academicJournals

Vol. 7(8), pp. 238-246, August, 2015
DOI: 10.5897/JENE2015. 0527
Article Number: 479233854995
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

An inventory and assessment of exotic and native plant species diversity in the Kenyan rangelands: Case study of Narok North Sub-County

Winnie W. Cheche[1], Eunice W. Githae[2]*, Stephen F. Omondi[3] and Adiel M. Magana[2]

[1]School of Natural Resources Management, Maasai Mara University, P. O. Box 861, Narok, Kenya.
[2]Department of Biological Sciences, Chuka University, P. O. Box 109-60400, Chuka, Kenya.
[3]Department of Tree Breeding and Biotechnology, Kenya Forestry Research Institute, P. O. Box 20412-00200, Nairobi, Kenya.

Received 25 May, 2015; Accepted 10 Aug, 2015

A botanical inventory and diversity of exotic and native species was assessed in the rangeland of Narok North sub-County, Kenya. A total of 72 species were recorded, composed of 64 species of trees and shrubs and eight species of herbs. They belonged to 34 families and 52 genera. Fabaceae was the richest family with 16 species, followed by Euphorbiaceae (five), Moraceae and Myrtaceae (four each). In total, 48 species were native and 24 exotics with a diversity index *H* of 1.082 and 0.604, respectively. *Hypericum revolutum,* a native shrub, was the most dominant with an importance value of 3.81, followed by three exotic species; *Datura suaveolens* (an invasive species), *Dovyalis caffra* and *Hibiscus rosa-sinesis* with importance values of 3.40, 3.35 and 3.23, respectively. The native species were abundant in undisturbed areas while the exotics were most common in areas with vegetation cover less than 60%. Four invasive alien species were encountered namely; *D. suaveolens*, *Lantana camara*, *L. trifolia* and *Opuntia ficus-indica*. They all had a high density that indicated greater establishment success. This inventory affirms that the rangelands of Narok North are undergoing serious changes in vegetation structure and composition due to human activities and requires urgent attention to conserve biodiversity and genetic resources.

Key words: Dominance, importance values, invasive species, inventory, semi-arid lands

INTRODUCTION

Human-induced disturbance alter ecosystem structure and function and is likely to cause significant loss of plant diversity. Human activities have altered the frequency and intensity of ecosystem disturbance through the introduction of invasive non-native species that reduce or displace native species (Hobbs and Hueneke, 1992). These introduced species become invasive when they get into new areas where they establish themselves quickly or have other negative effects on the local ecosystem (Hedja et al., 2009). Certain invasive plants

*Corresponding author: egithaeh@gmail.com, egithae@mmarau.ac.ke; Tel: +254 725 286095.

may have higher impacts to ecosystem structure and function as a result of their association with humans, which may enable them to colonize better and persist for a longer period of time (Catford et al., 2012). Their invasion has become a conservation concern and effective ecological management will require a detailed understanding of relationships among disturbance, invasion and diversity (Hulme, 2006).

Rangelands occupy approximately 51% of the earth's surface and supports different vegetation types that are primarily native (Heady and Child, 1994). They are traditionally used for livestock and wildlife production. Despite their potential in providing ecosystem services to rural livelihoods, most rangelands are partially dominated by ''emerging'' ecosystems that arise as a result of direct or indirect human influence, which create opportunities for invasions (Belnap et al., 2012). Although many species have been intentionally introduced to rangelands for their benefits, others may have produced unintended and damaging consequences by threatening native biological diversity and functioning, and may even cause an economic challenge in controlling them (Pauchard and Alaback, 2004; Ditomaso, 2000). They affect grasslands by lowering yield and quality of forage, obstruct grazing, poison or injure animals and this contributes to reduced livestock productivity (Ditomaso, 2000). They also deplete soil and water resources (Dogra et al., 2010). Their expansion into rangelands is mainly attributed to plant traits such as high seed production and dispersal that aids in dominance (Edward et al., 2010), and this invasion is likely to increase with time as exacerbated by changes in land use and climate. However, one potential set of their characteristics that have been poorly studied is their diversity, which is often used as an indicator of vegetation change and ecosystem health in a variety of contexts as well as for development of management actions for conserving biodiversity (Ditomaso, 2000).

