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Utilisation and conservation status of indigenous woody plant species in a sedentary pastoral production system in south-western Uganda

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Abstract

Indigenous woody plant species play a significant role in sustaining pastoral production systems in sub-Saharan Africa. Outside protected areas in Uganda, populations of useful naturally growing woody species are threatened with extinction. Moreover, little is known about the population structure of woody plant species in such unprotected sites to guide conservation strategies. The objective of this study was to identify indigenous woody plant species utilised by the pastoralists in the dry lands of south western Uganda and assess the population structure of the species utilized. A survey involving 100 households was conducted to inventorise woody plants in 55 nested plots of 50 m × 50 m. A total of 70 indigenous woody plant species were utilised by the pastoralists to serve nine purposes. High utilisation of the plant species was in the order of medicine for humans and livestock, firewood, fodder, timber, poles, shade, food and least in crafts. The major woody plant species utilised included *Vernonia ammygdalina, Acacia sieberriana, Acacia hockii, Carissa edulis* and *Albizia coriaria. Allophylus sp* was valuable for all the nine purposes, though particularly for human medicine and poles. In terms of conservation status, trees conformed to inverse J shape and bimodal patterns of population structure, indicating current sustainable conservation in some species and an imbalance in species with a bimodal pattern. Most shrubs reflected irregular population structure indicative of unsustainable conservation status. Seedlings for both trees and shrubs were in the low level of abundance, according to Braun- Blanquette cover scale. Sustainable conservation of indigenous woody plant species in a sedentary pastoral system requires aided regeneration

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that involves supplementing natural regeneration with similar plant species, as well as zoning sites with high woody species diversity. Promotion of community based conservation platforms where pastoralists can be trained on sustainable plant conservation is recommended.

Key words: Population structure, *Vernonia ammygdalina*, woody plants

Introduction

Indigenous woody plant species play a major role in sustaining the livelihoods of pastoralists in the dry lands of sub-Sahan Africa. They provide a wide range of products and ecosystem services, and are regarded as vital components of sustainable pastoral production systems (Sinare and Line, 2015). Indigenous woody plant species are utilised variably by pastoralists across locations, as dictated by livelihood strategies (Balehegn *et al.*, 2015). However, outside protected areas in Uganda, pastoralism production lands constitute part of the increasingly important human inhabited areas, where populations of useful naturally growing woody species are threatened with extinction (Tabuti, 2007). Moreover, little is known about the population structure of woody species in such unprotected sites to guide conservation strategies.

Traditionally, pastoralism production systems were sustained through nomadism (Wurzinger *et al.*, 2008), a practice where pastoralists moved through pre-determined routes with their cattle, in search of water and pasture. Gidske *et al.* (2014) reported that woody plants serve as livelihood security for the survival of people and livestock during the long dry seasons. Seasonal migration of pastoralists ensures that sustainable utilisation of indigenous woody species for socio-economic and ecosystem functioning is achieved. The time lag of no active pastoralism in a particular area promotes natural regeneration of woody species in previously utilised land and sustainable conservation of indigenous woody plant species are enhanced (Flintan *et al.*, 2013).

However, sedentary pastoralism where pastoralists keep considerable herds of cattle in a defined area and on permanent basis (Hansen *et al.*, 2012), is gradually replacing the traditional nomadic pastoralism in sub-Saharan Africa. Roba *et al.* (2013) reported that this change in livestock production practices has adversely affected the conservation of woody species in the wild, but the magnitude is unclear thus necessitating investigation. Information on population structure of plants which reflect diameter size class distributions is useful in giving insights on the probability of survival of indigenous woody plant species in a particular habitat and ascertain conservation status (Mekonen *et al.*, 2015).

Woody plant species display four patterns of population structure, including interrupted inverse J shape, J shape, Bell shape and Irregular pattern (Mekonen *et al.*, 2015). The type of population structure displayed by woody plants reflects the action of biotic and abiotic factors that a population has been exposed to in the past and therefore conservation status.

