cyphostema serpens	0.7				
L. marhmausie	0.7				
Gloriosa superba	0.7				

these tree species differed between Districts. *Acacia campylacantha* (18.5%), *Lannea humilis* (16.7%), *Balanite aegptica* (14.8%) and *Zizyphis abyssinica* (13.0%) were more abundant in Kotido District. On the other hand, *Lannea humilis* (51.6%), *Gmelina arborea* (25.5%) and *Acacia sieberiana* (12.9%) were more abundant in the Moroto woodlands.

During the dry season, only 37 woody forage plants were observed in the woodlands of the sub-region with *Grewia holstii* (8.1%), *Ocimum canum* (7.3%)

Table 8. Relative abundance of browse in woodlands during the dry season

Sub-region	%	Kotido District	%	Moroto District	%
G. holstii	8.1	*O. canum*	7.9	*G. holstii*	28.6
O. canum	7.3	*A. conyzoides*	7.9	*Urena* spp.	22.9
Urena spp.	6.5	*D. rotundifolia*	6.7	*A. flagellaris*	5.7
A. rwenzorensis	5.6	*C. obtusifolia*	6.7	*E. tiricalli*	5.7
Argeratum conyzoides	5.6	*Vernonia* spp.	5.6	*Acacia* spp.	5.7
Vernonia spp.	4.8	*Aloe* spp.	5.6	*C. farinosa*	5.7
D. rotundifolia	4.8	*Flueggea* spp.	4.5	*O. canum*	5.7
C. obtusifolia	4.8	*A. brevispica*	4.5	*Aloe* spp.	5.7
Flueggea spp.	4.0	*S. robusta*	4.5	*V. apiculata*	5.7
C. farinosa	3.2	*T. annua*	3.4	*Vernonia* spp.	2.9
A. brevispica	3.2	*S. incanum*	3.4	*Flueggea* spp.	2.9
S.a robusta	3.2	*Acacia senegal*	3.4	*T. asiatica*	2.9
Triumfetta spp.	2.4	*H. auriculata*	3.4		
Euphorbia tiricalli	2.4	*M. pseudopetalosa*	2.2		
S. incanum	2.4	*L. martinicensis*	2.2		
A. senegal	2.4	*C. farinosa*	2.2		
H. auriculata	2.4	*A. campylacantha*	2.2		
M. pseudopetalosa	1.6	*Acalypha* spp.	2.2		
A. flagellaris	1.6	*A. oerfota*	2.2		
L. martinicensis	1.6	*A. aspera*	2.2		
Acacia spp.	1.6	*B. pilosa*	2.2		
Acacia campylacantha	1.6	*Desmondium* spp.	1.1		
Acalypha spp.	1.6	*E. tiricalli*	1.1		
Vangueria apiculata	1.6	*C. floribunda*	1.1		
A. oerfota	1.6	Tapkonoit	1.1		
A. aspera	1.6	Akakwansokwanso	1.1		
Bidens pilosa	1.6	*A. hirtum*	1.1		
Desmondium spp.	0.8	*Hibiscus* spp.	1.1		

Conyza floribunda	0.8	*S. biflora*	1.1
Tapkonoit	0.8	*O. canum*	1.1
Rhus vulgaris	0.8		
A. hirtum	0.8		
Hibiscus spp.	0.8		
Todalia asiatica	0.8		
Satureja biflora	0.8		
O. caanum	0.8		

Xanthium strumarium is an invasive species common along roadsides, gardens, and settlements; poisonous to ruminant bodies.

and *Urena* sp. (6.5%) showing high abundance. *Ocimum canum* (7.9%), *Argeratum conyzoides* (7.9%) and *Dombeya rotundifolia* (6.7%) reflected high abundance in this sub-region. The overall relative abundance of all species observed in the woodlands in the sub-region and respective districts during the dry season is summarised in Table 8.

Relative Abundance of Grasses and Woody Species in Thickets and Shrublands

Researchers and FGD identified 12 grass species during the wet season in the thicket and shrublands at sub-regional level (Table 9). *Chloris pychnothrix* (38.7%), *Aristida adescensiones* (24.4%), *Chloris virgata* (8.4%), *Eragrostis tenufolia* (6.7%) and *Hyparrhenia diplandra* (5.9%) were the most abundant grasses. In the sub-

Table 9. Relative abundance of grass species in the thickets and shrublands during the wet season

Sub-region	%	Kotido District	%	Moroto District	%
C. pychnothrix	38.7	*C. pychnothrix*	44.8	*A. adescensiones*	55.8
A. adescensiones	24.4	*C. virgata*	14.9	*C. pychnothrix*	30.8
C. virgata	8.4	*E. tenuifolia*	11.9	*H. diplandra*	5.8
E. tenuifolia	6.7	*P. Polystachion*	7.5	*S. stapfianus*	3.8
Hyparrhenia diplandra	5.9	*P. unisetum*	6.0	*B. platynota*	3.8
Pennisetum polystachion	4.2	*H. diplandra*	6.0		
Pennisetum unisetum	3.4	*H. filipendula*	4.5		
H. filipendula	2.5	*S. stapfianus*	1.5		
S. stapfianus	2.5	*Digitaria* spp.	1.5		
B. platynota	1.7	*C. dactylon*	1.5		
Digitaria spp.	0.8				
C. dactylon	0.8				

Table 10. Relative abundance of grass species in the thickets and shrublands during the dry season