Rangelands cover about 85% of the total land surface in Kenya, supporting more than 30% of the Country's population (mainly pastoralists and agro pastoralists) and over 60% of the country's livestock population (GOK, 2007). Despite their potential in socio-economic development, major issues of land degradation and desertification exacerbated by climatic variability and change are extensive (FAO, 2010). They have also been under excessive pressure due to growing population demand and overexploitation for livelihoods and subsistence farming. Nine species have been known to be invasive and out-compete native species thereby deteriorating habitats and ecosystems. Among those threatening and replacing rangeland native species are *Lantana camara* L. (tick berry), *Prosopis juliflora* (Sw.) DC. (mesquite) and *Opuntia* Mill. (prickly pear) (IUCN, 2004). However, knowledge base on these and others in the Kenyan rangelands is quite inadequate and limited (Stadler et al., 2000; GOK, 2007; Obiri, 2011). There is a great need of comprehensive inventory revealing the status and impacts of these species in the Kenyan rangelands, which would contribute significantly in conservation of biodiversity and genetic resources (Pauchard and Alaback, 2004).

Narok County was selected for this study since it is among the Kenyan rangelands that are of economic importance and located in the southern parts of Kenya. The area hosts several biodiversity hot spots including the Maasai Mara Game reserve that is of particular importance for conservation. About 60% of the households fall below poverty line and highly depend on rangeland-based livestock systems (National Environment Management Authority [NEMA], 2009). These systems have been threatened by the current encroachment of land-use changes including urbanization and agricultural activities that have reduced grazing resources (Fratkin, 2001). Due to this encroachment, land has become degraded and adversely affected by invasive alien plant species (Maina, 2013). The objective of this study was therefore to assess diversity, density, frequency and cover of both exotic and native plant species in the rangelands of Narok North area. In addition, the study was to document and enumerate the non-native plant species of invasive character and to generate awareness about their adverse impacts. A checklist of plant species encountered has been established for future reference. This is the first study to carry out a botanical inventory in this area.

MATERIALS AND METHODS

Study area

Narok County covers an area of 15,087.8 km^2 and lies between latitudes 0°50' and 2°05' South and longitudes 35°58' and 36°0' East (Figure 1). The Narok North occupies an area of about 1045 km^2. The climate is semi-arid with a bimodal pattern of rainfall with long rains (March – June) and short rains (September-November) and averaging 500 mm per annum or less (NEMA, 2009). Temperatures vary widely throughout the year and range from 5 to 20°C per annum. The soils are shallow and poorly drained with the main livelihoods being livestock-based systems. Topography is about 1000 m above sea level and dominated by typical dryland species (Reed et al., 2009). The area is also rich in wildlife that is reported to improve the country's tourism industry (GOK, 2007).

Vegetation sampling and description

This study combined two essential methods of vegetation sampling; transect sampling (using a single line) and quadrat sampling (counted within a frame). This was in order to gather information in a standardized way and to provide more accurate data with minimal time. Three line transects of one km long were laid in different levels of vegetation cover where vegetation communities did not change with distance. Cover was estimated by Daubenmire cover scale of 1 to 5 where 1 = less than 20% cover, 2 = 20-40% cover, 3 = 41-60%, cover, 4 = 61-80% cover, and 5 = 81-100% cover (Bonham et al., 2004). Cover was related with disturbance because land use change was one of the main causes of vegetation cover in this region. Transect A was placed in heavily disturbed vegetation