This study assessed the indigenous woody plant species utilised by pastoralists of south western Uganda and their population structure patterns. The information generated will be useful in

enhancing sustainable conservation of indigenous woody plant species in sedentary pastoral production systems.

MATERIALS AND METHODS

Study site

The study was conducted in Ankole ranching scheme (in four sub-counties), located in Nyabushozi County, Kiruhura district (00° 12×S, 31° 00×E) in south-western Uganda, during September to October, 2013. Kiruhura district lies in the cattle corridor belt of Uganda. Ranch 48b

The climate of this belt is semi-arid, with average annual rainfall of 1000 mm (Kansiime *et al.*, 2014), distributed in a bimodal pattern. Temperatures range between 20° and 30°C, with peaks in July. The altitudinal range of the district is 1250 -1525 m above sea level. The vegetation is dominated by savannah grassland with scattered trees typical of semi-arid areas. Livestock production is the main livelihood support activity, characterised by ranching in extensively grazed transhumant herds of cattle and goats in a sedentary practice. The human population of Kiruhura district is 14,000 people (UBOS, 2012).

Indigenous woody plant species utilised by pastoralists

Data of indigenous woody species used by pastoralists were collected through a cross-sectional survey of 100 households in the Ankole Ranching Scheme. Households were selected using simple random sampling techniques (Kotrlik and Higgins, 2001) and over 10% of the households benefiting from the scheme were interviewed. Data were collected on the names of indigenous woody plant species utilised in their livelihoods and the purposes for which they were utilised.

Population structure of indigenous woody plant species

The population structure of indigenous woody species utilised by pastoralists was assessed in 11 ranches selected using simple random techniques in the sub-counties of Kikatsi, Kenshunga, Nyakashashara and Sanga. Using measuring tapes of 100 meter length, nested plots of 50 m x 50 m were established 100 meters away from the edge of every ranch, along a transect of approximately 1 kilometer. Each plot was divided into smaller plots of 25 m x 25 m and 10 m x 10 m. Diameter at breast height (DBH) of woody plants was determined. Trees (>20 cm DBH) and poles (10 -19.9 cm DBH) were assessed in the entire plot of 50 m x 50 m. Saplings (5.5 -9.9 cm DBH) were assessed in a smaller plot of 25 m x 25 m; while seedlings (d" 30 cm height) were assessed in a sub plot of 10 m x 10 m (Cole *et al.*, 2012). The first plot was selected randomly by allocating and picking a number indicating a side of a transect line. Subsequent plots were established 50 meters apart, in an alternate pattern along a transect line laid in the longest direction in each ranch. Up to 5% of every ranch was assessed and a total of 55 plots representing 13.75 hectares were covered. Seedlings were evaluated based on the principles of vegetation cover analysis by Braun-Blanquette (Westhoff and Van Der Maarel, 1980). This method enables quick evaluation of small classes of vegetation by using area cover scales. Usually, a scale of 1-5 is used where 1 represents 1-20% species area cover, 2= 21-40%, 3 =41-60%, 4= 61-80%, 5= 81-100%.

Preliminary identification of woody plants was done by key informants who gave the local names of the species.

However, specimens of each species encountered were collected, pressed in paper materials and delivered to Makerere University herbarium for confirmation.

Data analysis

The data collected were entered in SPSS.16.0 and Microsoft Excel computer packages for processing. Descriptive statistics were used to generate frequency tables and population structure graphs. The population of seedlings was subjected to Braun-Blanquette scale to determine the area cover scales.

RESULTS

Indigenous woody plant species utilised by pastoralists

A total of 70 indigenous woody plant species (40 shrubs and 30 trees) occurring in 31 plant families was utilised by the pastoralists to serve nine purposes (Table 1s). The uses included food, fodder, human medicine, animal medicine, fuel wood, poles, timber, crafts materials and provision of shade (Table 1). High utilisation of the species was in the order; medicine for humans and livestock, firewood, fodder, timber, poles, shade, food and least in crafts (Fig. 1).