Sub-region	%	Kotido District	%	Moroto District	%
C. pychnothrix	33.1	*C. pychnothrix*	45.5	*A. adscensiones*	34.3
A. adscensiones	24.3	*A. adscensiones*	13.6	*S. stapfianus*	21.4
S. stapfianus	17.6	*S. stapfianus*	13.6	*C. pychnothrix*	21.4
B. platinota	9.6	*C. dactylon*	10.6	*B. platinota*	15.7
C. dactylon	8.8	*H. rufa*	6.1	*C. dactylon*	7.1
H. rufa	2.9	*S. sphacealata*	4.5		
S. sphacealata	2.2	*B. platinota*	3.0		
Heteropogon contortus	0.7	*H. contortus*	1.5		
M. kunthii	0.7	*M. kunthii*	1.5		

region, *Chloris pychnothrix* (44.8%), *Chloris virgata* (14.9%) and *Eragrostis tenufolia* (11.9%) had high abundance. In Moroto District, *Aristida adescensiones* (55.8%), *Chloris pychnothrix* (30.8%) and *Hyparrhenia diplandra* (5.8%) showed higher abundance, while in Kotido District, *Bracharia platynota* and *Digitaria* sp. grass species had a high relative abundance during the wet season.

Only 9 of the 12 grass species were observed at sub-regional level during the dry season. *Chloris pychnothrix* (33.1%) and *Aristida adescensiones* (24.3%) maintained higher relative abundance. However, there was increased abundance of *Sporobolus stapfianus* at 17.6% from about 2.5% observed during the wet season. Bracharia platynota showed a similar trend (Table 10). When these results were disaggregated at the district level, results showed that *Chloris pychnothrix* (45.5%) and *Aristida adscensiones* (13.6%) maintained higher relative abundance in Kotido while *Arisitida adscensiones* (34.3%) and *Chloris pyschnothrix* (21.4%) maintained high relative abundance in Moroto District, with an increased presence of *Sporobolus stapfianus* to 21.4% (Table 10).

Tables 11 and 12 present a summary of the relative abundance of woody forage species observed in the wet and dry seasons at the sub-regional level. During the wet season, a total of 43 woody species were observed, with *Maerua pseudopetalosa* (12.2%), *Triumfetta anua* (10.4%), *Cadaba farisnosa* (7.3%) and

Table 11. Relative abundance of browse species in thickets and shrublands in the wet season

Sub-region	%	Kotido District	%	Moroto District	%
M. pseudopetalosa	12.2	*T. anua*	13.7	*M. pseudopetalosa*	16.1
T. anua	10.4	*A. drepanalobium*	8.9	*C. farinosa*	12.9
C. farinosa	7.3	*M. pseudopetalosa*	8.1	*C. tormentosa*	9.0
Acacia drepanalobium	6.9	*A. hirtum*	6.5	*A. kirkii*	9.0
C. tormentosa	5.6	*S. incanum*	5.6	*T. anua*	8.4
Acacia kirkii	4.9	*I. erecta*	4.8	*D. tortuosum*	7.1
D. tortuosum	4.5	*A. flagellaris*	4.8	*I. vitivensis*	6.5

A. flagellaris	4.2	*I. kituiensis*	4.0	*T. asiatica*	6.5
S. incanum	3.8	*L. martinicensis*	4.0	*A. flagellaris*	3.9
I. vitivensis	3.5	*G. holstii*	3.2	*S. incanum*	2.6
T. asiatica	3.5	*H. auriculata*	3.2	*A. oerefota*	2.6
G. holstii	2.8	*A. gigantea*	3.2	*G. holstii*	2.6
A. hirtum	2.8	*S. cordigolia*	3.2	*U. lobata*	1.9
I. erecta	2.1	*C. obtusifolia*	2.4	*A. brevispica*	1.9
A. oerefota	1.7	*C. serpens*	2.4	*L. nepetifolia*	1.3
H. auriculata	1.7	*H. aethiopicus*	1.6	*A. rwenzorensis*	1.3
I. kituiensis	1.7	*A. subpetiolatum*	1.6	*S. cumeifolia*	1.3
L. martinicensis	1.7	*D. tortuosum*	1.6	*Z. mauritianum*	1.3
U. lobata	1.4	*O. trichocarpum*	1.6	*S. biflora*	0.6
A. gigantea	1.4	*C. tormentosa*	1.6	*H. auriculata*	0.6
Sida cordigolia	1.4	*C. floribunda*	1.6	*C. spinosa*	0.6
C. obtusifolia	1.0	*A. mossambicensis*	1.6	*O. canum*	0.6
Cyphostemma serpens	1.0	*O. canum*	1.6	*S. edulis*	0.6
S. cumeifolia	1.0	*C. serpens*	1.6	*B. aegyptica*	0.6
O. canum	1.0	*U. lobata*	0.8		
A. brevispica	1.0	*L. capensis*	0.8		
Zizphus mauritiana	1.0	*P. capensis*	0.8		
L. nepetifolia	0.7	*A. oerefota*	0.8		
A. rwenzorensis	0.7	*C. farinosa*	0.8		
H. aethiopicus	0.7	*V. porkeri*	0.8		
A. subpetiolatum	0.7	*R. patula*	0.8		
O. trichocarpum	0.7	*S. cuneifolia*	0.8		
C. floribunda	0.7	*Z. mauritiana*	0.8		
A. mossambicensis	0.7				
C. serpens	0.7				
L. capensis	0.3				
P. capensis	0.3				
S. biflora	0.3				
V. porkeri	0.3				
Ruellia patula	0.3				
Crotalaria spinosa	0.3				
S. edulis	0.3				
Balanite aegyptica	0.3				

Table 12. Relative abundance of browse species in the thickets and shrublands in the dry season