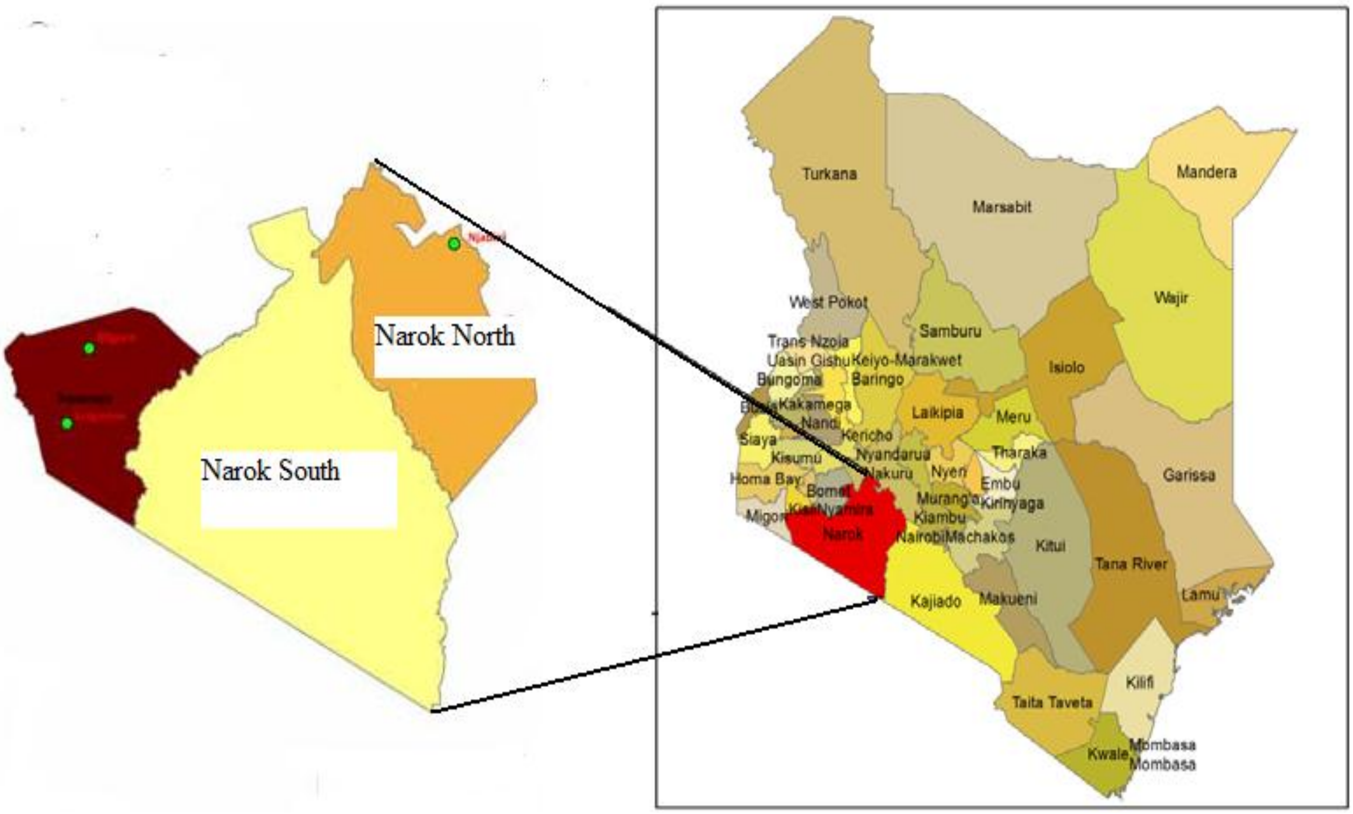

Figure 1. Map of Kenya showing the location of the study site.

with less than 40% cover, B in vegetation with little disturbance (above 60% vegetation cover), while C was located in an intermediate area with 41-60% cover.

An inventory of trees, shrubs and herbs was carried out in 25 × 25 m plots within transects at an interval of 50 m apart to enumerate both exotic and native plant species. In each plot, the number of individual species were counted and recorded. The height and diameter at breast height (≥ 5 cm) of trees and shrubs was measured. In total, 60 vegetation plots were sampled. For each species, relative density (Rd) was calculated as the number of individuals of a species divided by the total number of individuals of all species multiplied by a hundred. Relative frequency (Rf) was calculated as the frequency of a species divided by the sum of frequencies of all species multiplied by a hundred, relative dominance (RD) is the basal cover and was calculated as the basal area of a species divided by the sum of basal area of all species multiplied by a hundred while importance value (IVI) was the summation of the relative frequency, relative density and relative dominance (Curtis, 1959). Diversity of the plant community was described by means of the Shannon-Wiener index (H) (Shannon and Wiener 1963). Data was analyzed using Biodiversity-R software (Kindt and Coe, 2005). Documentation of the exotic species of invasive character and their adverse impacts was evaluated using literature from various sources.

RESULTS AND DISCUSSION

Species richness and diversity

Plant species richness and diversity are two characteristics that are useful and appropriate in maintaining biodiversity in rangelands. A total of 72 species of trees and shrubs were recorded including 64 species of trees and shrubs and eight species of herbs. They belonged to 34 families and 52 genera (Table 1). The high species richness observed could have been attributed to the introduction of exotic species by humans or by disturbance. It is reported that moderate frequencies or intensities of disturbance promote maximum species richness (Hobbs and Hueneke, 1992). For example, grazing is described to maximize the richness of herbaceous species by reducing the highly preferred species and increasing the superior unpalatable competitors (Kamau, 2004). Other observational studies have found that habitats with higher species diversity are actually more invaded (Liu et al., 2005).

Plant families are a useful way to group vegetation according to differences in environmental adaptation (Dale et al., 2002). The richest family was Fabaceae with 16 species; with more than 60% belonging to the genus *Acacia*- a typical drought tolerant nitrogen-fixing dryland species. This is similar to that observed in the rangelands of Laikipia in Northern Kenya where shrub encroachment primarily *Acacia* species have been increasing due to suppression of wild fires (Augustine, 2003). In rehabilitating degraded lands, these species are reported to increase soil nutrients with time especially carbon and

Table 1. A checklist of plant species encountered in the rangelands of Narok North sub-County arranged in alphabetical order of families.