Most indigenous woody plant species were described as multipurpose to pastoralists. However, *Allopyhlus* sp. was identified to be valuable for all the nine purposes reported (Table 1). This was followed by *Ficus natalensis* and *Nuxius congesta,* which were utilised for eight purposes. Species *Microglossa pyrifolia, Bosci coriaceae, Astripomoe amalvaceae, indigofera emerginella, macrotyloma axillare, Myrica kandtiana, Boerhavia diffusa,* had the lowest level of utilisation whereby only one purpose of utilisation was reported. The purpose for which such species were utilised was source of medicine either to human or livestock (Table 1).

Vernonia ammygdalina dominated the species used for human and animal medicine (Table 2). Several species were used for firewood (40 species) with *Acacia sieberriana* being the dominant (Table 2). For other purposes, *Acacia hockii, Albizia coriaria Carissa edulis* and *Grewia kakothamnos* dominated species utilised for fodder, timber, food and crafts, respectively. *Albizia coriaria* was as well found to be useful in providing shade in the grazing grounds. Although 14% of the species were reported to be utilised for food purposes, 99% of the respondents utilised the species to obtain fruits and nuts (Table 2).

Population structure of indigenous woody plant species

Plant inventory for assessing plant population structure recorded 39 indigenous woody plant species comprising 22 shrubs and 17 trees, in 55 plots covering 13.75 ha. The woody plant species recorded in the plant inventory displayed three types of plant population structure and these were Inverse J shape, bimodal and irregular shape patterns.

Trees displayed the Inverse J shape and bimodal patterns of population structure. The inverse J shape pattern for trees was constituted by *Acacia hockii, Grewia mollis. Allophylus sp* and *Teclea nobilis;* while the bimodal pattern was constituted by *Acacia gerrardii, Jasminum pauciflorum, Acacia persiciflora* and *Euphorbia candelabrum* (Figs. 2a and b.). Shrubs, on the other hand, displayed the inverse J shape and irregular patterns of plant population structure. The inverse J shape of shrubs was constituted by *Rhus*

Table 1. Top 20 indigenous woody plant species used by pastoralists of south-western Uganda

Family	Species (Scientific name)	Local name	Responses for uses of species from 100 households									
			Food	Fodder	Human medicine	Animal medicine	Fire wood	Poles	Timber	Shade	Crafts	Cumulative frequency of responses
Fabaceae	*Albizia coriaria Oliv.*	Omusisa	0	37	59	58	73	77	79	24	0	407
	Acacia sieberiana DC.	Omutyaza	0	46	40	41	77	69	55	15	0	343
	Acacia gerrardii Benth.	Omutongole	0	42	39	42	74	68	44	8	0	317
Anacardiaceae	*Rhus natalensis Bernh. ex Krauss*	Omusheshe	84	70	47	35	37	28	12	0	0	313
Fabaceae	*Acacia hockii De Wild.*	Orugando	0	75	40	46	62	37	24	0	0	282
Sapindaceae	*Allophylus Sp*	Omutete	24	45	46	41	45	46	21	3	1	272
Tiliaceae	*Grewia mollis Juss.*	Omukoma	0	60	19	25	46	44	29	3	0	226
Asteraceae	*Vernonia amygdalina Delile*	Omubirizi	0	57	78	71	11	0	0	0	0	217
Apocynaceae	*Carissa edulis (Forssk.) Vahl*	Omuyonza	99	28	23	13	5	0	0	0	0	168
Moraceae	*Ficus natalensis Krauss ex Engl.*	Omutooma	0	24	15	23	33	30	27	6	2	160
Fabaceae	*Erythrina abyssinica DC.*	Ekiko	0	0	33	23	37	36	15	1	1	146
Ulmaceae	*Scutia myrtina (Burm. f.) Kurz*	Omugashia	81	15	13	9	18	1	5	0	0	142
Verbanaceae	*Lantana trifolia L.*	Ehuuki	71	4	33	31	3	0	0	0	0	142
Celastraceae	*Maytenus senegalensis (Lam.) Exell*	Omunyabiruku	0	11	42	42	17	15	4	0	0	131
Capparaceae	*Maerua triphylla A. Rich.*	Omwoyante	0	64	23	24	6	2	2	0	0	121
Euphorbeaceae	*Flueggea virosa (Roxb. ex Willd.) Royle*	Omubwera	0	13	34	30	10	8	3	0	0	98
	Euphorbia candelabrum Tremaux ex Kotschy	Enkukulu	0	0	46	29	7	5	2	0	0	89
Ebeneaceae	*Euclea latidens Stapf*	Omusikizi	0	5	18	21	17	15	8	0	0	84
Solanaceae	*Capsicum frutescens L*	Esheka	54	2	15	6	3	0	0	0	0	80
Fabaceae	*Erythrophleum pyrifolia*	Omurama	0	4	18	16	18	14	4	3	0	77