Sub-region	%	Moroto District	%	Kotido District	%
T. anua	14.3	*M. pseudopetalosa*	12.3	*T. anua*	14.0
M. pseudopetalosa	11.8	*T. anua*	11.8	*A. drepanolobium*	12.1
A. drepanolobium	9.3	*A. kirkii*	11.2	*M. pseudopetalosa*	9.3
Desmondium sp.	8.0	*Desmondium SP*	10.7	*A. oerfota*	7.0
A. kirkii	8.0	*C. farinosa*	8.6	*Indigofera* spp.	4.7
A. oerfota	5.8	*G. holstii*	6.4	*Desmondium* spp.	4.2
C. farinosa	4.4	*Sida* spp.	5.9	*Vernonia* spp.	4.2
S. cuneisolia	3.3	*C. tormentosa*	4.3	*L. martinicensis*	3.7
G.holstii	3.3	*A. drepanolobium*	4.3	*A. kirkii*	3.7
I. erecta	2.7	*A. oerfota*	3.2	*A. melifera*	3.7
V. campanea	2.7	*A. flagellaris*	2.7	*Ipomea* spp.	3.3
C. tormentosa	2.5	*Urena* spp.	2.7	*H. auriculata*	3.3
L. martinicensis	2.5	*Aloe* spp.	2.1	*A. hirtum*	2.8
A. hirtum	2.5	*S. incanum*	1.6	*L. Capensis*	1.9
A. flagellaris	1.9	*E. tiricalli*	1.6	*C. obtusifolia*	1.9
I. kituiensis	1.9	*A. hirtum*	1.6	*S. incanum*	1.4
H. auriculata	1.9	*A. mellifera*	1.6	*A. nilotica*	1.4
S. incanum	1.6	*B. aegypticum*	1.1	*A. flagellaris*	0.9
Urena spp.	1.4	*L. martinicensis*	0.5	*Tragia* spp.	0.9
Aloe spp.	1.1	*Vernonia* spp.	0.5	*C. tormentosa*	0.5
L. Capensis	1.1	*O. canum*	0.5	*Sida* spp.	0.5
C. obtusifolia	1.1	*T. asiatica*	0.5	*B. aegypticum*	0.5
E. tiricalli	0.8	*S. biflora*	0.5		
Nimosa pigra	0.8	*A. aspera*	0.5		
A. nilotica	0.8	*A. oreberiana*	0.5		
B. aegypticum	0.8	*A. nilotica*	0.5		
Tragia spp.	0.5				
O. canum	0.3				
T. asiatica	0.3				
A. mellifera	0.3				
Acacia oreberiana	0.3				
A. mellifera	0.3				
S. biflora	0.3				
Sida SP	0.3				
A. aspera	0.3				

Acacia drepanolobium (6.9%) showing higher abundance in the sub-region. The disaggregated results however showed that *Triumfetta anua* (13.7%), *Acacia drepanalobium* (8.9%), *Maerua pseudopetalosa* (8.1%) had higher abundance in Kotido District, while *Maerua pseudopetalosa* (16.1%), *Cadaba farinosa* (12.9%), *Caparis tormetosa* (9%) and *Acacia kirkii* (9%) had high abundance in Moroto District (Table 11). Further, disaggregated results revealed a seasonal variation in woody species in the sub-region (Table 12).

Diversity and Richness of Grass and Browse Species

Table 13 portrays species richness results for grasslands, woodlands and thicket and shrublands in the sub-region, district, and land cover type, between and within seasons. At the sub-regional level, results showed that species richness was generally higher during the wet season compared to the dry season. For example, at the sub-regional level, there were 33 grass species observed in the wet season compared to only 17 species in the dry season. Similarly, there were 14 and 11 grass species in Kotido, 17 and 7 in Moroto, and 21 and 9 in Napak grasslands observed between the wet and dry seasons (Table 13). However, results of woody browse plants showed that the difference between wet and dry season richness was minimal among all grazing land cover as well as at sub-regional level. Only the woodlands recorded a wet-dry seasonal species richness variation of up to 10 species. Shanon's index of diversity showed a moderate range of diversity for both grass and browse forage plants for dry and wet seasons (Table 13). Although species varied across space and time, the most dominant grass and woody-browse species included species such as *Chloris pychnorix*, *Aristida adescensiones*, *Hyparrhenia rufa*, *Triumfetta anua*, *Acacia kirkii*, and *Acaia mellifera* among others (Table 14).

Table 13. Diversity and richness of forage species in the monitoring sites

Land cover	Location	Number of species					
		Dry season			Wet season		
		Grass	Shrubs and herbs	Trees	Grass	Shrubs and herbs	Trees
Grasslands	Sub-regional	17	27	10	33	35	9
	Kotido	11	12	6	14	15	5
	Moroto	7	22	5	17	26	7
	Napak	9	13	3	21	19	6
Woodlands	Sub-regional	18	37	15	26	47	18
	Kotido	13	31	10	15	29	14
	Moroto	15	12	10	17	30	6
Thicket and shrublands	Sub-regional	12	36	6	9	43	4
	Kotido	10	26	4	9	33	5
	Moroto	5	28	5	5	24	3
Shannon index		*2.24*	*2.23*	*2.19*	*2.19*	*2.25*	*2.15*

Table 14. Relative abundance of most dominant grass and woody-browse species

Grass species	%	Woody species	%
C. pychnothrix	10.6	*T. anua*	22.2
A. adescensiones	6.7	*I. erecta*	12.4
S. sphacealata	7.0	*M. pseudopetalosa*	10.0
B. decumbens	5.6	*A. drepanolobium*	7.6
B. brizantha	5.5	*G. holstii*	7.4
S. stapfianus	4.8	*A. kirkii*	6.6
H. filipendula	4.7	*A. mellifera*	6.2
H. rufa	4.7	*A. tortilis*	6.2
H. diplandra	4.4	*O. canum*	6.0
P. maximum	4.4	*A. bipartite*	5.5
H. newtonii	4.4	*S. incanum*	5.3
P. unisetum	4.2	*A. oerfota*	4.8