Family	Species name	Habit	Origin
Acanthaceae	*Acanthus eminens* C.B. Cl	Herb	Native
Amaranthaceae	*Achyranthes aspera* L.	Herb	Native
Anacardiaceae	*Rothmannia urcelliformis* (Hiern) Robyns	Tree	Native
	Schinus molle L.	Shrub	Exotic
Apocynaceae	*Thevetia peruviana* (Pers.) K. Schum.	Tree	Native
Arecaceae	*Phoenix reclinata* Jacq.	Tree	Exotic
Asteraceae	*Psiadia punctulata* (D.C.) Vatke	Shrub	Native
	Tarchonanthus camphorates L.	Shrub	Native
	Solanecio manni (Hook.f.) C. Jeffrey	Herb	Native
Bignoniaceae	*Jacaranda mimosifolia* D. Don.	Tree	Exotic
	Markhamia lutea (Benth.) K. Shum	Tree	Native
Burseraceae	*Commiphora campestris* Chiov.	Tree	Native
Cactaceae	*Opuntia ficus-indica* (L.) Mill	Shrub	Exotic
	Quibentia chacoensis Backeb.	Shrub	Native
Canellaceae	*Warburgia ugandensis* Sprague	Tree	Native
Compositae	*Aspilia pluriseta* Schweinf.	Herb	Native
	Plectranthus barbatus Andr.	Herb	Native
Cupressaceae	*Juniperus procera* Endl.	Tree	Native
Euphorbiaceae	*Croton dichogamus* Pax	Shrub	Native
	Croton megalocarpus Hutch.	Tree	Native
	Euphorbia candelabrum Kotschy	Tree	Native
	Euphorbia heterochroma Pax	Shrub	Native
	Ricinus communis L.	Shrub	Native
Fabaceae	*Acacia abyssinica* Benth.	Shrub	Native
	Acacia brevispica Harms	Shrub	Native
	Acacia drepanolabium Sjøstedt	Shrub	Native
	Acacia gerrardii Benth.	Shrub	Native
	Acacia hockii De Wild.	Shrub	Native
	Acacia kirkii Oliv.	Shrub	Native
	Acacia nilotica (L.) Del.	Shrub	Native
	Acacia senegal (L.) Willd.	Tree	Native
	Acacia seyal Del.	Tree	Native
	Acacia xanthophlea Benth.	Tree	Native
	Albizia amara (Roxb.) Boiv.	Tree	Native
	Albizia gummifera (J.F Gmel.) C.A. Sm	Tree	Native
	Albizia lebbeck (L.) Benth.	Tree	Exotic
	Bauhinia variegata L.	Tree	Exotic
	Mimosa pigra L.	Shrub	Native
	Senna didymobotrya (Fresen.) Irwin & Barneby	Shrub	Native
Flacourtiaceae	*Dovyalis caffra* (Warb.)	Shrub	Exotic
	Dovyalis macrocalyx (Oliv.) Warb.	Shrub	Exotic
Guttiferae	*Hypericum revolutum* Vahl.	Shrub	Native

Table 1. Contd.

Family	Species name	Habit	Origin
Labiatae	*Ocimum suave* Willd.	Shrub	Native
	Leonotis mollissima Gürke	Herb	Native
	Plectranthus barbatus Andr.	Herb	Native
Lauracea	*Persea americana* Mill	Tree	Exotic
Malvaceae	*Hibiscus rosa-sinesis* L.	Shrub	Exotic
Moraceae	*Ficus elastica* Roxb. ex Hornem.	Tree	Exotic
	Ficus sur Forssk.	Tree	Native
	Ficus sycomorous L.	Tree	Native
	Ficus thonningii Bl.	Tree	Native
Musaceae	*Ensete edule* (J.F. Gmel.) Horan	Tree	Native
Myrtaceae	*Callistemon citrinus* (Curtis) Skeels	Shrub	Exotic
	Eucalyptus citriodora Hook.	Tree	Exotic
	Eucalyptus globulus Labill.	Tree	Exotic
	Eucalyptus maculata (J.D.Hooker) Hill & Johnson.	Tree	Exotic
Nyctaginaceae	*Bougainvillea glabra* Choisy.	Shrub	Exotic
Olacaceae	*Ximenia americana* L.	Shrub	Native
Poaceae	*Bambusa vulgaris* Schrad. ex J. C. Wendl.	Tree	Exotic
Podocarpaceae	*Podocarpus falcatus* Mirb.	Shrub	Native
Proteaceae	*Grevillea robusta* A. Cunn.	Tree	Exotic
Rhamnaceae	*Ziziphus mucronata* Willd.	Tree	Native
Rosacea	*Eriobotrya japonica* (Thunb.) Lindley.	Tree	Exotic
Rubiaceae	*Rotheca myricoides* (Hochst.) Steane & Mabb.	Shrub	Native
Rutaceae	*Citrus sinensis* (L.) Osbeck,	Tree	Exotic
	Vepris glomerata (F. Hoffm) Engl.	Tree	Native
	Zanthoxylum chalybeum Engl.	Shrub	Native
Scrophulariaceae	*Cycnium tubulosum* (L.f.) Engl.	Herb	Native
Solanaceae	*Datura suaveolens* Willd.	Shrub	Exotic
	Solanum incanum L.	Shrub	Native
Verbenaceae	*Lantana camara* L.	Shrub	Exotic
	Lantana trifolia L.	Shrub	Exotic

nitrogen (Brockwell et al., 2005; Raddad et al., 2005; Macedo et al., 2007).