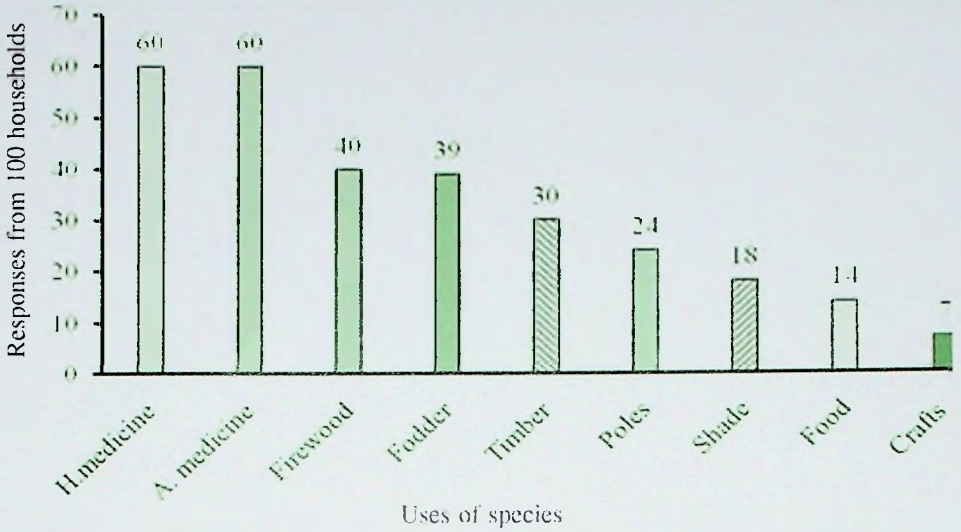

Figure 1. Utilisation of indigenous woody plant species in the pastoralist systems of south-western Uganda.

Table 2. Major indigenous woody species used for different purposes in the pastoralist systems of south-western Uganda

Purpose	Major woody species utilised	Family	Frequency of responses (N=100 households)
Food	*Carissa edulis*	Apocynaceae	99
Timber	*Albizia coriaria*	Fabaceae	79
Human medicine	*Vernonia ammygdalina*	Asteraceae	78
Firewood	*Acacia sieberriana*	Fabaceae	77
Fodder	*Acacia hockii*	Fabaceae	73
Animal medicine	*Vernonia ammygdalina*	Asteraceae	71
Poles	*Acacia sieberiana*	Fabaceae	69
Shade	*Albizia coriaria*	Fabaceae	24
Crafts	*Grewia kakathamnos*	Tiliaceae	3

natalensis and *Scutia myrtina;* while the irregular pattern was constituted by *Hoslundia opposite, Asparagus flagellaris, Carissa macrocarpa, Capparis fascicularis, Clerodendrum myricoides, Duranta erecta., Flueggea virosa., Pluchea ovalis., Lantana. trifolia, Rytigyna macrura* and *Grewia kakothamnos.* (Figs. 3a. and b.).