Relative Abundance of Grass and Browse Species as Perceived by the Community

A total of 65 grass species were documented as forage by the community of herders, scouts, and elders among the different grazing land cover in Karamoja (Table 15). This was higher than the 33 species documented from onsite monitoring plots. The perceived abundance of grasses ranged from 10% to 80% during both wet and dry seasons. Nyesiloit (*Setaria sphacealata*), Emaa (*Hyparrhenia newtonii*), Elet (*Bracharia brizantha*), and Nyepipa as well as Ngiiru, whose botanical names have not yet been established, were perceived to be highly abundant to about 80% during the wet season (Table 15). On the other hand, Nyekaletete and Ekutukutachwe (*Bracharia decumbens*) showed high abundance during the dry season at 80% and 70%, respectively. Grass species that were highly abundant during both dry and wet seasons included Ngiletio (*Eragrostis pilosa*), Erereng (*Hyparrhenia rufa*), and Ekode (*Chloris pychnothrix*), with 70–80% relative abundance range. The least occurring grasses (*perceived abundance* at 10%) according to the community included Lojomio (*Dinebra retroflexa*), Ereirei (*Testrapogon villosus*), Ewor/Nyewuroth (*Aristida* sp.), Ekoriebu, Nyetuko, Nyemekui, Nyekou, Nyekuleu, and Nyenyimanyim (Table 15).

In terms of browseable woody species, a total of 110 plants were identified in the FGDs (Table 16). This was higher than the 47 species that were documented in the monitoring sites. Eregai (*Acacia mellifera*, invasive in nature), Eiring (*Cadaba farinosa*), Epeet (*Acacia oerfota*, also invasive in nature), Eyelel (*Acacia drepanolobium*), Erogorogoit (*Caparis tormentosa*), and Ekwanyaro (*Triumfetta anua*) were perceived to have higher abudance (80%) in the grazing land cover during both wet and dry seasons. During the dry season Nyemuleria

Table 15. Relative abundance of grass species in Karamoja Sub-region as perceived by the community

Local name	Scientific name	Description of location characteristics	Perceived abundance (%)	Season
Abirir	*E. racemosa*	Open grasslands. Some low lying areas with limited flooding occurrence.	20	Wet
Ajanet (Ngajien)	*S. pyrimidalis*	Areas where grazing pressure has been high. May be grassland, thicket, shrubland or woodland where movement routes exist.	30	Both
Apanakwuachin	-	Occurs near homesteads. Common delicacy for donkeys.	10	Wet
Ebirwae	*S. arundainacium*	Open grasslands and areas of former kraals (bomas).	10	
Edodo*	-	Bushlands to woodlands and grasslands. Locally known as Atalewo and Ekuwath.	30	Dry
Egwogwong	*C. virgata*	Easily flooded lowland grasslands.	30	Wet
Ekawuduwudu	*M. kunthii*	Mainly in areas with black cotton soils in lowland grasslands.	30	Both
Ekirao	*Loudetia simplex*	Associated with bushlands and woodland environments.	20	Both
Ekodareng	*Cynodon* sp.	Common around homesteads (manyattas) and former bomas.	60	Both
Ekode	*C. pychnothrix*	Common on gentle slopes in thicket and shrublands to areas with stony soils, locations locally addressed as Nyangromit.	70	Both
Ekopir	-	Grasslands to shrublands (e.g., Borders with Turkana).	50	Both
Ekoriebu	-	Open grasslands with limited trampling.	10	
Ekosimatuk	-	Open lowland grasslands (e.g., around Arecheke in Iriiri, Napak).	70	Wet
Ekutukutachwe	*Bracharia decumbens*	In grasslands and around manyattas.	70	Dry
Elepane**	*B. jubata*	Grasslands with black cotton soils.	50	Both
Elet	*Bracharia brizantha*	Grasslands and lowlands (e.g., Iriiri),	80	Both
Emaa***	*H. newtonii*	Grasslands with sandy to black cotton soils, in parts of Kacheri sub-county and Longor in Kotido District.	80	Wet
Emogorat	-	Grasslands.	40	Wet

Table 15. (Continued)

Local name	Scientific name	Description of location characteristics	Perceived abundance (%)	Season
Epetareng	*Dactyloctenium aegyptica*	Occur in areas with sandy soils and black cotton soils. May include grasslands, thicket and shrublands and woodlands.	40	Both
Epinyait/Etidot	*L. kagerensis*	Grasslands with black cotton soils.	50	Both
Ereirei	*Tetrapogon villosus*	Grasslands and thicket and shrublands with sandy soils.	10	Wet
Erereng	*H. rufa*	Grasslands with black cotton and sandy soils.	70	Both
Etanako	*Setaria verticilata*	May occur in thicket and shrublands and bushlands with sandy soils, locally called *Nyekuwath*.	30	Both
Ethali	*C. nlemfuensis*	Wide spread in bushlands, grasslands and woodlands.	40	Both
Ewat/Euwat*	*Oxytenanthera abyssinica*	Along river streams (e.g., Lomogol River near Nagololapolon in Kotido).	20	Both
Ewuroth/Eworoi	*Aristida* spp.	Lowland grasslands with light crackly soils, but generally black cotton soils.	10	Wet
Lochen	*H. schimperi*	Grasslands. This grass species is locally known to have a bitter taste.	60	Wet
Lojokopolon	*Hyparrhenia* spp.	Grasslands with sandy to black cotton soils in parts of Kacheri Sub-county and Longor in Kotido District.	80	Wet
Lojomio	*Dinebra retroflexa*	Associated with slaughter places such as shrines and other bushlands.	10	Wet
Lokala	-	Open grasslands to thicket and shrublands in the eastern parts of Kotido towards the espcarpments with Turkana. This grass is believed to have been brought by the Turkana livestock.	29	Dry
Lomedotin	*S. pumila*	Woodlands and bushlands locally referred to as Ekitela. May also occur around manyattas.	60	Both
Lomirio	*Pennisetum mezainum*	Grasslands with black soil, called *Nyaro*.	40	Both
Lomukur	*A. adscensiones*	Rapidly flooding lowland grasslands.. Areas in *Nyaro* particularly locally called *Nyakao*.	30	Wet