Others are of economic importance such as *A. senegal*, which is valued for its exudate named "gum arabic'' that is used internationally in the processed food (confectionary, beverages, baked products and dry packaged products), pharmaceuticals (as carriers in capsules and in highly soluble fiber supplements) and cosmetics (creams and lotions) industries.

The gum is also widely used in the manufacture of dyes, polish, glues and thickeners because of its unique emulsification (Maundu and Tengnäs, 2005). This indicates the potential of *Acacia* species in providing both environmental and socio-economic benefits to dryland communities if properly managed.

The second largest family was Euphorbiaceae with five species (all native) followed by Moraceae and Myrtaceae (all exotics) with four species each (Table 1). The rest of the families were represented by less than three species. Species of Euphorbiaceae are reported to produce different compounds of industrial and medicinal purposes (Rizk, 2008; Rahman and Akter, 2014).

Native plant species of economic importance

A total of 40 native trees and shrubs were encountered

Table 2. Species of native trees and shrubs encountered in the study area with their relative density (Rd), relative frequency (Rf), relative dominance (RD) and importance value index (IVI); arranged from the highest to the lowest IVI.

Species name	Rd	Rf	RD	IVI
Hypericum revolutum	3.80	0.01	0.01	3.82
Euphorbia candelabrum	3.15	0.01	0.03	3.19
Ziziphus mucronata	3.06	0.01	0.04	3.11
Euphorbia heterochroma	3.06	0.01	0.02	3.09
Mimosa pigra	3.06	0.02	0.01	3.09
Ocimum suave	3.06	0.02	0.01	3.09
Podocarpus falcatus	3.06	0.02	0.01	3.09
Quibentia chacoensis	3.06	0.02	0.01	3.09
Ricinus communis	3.06	0.02	0.01	3.09
Rotheca myricoides	3.06	0.02	0.01	3.09
Senna didymobotrya	3.06	0.02	0.01	3.09
Tarchonanthus camphoratus	3.06	0.02	0.01	3.09
Croton megalocarpus	2.75	0.02	0.03	2.80
Zanthoxylum chalybeum	2.45	0.02	0.01	2.48
Acacia xanthophlea	0.79	0.02	0.04	0.84
Acacia abyssinica	0.31	0.02	0.05	0.37
Albizia gummifera	0.31	0.00	0.03	0.35
Acacia gerrardii	0.29	0.01	0.04	0.35
Markhamia lutea	0.30	0.02	0.02	0.34
Vepris glomerata	0.29	0.01	0.04	0.34
Solanum incanum	0.31	0.02	0.01	0.34
Ensete edule	0.29	0.01	0.01	0.31
Ficus thonningii	0.23	0.02	0.01	0.26
Acacia brevispica	0.23	0.02	0.01	0.26
Acacia nilotica	0.24	0.01	0.01	0.26
Ficus sycomorous	0.23	0.01	0.01	0.25
Rothmannia urelliformis	0.23	0.01	0.01	0.25
Acacia drepanolabium	0.16	0.01	0.05	0.22
Juniperus procera	0.15	0.02	0.05	0.22
Warburgia ugandensis	0.16	0.01	0.05	0.22
Commiphora campestris	0.15	0.01	0.04	0.21
Ximenia Americana	0.18	0.00	0.01	0.20
Albizia amara	0.15	0.00	0.01	0.17
Acacia hockii	0.13	0.01	0.01	0.16
Acacia senegal	0.07	0.02	0.04	0.12
Croton dichogamus	0.10	0.01	0.01	0.12
Acacia seyal	0.10	0.01	0.01	0.12
Ficus sur	0.07	0.02	0.01	0.10
Acacia kirkii	0.07	0.01	0.01	0.09
Albizia lebbeck	0.03	0.01	0.03	0.07

(Table 2). The IVI ranged from 3.82 to 0.07 with a species diversity index *H*'=1.082. These species did not show greater richness in the most disturbed plots but were most common in those that had more than 60% vegetation cover. This suggests that native plant species richness was mainly determined by the natural conditions of the regions (Liu et al., 2005). The most common species were shrubs namely; *Hypericum revolutum*, followed by *Euphorbia candelabrum* (IVI=3.19) and *Ziziphus mucronata* (IVI=3.11). *Hypericum revolutum* (commonly known as St. Johns wort) is reported to maintain soil fertility and also provide other environmental and socio-economic benefits. For example in Ethiopia, the tree is retained in the farmlands of the local people to