Among tree species, *Albizia coriaria, Albizia glaberrima, Nuxius congesta, Euclea latidens., Erythrina abyssinica., Gardenia sp., Ficus ovata* and *Croton megalocarpus* had low plant populations

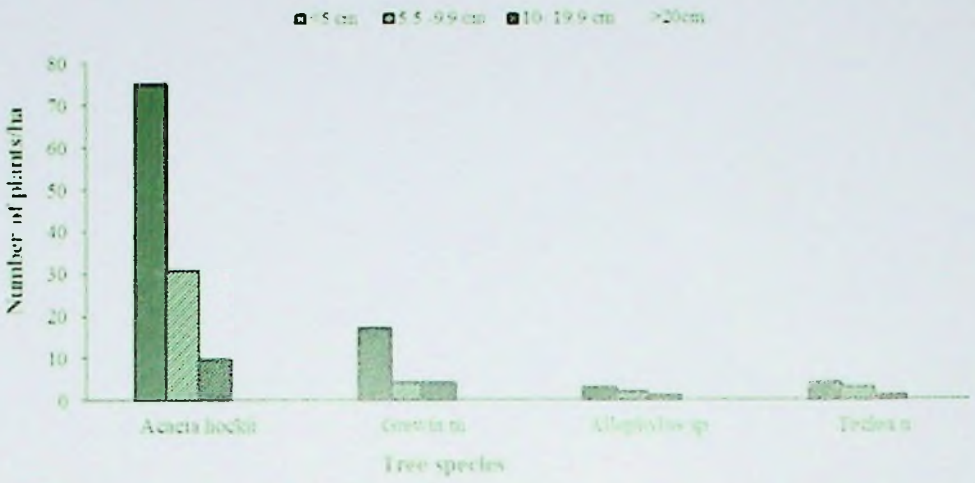

Figure 2a. Inverse J shape population structure of trees in the pastoralist systems of south-western Uganda.

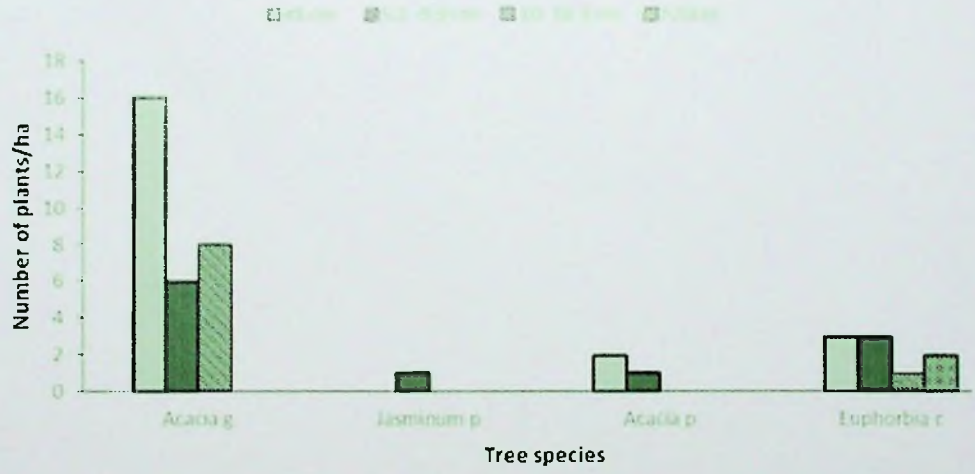

Figure 2b. Bimodal pattern population structure of trees in the pastoralist systems of south-western Uganda.

per hectare, to generate population structure curves which was the case for *Carissa edulis., Microglossa pyrifolia., Solanum renschii., Ehretia cymosa., Maytenus senegalensis, Maytenus heterophylla., Triumfetta rhomboidea* and *Erythrococca bongensis* among shrubs.