Lomurio	*Cenchrus ciliarus*	Grasslands with black cotton soils.	40	Both
Losaricoo	*P. maximum*	Areas with black cotton soils. May either be woodlands and/ or grasslands.	70	Both
Neymuria/Emuria	*C. dactylon*	Common around manyattas and former bomas.	60	Both
Ngejenet	*E. ciliaris*	Areas with sandy and light soils. May include thicket and shrublands on gentle slopes.	60	Both
Ngeletio***	*E. pilosa*	Grasslands and lowlands,	60	Both
Ngiiru	-	Grasslands and bushlands (e.g., Kopori and Nalos).	80	Wet
Nyakwuanga	-	Marshy Grasslands.	30	Wet
Nyapuna/Apuna	*Bulbostylis pusilla*	Occurs in lowland grasslands with black cotton soils. Often easily waterlogs	40	Both
Nyejaao***	-	Hilly and valley areas.	70	Wet
Nyekala	-	Shrublands and Grasslands (e.g., Kacheri-Longor).	20	Wet
Nyekaletete	-	Lowlands, hilly areas and old bomas.	80	Dry
Nyekipiit**	-	Open valleys and lowlands.	20	Wet
Nyekoromuar	-	Homesteads.	30	Wet
Nyekou	*Hyparrhenia cymbaria*	Grasslands with black cotton soils. Parts of grasslands are locally called Akao.	30	Wet
Nyekou***	-	Marshy Grasslands.	10	Wet
Nyekuleu	-	Homesteads, thicket, and shrubland areas. May have sandy soils. Locally called, asinyonoit.	30	Wet
Nyelalojait/Elalajait	-	Grasslands (e.g., areas of Kapeta and Lolelya).	60	Wet
Nyemekui	-	Homesteads and shrublands.	10	Wet
Nyemirierit	*S. sphacealata*	Open lowland grasslands (*Nyaro-Nyakao*) attributed to be common in the Apeitolim-Lopei-Toor apex.	50	Wet
Nyemomwa (sorghum straws)	*Sorghum bicolor*	Raised areas on grasslands, former thickets and shrublands converted to farmlands.	60	Wet
Nyenyimanyim	-	Broad valleys and hilly areas. (In Apeitolim, Lopei River areas.)	10	Wet

Table 15. (Continued)

Local name	Scientific name	Description of location characteristics	Perceived abundance (%)	Season
Nyepipa	-	Around homesteads and old bomas. Particularly locally referred to as Asinyonoit (areas with sandy soils).	80	Wet
Nyerau*	-	Bushlands to woodlands and grasslands. These places are locally known as Atalewo and Ekuwath.	20	Dry
Nyereirei/Ereiri***	-	Grasslands.	20	Wet
Nyesiloit**	*S. sphacealata*	Lowland grasslands with easily flooding soils.	80	Wet
Nyetuko***	-	Grasslands and bushlands (e.g., Koteen grasslands).	10	Both
Nyetuko/Lolepan	*E. haplocada*	Lowland grasslands with black soils.	40	Both
Nyewu	*Rottboeria cochinchinensis*	This is wild sorghum common in grasslands and thickets that have ever been cultivated, or around homesteads and former bomas. Open grasslands with sandy and light soils with gentle slopes.	10	Wet
Okwarath****		Mountains and hills of the Kaabong, Napak, Labwor and Moroto.	60	Dry

*These grasses, generally known as Asakatan, are said to bring disease to livestock. **These grasses were believed to induce cattle to provide high milk yields. ***Grasses perceived as very good for livestock. ****These grasses that are generally found on mountains and hills. Several hills identified include Kogwele, Kanamerinjor, Katipus, Morutit, Kapernakori in Kotido District; Koromwae, Napakgngaran, Turusuk, Nyanga, Theno, Arakas, Kolung, Nakithilet hills in Kotido-Kaabong. There were also grasses identified in Kotido FGD as bad grasses, including Nyabune, Nyemurecho, Nyakouma, Nymadong, and Nyethak. These grasses were also identified in some parts of Nagirigiroi in Kotido District. The botanical names of these grasses still need to be identified.

Table 16. Relative abundance of browse forage species in Karamoja as perceived by the community

Local name	Species scientific name	Consumption	Description of location characteristics	Perceived abundance (%)	Season
Aboinakinei	*Otiophora pauciflora*	GS	Loamy and sandy	60	Wet
Ajim/Edomeo	*A. aspera*	GSC	Loamy	60	Dry
Alolot	*Corchorus olitorius*	GSC	Loamy soils	80	Wet
Alolot-Eligo	*Hisbiscus abyssinica*	GSC	Loamy	70	Both
Amanakuri-Asangsang	*Cyphostema serpens*	GS	Loamy and sandy	60	Both
Athuran	*Paviona arabicum*	GSC	Sandy soils	50	Both
Athuran	*S. cordifolia*	GSC	Loamy and sandy	50	Both