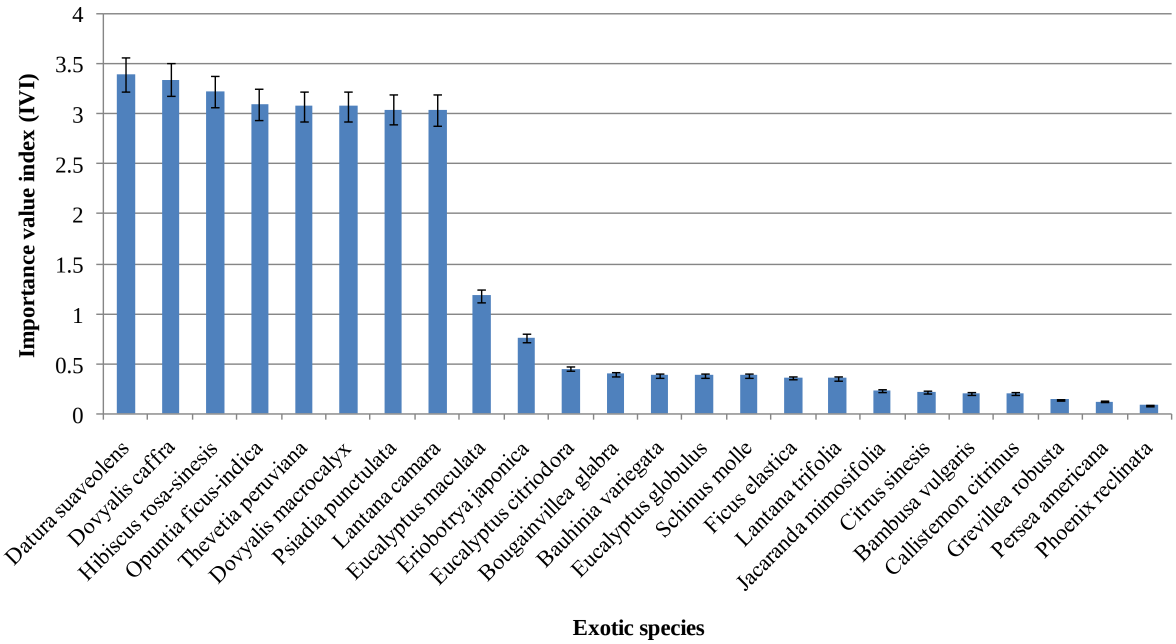

Figure 2. Species of exotic trees and shrubs encountered in the study area showing their importance value index (IVI).

improve livelihoods (Kewessa et al., 2015). Furthermore, *Hypericum* products are marketed as dietary supplements and majority of the species are cultivated as ornamentals and various hybrids and cultivars have been developed for use in horticulture (Nürk, 2011). This indicates its potential for dryland agroforestry programmes to improve the rural livelihoods and the environment. However, some species such as *H. perforatum*, *H. canariense* and *H. androsaemum* are commonly found in disturbed areas and recognized as invasive species in the rangelands of USA, Australia and New Zealand that lower the yield and quality of forage (Ditomaso, 2000). On the other hand *E. candelabrum* and *Z. mucronata* are most common in dry areas, are resistant to drought and perform well in sandy soils (Orwa et al., 2009).

Tree species of economic importance were also found although they had a very low density ranging from 0.79 – 0.03 (Table 1). These were *Acacia* and *Albizia* species, *J. procera*, *W. ugandensis*, *C. dichogamous,* among others. The low density indicates their elimination due to the increasing demand for fuel wood, charcoal and timber, which has led to loss of vegetation cover (Maina, 2013). On the other hand, invasive species have been shown to reduce species richness and diversity of native plants. For example, invasive *Euphorbia esula* is reported to reduce native species richness by almost 75% in a mixed-grass prairie (Belcher and Wilson, 1989).

Indicators of anthropogenic disturbance

Plant species reported to be indicators of disturbance were identified in this study including all the eight woody herb species (*Acanthus eminens, Achyranthes aspera, Solanecio manni, Aspilia pluriseta, Plectranthus barbatus, Leonotis mollissima, Plectranthus barbatus* and *Cycnium tubulosum*) and other shrubs namely; *Solanum incanum*, *Ocimum suave, Ricinus communis* and *Tarchonanthus camphorates.* Their densities were high above 3.0 and were most common in exposed canopies and disturbed roadside vegetation where cover was below 40%. These indicator species can be used to assess the condition of the range and provide early warning signs of vegetation change and the causes of the problem. They provide a useful tool for improving understanding of ecological effects and for monitoring and management (Dale et al., 2002). On the other hand, roadsides indicate potential range of invasion since they are the first to be colonized by exotic species and the starting points of spread to undisturbed habitats (Pauchard and Alaback, 2004). The absence of exotic herbs might have been due to the inability to adapt to the harsh climatic conditions of the rangeland or elimination by grazing.