Assessment of populations of seedlings using the Braun-Blanquette method revealed that the general pattern for the population of seedlings in trees and shrubs was scale 1 (1-20%) area cover (Fig. 4). This was mainly composed of *Acacia hockii* for trees and *Asparagus*

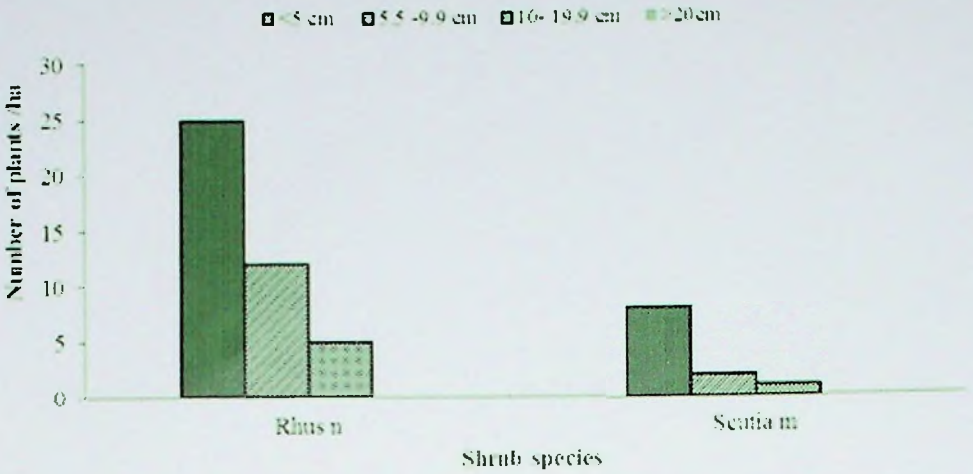

Figure 3a. Inverse J shape population structure of shrubs in the pastoralist systems of south-western Uganda.

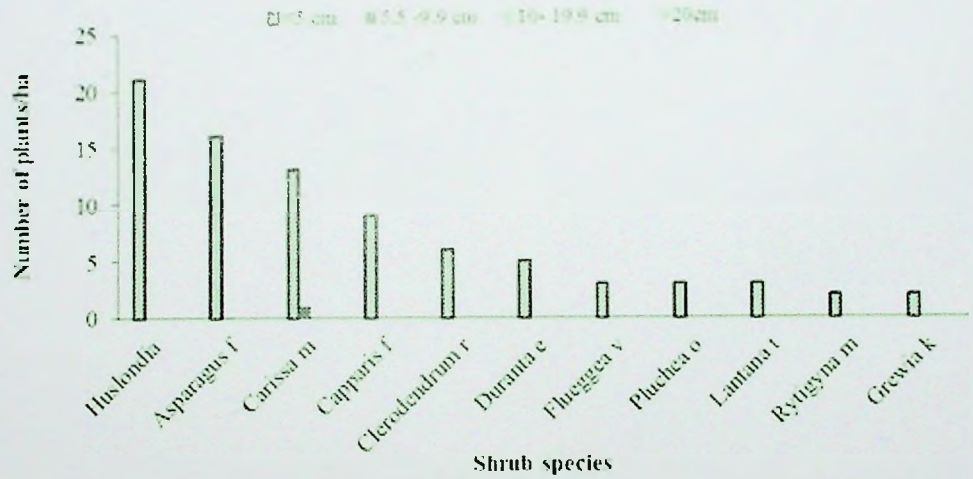

Figure 3b. Irregular shape population structure of shrubs in the pastoralist systems of south-western Uganda.