Ecucuka	*A. rwenzorensis*	GSC	Loamy and sandy	80	Wet
Edodo	*Crotalaria olitorius*	GSC	loamy soils/ swampy river sides	60	Dry
Edodoi	*Kigelia africana*	GS	Loamy, along river banks with marshes	80	Both
Edome	*Cordia sinensis*	GSC	Loamy and sandy	80	Both
Edondongmuroi	*Solanum anguivii*	G	Sandy soils	50	Wet
Edupamal	*Hisbiscus micrantha*	GSC	Loamy and sandy	80	Both
Egigith	*Cissus quadrangularis*	GSC	Loamy and sandy	40	Dry
Egirigiroi	*A. campylacantha*	GSC	Loamy and sandy	60	Dry
Ejojor	*Balanite grabra*	GSC	Loamy and sandy	80	Both
Ekaburu	*Maytenus heterophylla*	GSC	Sandy soils	60	Wet
Ekadele	*C. africana*	GSC	Loamy and sandy	40	Both
Ekaleruk	*Cucumis figarei*	GSC	Loamy and sandy	40	Dry
Ekalitete	*Portulaca orereceae*	GSC	Sandy soils	60	Wet
Ekaliye	*G. mollis*	GSC	Sandy	70	Wet
Ekarei	*Ficus natalensis*	GSC	Loamy and sandy	60	Both
Ekedeloi/ Ekadoliae	*Caparis fascicularis*	GSC	Loamy soils and at times in low land areas	70	Both
Ekere	*Harrisonia abbisinica*	GSC	Loamy and along river banks	60	Wet
Ekisemejo	*Lanata trifolia*	GS	Loamy and sandy	30	wet
Ekobeko	*Solanum taitense*	GSC	Loamy and sandy	50	Wet
Ekodokodoi	*Acacia senegal*	GSC	Loamy and sandy	80	Dry
Ekorete	*B. aegyptica*	GSC	Loamy and sandy soils	80	Both
Ekoromwai-Lokwang/ Ekapelimen	*A. nilotica*	GSC	Loamy	60	Both
Ekoromwai-Loreng	*Acacia xanthopholea*	GSC	Loamy soils and along marshlands	60	Both
Ekotachwe/ Abotachwe	*C. benghalensis*	GS	Loamy and sandy	40	Wet
Ekuleo/Emini	*C. orthancantha*	GSC	Loamy and sandy	80	All
Ekurr	*R. kwanoensis*	GSC	Loamy and sandy	60	Both
Ekurutapim	*Plectranthus longipes*	GS	Loamy and sandy	80	Both
Ekutukutacwe/ Ekalitet	*C. arachnoidea*	GSC	Loamy and sandy	60	Wet
Ekwanga	*A. hirtum*	GSC	Loamy soils	60	Both
Ekwangyaro	*T. annua*	G	Loamy and sandy	80	Dry
Ekwanpen/Achepa	*L. martinicensis*	GSC	Loamy	80	Dry
Eliaro	*I.kituiensis*	CS	Loamy	70	Wet
Eligoi	*E. tirucalli*	GS Ca	Loamy and sandy	80	Both

Table. 16. (Continued)

Local name	Species scientific name	Consumption	Description of location characteristics	Perceived abundance (%)	Season
Emalakan	*Hisbiscus diversifolius*	GSC	Loam soils and marshy conditions	60	Wet
Emaler	*Vangueria apiculata*	GSC	Loamy soils and valley soil river valleys	80	Both
Emaret	*V. membrancea*	GSC	Sandy soils	80	Both
Emejan	*A. hispidium*	GSC	Loamy and sandy	80	Wet
Emejan/Epopong	*E. candlebrum*	GS	Loamy and sandy	60	Both
Emekwe	*Crossandra subacautis*	C	Sandy	70	Wet
Eminii	*Barleria submollis*	GSC	Sandy	40	Both
Emotwai	*G. villosa*	C	Loamy and sandy	30	Both
Emuleria	*L. nepetifolia*	GS	Loamy and sandy	50	Wet
Enaminam	*Crabbea velutina*	GS	Loamy and sandy	80	Wet
Enyuri	*Hisbiscus* sp.	GSC	Loamy	80	Both
Epedur/Eperu	*Tamarindus indica*	GSC	Loamy and sandy	80	Both
Epeet	*A. oerfota*	GS	All landscapes	80	Both
Epiee	*G. arborea*	GSC	Loamy and sandy	60	Both
Epuook	*Buddelia polystachya*	GSC	Loamy and sandy	70	Dry
Erakanakui	*Codia quercifolia*	GSC	Sandy	60	Both
Eregai	*A. mellifera*	GS	All landscapes	90	Both
Eriring	*C. farinosa*	GSC	All landscapes	90	Both
Erogorogoite	*C. tormentosa*	GSC	Along river bank	80	Both
Erugwa	*G. similis*	GSC	Loamy and sandy	40	Wet
Erut	*M. edulis*	GSC	Loamy and sandy	80	Wet
Eseperwai	*Ormocapum trichocarpum*	GSC	Loamy and sandy	90	Both
Esikarakiru	*A. flagellaris*	GSC	Loamy and sandy soils	50	Wet
Esilang	*Z. abyssinicus*	GSC	Loamy and sandy	80	Both
Ethithi	*J. flavus*	GSC	Loamy and sandy Turkana origin	50	Both
Etiatia	*C. ochroleuca*	GSC	Loamy and sandy	80	Wet
Etiatia/Ekayeriyeri	*C.obtusifolia/Senna obtusifolia*	GSC	Loamy and sandy	60	Wet
Etir/Ewoi	*Acacia totilis*	GS	Loamy and sandy	90	Both
Etirai/Nyetirai	*Dicrostachys cinerea*	GSC	Loamy and sandy	50	Both
Etirir	*Acacia spirocarpa*	GSC	Loamy and marshy areas	40	Both
Etopojon	*L. humilis*	GSC	Loamy and sandy	80	Both
Etulelo	*S. incanum*	GSC	Loamy and sandy	80	Wet