Exotic species of invasive character and their adverse impacts

A total of 24 exotic trees and shrubs were encountered and sampled as show in Figure 2. They were most common in degraded areas with less than 40% vegetation cover. The high number of exotic species observed, suggest that they might have been introduced in the rangelands by human activities, either intentionally or un-intentionally for various purposes. The IVI of all the exotic species ranged from 3.39 to 0.08 with a species diversity index *H* of 0.604. The presence of exotic species in native communities is an indication of disturbance where soil has been exposed (Antonio and Meyerson, 2002). The most common species were *Datura suaveolens* (an invasive species) with an IVI of 3.39, followed by *Dovyalis caffra* and *Hibiscus rosa-sinesis* with importance values of 3.34 and 3.22, respectively (Figure 2). These three species were among the most common following the native *H. revolutum*. *Datura suaveolens* was found mainly in open bush-lands and is commonly used as an ornamental plant or live fence. *Hibiscus rosa-sinesis* on the other hand is extensively cultivated as an ornamental plant and its persistence in natural conditions is mainly associated with its strong root system (Kumar and Singh, 2012). The other common exotic species were *Opuntia ficus-indica*, *Thevetia peruviana*, *Dovyalis macrocalyx*, *Psiadia punctulata* and *Lantana camara*. All these were introduced as ornamental plants. This study complements the general opinion that human activities have an important influence on the diversity and cover of exotic plants (Liu et al., 2005), with the main contributor being the ornamental horticulture industry (Niemiera and Holle, 2009).

Exotic species recorded in this study that have been classified as invasive alien species by IUCN (2004) are *Datura suaveolens*, *Lantana camara, L. trifolia* and *Opuntia ficus-indica*. They had a high density with an IVI greater than 3.0 (Table 2). Exotic species that can rapidly achieve high densities may have greater establishment success and dominate invaded communities to the exclusion of native species (Dogra et al., 2010). These are responsible for extensive and unpredictable irreversible changes to the natural habitats. Invasion of these species is reported to be very high particularly in shrub-lands and woodlands located near urban areas (Vila` et al., 2003). The findings of this study are similar to those of Maina (2013) who reported that invasive species associated with overgrazing were well established in the rangelands of Narok County and included species of *Solanum*, *Datura*, and *Lantana*.

According to observations by NEMA (2009), species of *Lantana* and *Opuntia* are the most prominent invasive species in Narok rangelands that reduce pasture and biodiversity. The shoots and roots of *Lantana* are reported to produce allelopathic substances that replace native species of grasses and herbs (Tiwari et al., 2005). The replacement of native pastures by *Lantana* is reported to threaten the habitat of antelope in Kenya. In some parts of the world, the species is alleged to invade pasture and grazing lands and has threatened and caused extinction of many native species (Sankaran, 2015).

According to a report by Sankaran (2015) the species also interferes with crop harvesting and has been identified as a potential threat to more than 60 plant and animal species of conservation significance in Queensland. Another serious invasive plant is the *Opuntia ficus-indica* (prickly pear cactus), which is famous for the spines that cause injury to animals and humans. It was introduced as a hedge plant but it spreads rapidly and is blamed for destroying grazing land in the Kenyan and Tanzanian rangelands (Obiri, 2011).

Seeds can remain viable in the soil for several years and the plants are resistant to high temperatures and strong winds. Climatic models predict its increase in productivity and invasion with rising temperatures and atmospheric carbon (Monteiro et al., 2005). In the Northern rangelands of Kenya, bio-control of *Opuntia* species by cochineal beetle (*Dactylopius opuntiae*) was recently introduced in order to reduce invasion (CABI, 2015).

Conclusion and recommendation

This study indicates that the rangelands of Narok North have high species diversity with both native and exotic species. However, several native tree species of environmental and socio-economic value are threatened by human activities and therefore should be conserved. Pressure for wood and non-wood products can be alleviated through introduction of appropriate agroforestry practices. About 30% of the encountered species were exotic species that might have been introduced in the rangelands by human activities for various purposes. Those that are invasive may pose a serious threat to the ecosystem structure and function and might spread to the nearby biodiversity hot spots, which consequently may lead to loss of biodiversity. These should be monitored and properly managed to prevent further invasion. Numerous mechanical and cultural control options have been developed to manage these species in the rangelands and include mowing, prescribed burning, timely grazing and perennial grass reseeding (Ditomaso, 2000). The local communities should be involved in management plans through participatory approaches that can improve their livelihoods while simultaneously conserving plant genetic resources.