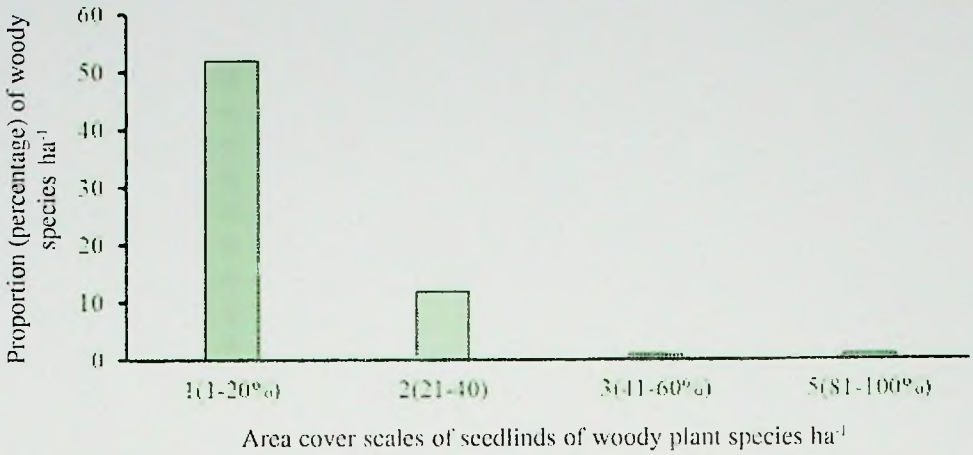

Figure 4. Area cover scales of seedlings of woody plant species per hectare in the pastoralist systems of south-western Uganda according to Braun-Blanquette assessment.

flagellaris, as well as *Grewia kakothamnos* for shrubs.

Discussion

Indigenous woody plant species utilised by the pastoralists

Knowledge of indigenous woody plants used by pastoralists and their patterns of utilisation is important in ensuring sustainable conservation of plant species. The 70 indigenous woody plant species recorded in this study (Table 1s.) and the nine different purposes for which they are utilised reflect the significance of indigenous woody plant species in sustaining the livelihoods of pastoralists. High utilisation of the species was in the order; medicine for humans and livestock, firewood, fodder, timber, poles, shade, food and least in crafts. Similar studies on utilisation of indigenous woody plant species in other communities in Uganda revealed a different pattern from the results of this study. A study by Eilu *et al.* (2007) revealed high utilisation of indigenous plant species in eastern Uganda in the order of food, medicine, firewood, construction, crafts, environmental services, provision of shade, and cultural purposes. The pattern of use of indigenous woody plant species varies across locations, as dictated by their livelihood strategies (Balehegn *et al.*, 2015). Such patterns may have implications regarding conservation of indigenous woody plant species in unprotected sites stemming from varying degree of species utilisation.

The high responses recorded for utilisation of indigenous woody plants as medicines (Fig. 1.) can be attributed to the role such species play in enhancing proper health care to people and curing livestock diseases (Tolossa *et al.*, 2013). Acceptance of traditional medicine by communities and the difficulty to access modern health care facilities in pastoral communities could be the underlying factors for the observed people-plant relationship. As study by Reynold *et al.* (2007) revealed that semi-arid areas where pastoralists operate are often isolate, thus limiting access to services.

The integral role of woody plant species in meeting health care needs provides an important opportunity for enhancing sustainable conservation of these species.

Besides health care needs, the relatively high utilisation of indigenous woody plant species for firewood justifies the current statistics of demand for fuel wood resources (Figure 1). Over 90% of Uganda's rural population depends on woody biomass for their domestic fuel needs. Unsustainable utilisation of woody plant species for fuel wood, especially for commercial purposes is one of the leading challenges for conservation of plant species outside protected areas (Sassen *et al.*, 2015). Such challenges call for identification of strategies that promote sustainable use of fuel wood resources.

More than half of the major indigenous woody plants documented in this study were reported to be sources of fodder (Table 1). This could be attributed to the scarcity of fodder, especially in the dry season. Woody plants provide supplementary feeds to livestock, especially in the dry season when ground forage is lacking (Teklehaimanot *et al.*, 2007). Retention of woody plants as supplementary feed is therefore, an opportunity to enhance conservation of plant species in a sedentary production system while providing social-economic benefits to pastoralists.