Eurukanyim	*Maerua parviflora*	GSC	Loamy soils and marshy conditions	60	Both
Eusugu	*Zanthoxylum calybeum*	GSC	Loamy and sandy	80	Both
Ewoi	*A. tortilis*	GSC	Loamy and sandy	60	Both
Ewologweth	*Heliotropium steudneri*	GSC	Loamy soils and marshy conditions	60	Wet
Eyelel	*A. drepanolobium*	C	Dry and sandy areas	80	Both
Lak	*Alternanthera sessilis*	GSC	Loamy soils along marshlands	50	Both
Lochikutai	*I. erecta*	GSC	Loamy Water available	80	Wet
Lojokosimat	*Striga gesnerioides*	GSC	Loamy and marshy soils	60	Both
Lokalabocho	*Marsdenia robicunda*	GSC	Loamy and sandy	50	Wet
Lokeny	*Barleria acanthoides*	GSC	Loamy and sandy	80	Both
Lokile	*Euphorbia prostrata*	GS	Loamy	80	Both
Lokiriketa	*U. lobata*	GSC	Loamy and sandy	90	Both
Lokwaturot	*Pentasia ouranogyne*	GSC	Loamy and sandy	50	Both
Lomerekin	*B. pilosa*	GSC	Swampy with loam soil	60	Both
Lomethegin/Lok	*A. hispidium*	GS	Loamy and sandy	40	Wet
Losigiria	*Maerua* spp.	GSC	Loamy and sandy	80	Both
Lotere	*R. patula*	GSC	Swampy with sandy loams	50	Both
Lotheru	*O.canum*	GSC	Loamy and sandy	60	Both
Lothiru	*Orthisiphon* spp.	GSC	Loamy and sandy	80	Both
Loururosi	*T. minuta*	GSC	Sandy soils	40	Wet
Nakankwen/ Epwatadele	*Gymnema sylivestre*	GSC	Loamy	80	Dry
Ngaturikeso	*A. bipartita*	GSC	Loamy and sandy	60	Both
Nyalakas	-	GSC	Loamy and sandy	50	Both
Nyechogoromoit	-	GSC	Loamy and sandy	80	Both
Nyedurokoit	*Acacia albida*	GSC	Loamy and sandy	60	Both
Nyekadetewua	-	GSC	Loamy and sandy	80	Both
Nyekapangiteng	*Albizia anthelmintica*	GS	Loamy and sandy	80	Both
Nyekorith	-	GSC	Loamy and sandy	40	Wet
Nyekuri	*Talinum caffrum*	GS	Loamy soils that often are marshy and flood	80	Both
Nyelel/Eyelel	*Acacia seyal*	GSC	Loamy and sandy	60	Wet
Nyesaguru	-	GSC	Loamy and sandy	60	Dry
Nyesobosob	-	GSC	Loamy and sandy	40	Wet
Nyetiaro	-	GSC	Loamy, along river banks and lowlands	60	Wet
Tataiikokol	*Pavetta gardenifolia*	GSC	Sandy soils	40	Wet

G = Goats, S = sheep, C = Cattle, Ca = camel, Both = wet and dry seasons.

(*Leonotis nepetifolia*), Emotwai (*Grewia villosa*), Ngaturikeso (*Acalypha bipartite*), Edome (*Cordia sinesis*), Lomethegin/Lok (*Acathospermum hispidium*) and Etiatia (*Crotalaria ochroleuca*) were perceived to be more abundant (>50%). On the other hand, Ekalitete (*Portulaca orereceae*), Emaret (*Vigna membrancea*), Aboinakinei (*Otiophora pauciflora*), Ekwanga (*Abutilon hirtum*), Lokiriketa (*Urena lobata*), Amana akuri-Asangsang (*Cyphostema serpens*) and Lowaturot (*Pentasia ouranogyne*) were perceived to have higher relative abundance (>80%) during the wet season (Table 16).

DISCUSSION

Forage Species Abundance in Karamoja

This study revealed the existence of a variety of grass and browse forage species in the sub-region. However, the forage species varied in relative abundance among land covers of grasslands, woodlands and thicket and shrublands, and by districts and season. Seasonal differences in forage species, particularly grasses, could be attributed to climatic variability in the sub-region. As a semi-arid area, the sub-region has considerable variability in rainfall total between wet and the long dry season. This kind of variability in rainfall at different timescales has been noted to influence phenological vegetation parameters, including among others germination, growth, and seed production of herbaceous plants (Holmgren et al., 2006). In addition, in Karamoja, variation in herbaceous forage species is attributed to the rainfall gradients in the sub-region (Roschinsky, 2009). This rainfall gradient leads to a high prevalence of *Hyparrhenia* in the wetter western parts of the sub-region. This was similarly observed in this study, as *Hyparrhenia* had high relative abundance in Napak District. On the other hand, *Setaria* spp. has been documented to be of high relative abundance in drier eastern Karamoja (Roschinsky, 2009). This study's results similarly revealed high relative abundance of *Setaria* in addition to *Sporobolus*, and *Chloris* in eastern Karamoja, Moroto District.

Differences in the relative abundance of grass species in the grazing land cover observed in this study can be attributed to tree-grass interactions as well as differences in grazing intensity. The open nature of the grasslands in Karamoja with limited tree cover allows for the survival of several grass species as opposed to woodlands and thickets/shrubland land cover. Trees have been found to have multifaceted effects on grasses, ranging from positive (facilitation) to negative (competition). All of this may be dependent on specific characteristics of the tree and grass growthforms, photosynthetic pathways, photosynthetic habit, resource requirements, and frequency, intensity, and extent of disturbances, such as fire and grazing intensity (Scholes & Archer, 1997).

Compared to all other land cover types, thicket and shrublands had fewer grass species recorded. This could be attributed to the dominance of browse plants and minimal grazing of cattle in the thickets and shrublands. Further, several growthforms that exist in the thicket and shrublands, such as succulents, woody shrubs and small stunted trees as well as various annuals, and herbaceous perennials could explain the relative low grass species richness (Jacobs & Jangle, 2008: 5). However, Jacobs and Naiman (2008) observed that spatial heterogeneity in land cover is a result of herbivory that often reduces the biomass and canopy cover of certain plants.