Whereas only 14% of the species documented were sources of food in form of fruits and nuts (Table 2), most of the species reported had high frequencies of utilisation from the respondents. For instance, *Carissa edulis* was reported to be a source of food to 99% of the households interviewed. Accoding to McGarry and Shackleton (2009), such information re-emphasises the importance of indigenous wild woody species as safety nets for food security in pastoralism production systems. Promoting large scale production of such species can increase social economic benefits of the species while enhancing conservation.

Population structure of indigenous woody plant species

The inverse J shape displayed in this study by some species of trees and shrubs reflects sustainable conservation status of such species. Mekonen *et al.* (2015) reports that woody plant species display the inverse J-shape of population structure when species' frequency distribution has higher frequencies in the lower diameter classes and a gradual decrease towards the higher classes. In such a pattern there are many seedlings that could be recruited into successive growth stages and therefore enhance sustainable conservation of woody plant species. The population structure patterns of woody plant species provide an important indicator of conservation status of plant species. The action of biotic and abiotic factors to which a population is exposed in the past can be predicted from population structure information (Alexandra, 2007).

Besides the inverse J shape of plant population structure, over 28% of the indigenous woody plant species displayed an irregular pattern of plant population structure with majority being shrubs (Fig. 3b.). Most of the species which constituted this type of population structure in the study had individuals in the lower diameter size class (seedlings) and few or no individuals in subsequent diameter size classes. When species display this kind of diameter size class distribution, it implies that regeneration is not keeping pace with mortality and disturbance above a fixed diameter limit removes woody

plants that could be recruited into bigger size classes (Mekonen *et al.*, 2015). This usually happens if a large number of poles and mature individuals are harvested before seed production to sustain recruitment (Mueller *et al.*, 2005). Such observation could as well explain the relatively large number of species with low populations.

Traditionally, survival of indigenous woody species in pastoralism production systems was permitted by the seasonal migration behavior of pastoralists (Alexandra, 2007). The time lag of no active pastoralism in a particular area ensured natural regeneration and recruitment of woody species in a previously utilised land. In the current sedentary pastoralism, the rate of animal turnover on grazing lands is increasing. livestock populations have not only altered the species composition of these areas but also altered the size class distribution of certain species (Zhao *et al.*, 2007). Such secondary data is further confirmed by the low level of seedling abundance according to Braun Blanquette cover scale.

In relation to conservation status of indigenous woody plant species, conformity of *Allophylus sp.* to the inverse J shape, which species was reported to be useful for all the nine purposes reported in the household survey results indicate deliberate conservation of the species thus the relatively sustainable conservation status. However, *Ficus natalensis* and *Nuxius congesta* which similarly to *Allophylus* sp. had numerous purposes of utilisation (8 purposes) had low individual populations, which depicts unsustainable conservation. Social economic and ecological factors underlying conservation of species which conformed to the inverse J shape need to be explored. These will give insights for sustainable conservation of other woody plant species which displayed a bimodal and irregular patterns of plant population structure as well as species which had low populations to generate population structure graphs.

Conclusion

This study documented a total of 70 indigenous woody plant species utilised by the pastoralists of south western Uganda. Although the major purposes for which the species were utilised was provision of medicine to human and livestock, the plant species were also used to provide firewood, fodder, timber, poles, shade, food and least in crafts. *Allophylus* sp. is found to be useful for all the nine purposes documented. Three types of plant population structure patterns are identified, where most of the trees conform to the Inverse J shape and bimodal patterns; while the shrubs mostly conform to the irregular pattern. The general trend of plant population structure observed does not suggest sustainable conservation status. Sustainable conservation of indigenous woody plant species in a sedentary pastoral system requires aided regeneration that involves supplementing natural regeneration with similar plant species. Further research is needed on propagation pathways of major species to aid regeneration. Zoning of sites with high woody species diversity as well as promotion of community based conservation platforms where pastoralists can be trained on sustainable plant conservation is recommended.

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