Abundance of Forage Species in Karamoja as Perceived by the Community

Community based assessment revealed more grass and browse species than the field based assessment in the grazing land cover in Karamoja Sub-region. This revelation confirms the fact that pastoral and agro-pastoral communities have detailed information on forage species resources available in their grazing land cover (Oba & Kaitira, 2006; Kgosikoma et al., 2012). Similarly, the Karamojong have hitherto been noted to possess vast knowledge of plant diversity embodied by the community arising from experiential use of plant resources overtime (Grade et al., 2009; Oba, 2012). Previous studies undertaken among pastoral communities in East Africa, such as among the Maasai (Mapinduzi et al., 2003; Oba & Kaitira, 2006) and the Orma and Afar of Ethiopia (Oba, 2012) have similarly revealed detailed community understanding of plant diversity in the rangelands. Secondly, the difference in the number of species documented could have arisen due to the fact that our assessment process did not restrict the participants to the land cover of their vicinity but to the land cover that they use for grazing livestock in the sub-region. Further, Rosenzweig (1995) noted that the probability for encountering more species as area increased even in uniform environments, because the total number of individuals often increased with area.

Both field and community based assessments revealed a relatively large number of grass species in the grazing land cover. The relative abundance of these grasses are however dominated by few grasses, such as *Chloris*, *Aristida*, *Hyparrhenia*, *Setaria*, *Cynodon*, *Panicum*, *Pennisetum* and *Sporobolus*. The relative abundance of these species also varied between the wet and dry season. Variation in the relative abundance of grass species between seasons is not uncommon, largely resulting from rainfall variability in rangeland areas (Ellis & Swift, 1988; Illius et al., 2000; Clarke et al., 2005). Notably, some of the grass species had high relative abundance during the wet season, but then decreased during the dry season while some increased in their relative abundance during the dry season. This is perhaps an indicator of differentiated species growth forms adaptation to rainfall variability in the sub-region. Grasses, such as *Chloris* and *Panicum* identified in the sub-region with moderate relative abundance have hitherto been observed to have good to high nutritive value (Moore et al., 2006; Heneidy & Hamly, 2009) with ability to adapt to both wet and dry conditions (Sage & Zhu, 2011). Other grasses, such as *Digitaria*, *Cenhrus* and *Eragrostis* previously documented (Keba et al., 2013) with high nutritive quality had marginal relative abundance in the sub-region.

On the other hand, grasses such as *Sporobolus*, *Hyparrhenia*, and *Aristida* observed with high relative abundance during both dry and wet seasons have been documented to have low nutritive value, because of their low protein content (Boonman, 1993; Roschinsky, 2009; Keba et al., 2013). This implies that during both seasons, livestock, particularly cattle in the sub-region are subjected to poor forage diets. This exposure to poor nutrition has been observed to negatively affect livestock production and performance in terms of milk yield, body condition, and growth rates as well as reproduction (Galvin et al., 2004; Thornton, 2010). It is also important to note that while there was a relatively high prevalence of grass species in the sub-region, legumeneous plant species were relatively scarce or absent in most of the grazing land cover. This could be attributed to the frequency of disturbance associated with intense fires that ravage the region destroying seeds thereby limiting seed recruitment. Leguminous plants have an important role of mediating livestock diet because of their high nutritive value (Abusuwar & Ahmed, 2010); their absence in the grazing land cover in the presence of grass species with low nutritive quality leads to poor livestock nutrition particularly during the dry seasons.

This study also revealed that the sub-region has a large number of woody plants that serve as browse for livestock. Browse has been noted to be dependable forage that is available over a longer growing season than grass. Its production may equal or exceed that of grass, and it may be the only forage available in heavily utilised areas (Illius et al., 2000) and during a drought period (Hungwe et al., 2013). Participants in the FGDs similarly reported the importance of browse forage species particularly during drought events. However, this relatively large presence of browse plants is not beneficial to cattle, the key livestock kept by the Karamojong in the sub-region. Cattle are essentially not suited to eating browse because they have an inflexible upper lip, and use their tongues to grasp and pull forage into their mouths (Hamilton, 2003). It nonetheless offers a greater opportunity for herding goats, sheep and camels in the sub-region. It is also important to note that some of the woody browse species (e.g. *Acacia mellifera*) identified by the community as having high relative abundance have been associated with bush encroachment, such as in the Kalahari (Thomas & Twyman, 2004). Bushland encroachment in the sub-region has been confirmed to be on the rise in the last decade in the sub-region (Egeru et al., 2014b).

Forage Species Diversity in Karamoja

A high species richness-diversity has been observed in this study. The species diversity index observed in this study could be attributed to the range of monitoring sites that were established across different grazing land covers and rain gradients in the sub-region. Further, it could be linked to continuous and transhumant grazing that allows for the transfer of species from one grazing land cover to the other and from one region to the other, thus further explaining the common species within these grazing biomes. In a study conducted in Laikipia, a semi-arid region in Kenya, Nduku (2012) observed high species richness in continuously grazed pastoral areas. Similarly, Maitima et al. (2004) observed that pastures in pastoral areas with moderate grazing support more plant species than in ungrazed areas. This could explain the relatively high species richness of both grass and browse plants observed in the sub-region.

CONCLUSION

The sub-region has a high diversity of herbaceous and woody forage species whose abundance is dominated by several species across space and time. Further, the study has shown that the Karamojong have detailed cultural knowledge of forage plant phenology, forage species types, and preferences by livestock species. The high species richness coupled with rich cultural knowledge should be taken into consideration in the improvement of livestock production and biodiversity conservation in the sub-region.

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