Conflict of interests

The authors did not declare any conflict of interest.

ACKNOWLEDGEMENTS

This study was a fourth year research project conducted as a partial fulfillment of Bachelor of Science degree in Wildlife Management in Maasai Mara University and was self-funded. The authors are grateful to Maasai Mara University and the surrounding communities for their support throughout the study period.

REFERENCES

Antonio CD, Meyerson LA (2002). Exotic plant species as problems and solutions in ecological restoration: a synthesi. Restor. Ecol. 10:703-713. http://dx.doi.org/10.1046/j.1526-100X.2002.01051.x

Augustine DJ (2003). Spatial heterogeneity in the herbaceous layer of a semi-arid savanna ecosystem. Plant Ecol. 167: 319-332. http://dx.doi.org/10.1023/A:1023927512590

Belcher JW, Wilson SD (1989). Leafy spurge and species composition of a mixed-grass prairie. J. Range Manage. 42:172-175. http://dx.doi.org/10.2307/3899318

Belnap J, Ludwig JA, Wilcox BP, Betancourt JL, Richard W, Dean J, Hoffmann BD, Milton SJ (2012). Introduced and Invasive Species in Novel Rangeland Ecosystems: Friends or Foes? Rangeland Ecol. Manage. 65:569-578. http://dx.doi.org/10.2111/REM-D-11-00157.1

Bonham CD, Mergen DE, Montoya S (2004). Plant cover estimation: a contiguous Daubenmire frame. Rangelands 26:17-22. http://dx.doi.org/10.2111/1551-501X(2004)26[17:PCEACD]2.0.CO;2

Brockwell J, Searle SD, Jeavons AC, Waayers M (2005). Nitrogen fixation in acacias: an untapped resource for sustainable plantations, farm forestry and land reclamation. ACIAR Monograph No. 115, 132p.

CABI (2015). Improving lives by solving problems in agriculture and the environment: Sap-sucking insects save livelihoods in Kenya http://www.cabi.org/news-and-media/2015/sap-sucking-insects-save-livelihoods-in-kenya/

Catford J, Vesk P, Richardson DM, Pyšek P (2012). Quantifying invasion level: towards the objective classification of invaded and invasible ecosystems. Global Change Biol. 18: 44-62. http://dx.doi.org/10.1111/j.1365-2486.2011.02549.x

Curtis JT (1959). The Vegetation of Wisconsin. An Ordination of plant communities, University Wisconsin press, Madison Wisconsin, 657p.

Dale A, Suzanne C, Beyeler VH, Jackson B (2002). Understory vegetation indicators of anthropogenic disturbance in longleaf pine forests at Fort Benning, Georgia, USA Ecol. Indicators 1: 155-170. http://dx.doi.org/10.1016/S1470-160X(01)00014-0

Ditomaso JM (2000). Invasive weeds in rangelands: Species, impacts, and management. Weed Sci. 48: 255-265. http://dx.doi.org/10.1614/0043-1745(2000)048[0255:IWIRSI]2.0.CO;2

Dogra KS, Sood SK, Dobha PK, Sharma, S (2010). Alien plant invasive and their impact on indigenous species at a global scale: a review. J. Ecol. Nat. Environ. 2: 175-186.

Edward AV, James JJ, Monaco TA, Cummings DC (2010). Invasive plants on rangelands: a global threat. Soc. Range Manage. 666: 1-5.

FAO (2010). Guidelines on sustainable forest management in drylands of sub-Saharan Africa. Arid Zone Forests and Forestry Working Paper No 1. Rome.

Fratkin E (2001). East African pastoralism in transition: Maasai, Boran and Rendille Cases. Afr. Stud. Rev. 44: 1-25. http://dx.doi.org/10.2307/525591

GOK (2007). The Vision 2030, Nairobi, Kenya: Government of Kenya.

Heady FH, Child RD (1994). Rangeland Ecology and Management. Westview Press, Boulder, Colorado.

Hobbs RJ, Hueneke LF (1992) Disturbance, diversity, and invasion: Implications for conservation. Conserv. Biol. 6: 324-337. http://dx.doi.org/10.1046/j.1523-1739.1992.06030324.x

Hulme PE (2006). Beyond control: wider implications for the management of biological invasions. J. Appl. Ecol. 43: 835–847. http://dx.doi.org/10.1111/j.1365-2664.2006.01227.x

IUCN (2004). Global invasive species database. IUCN – the World Conservation Union species survival commission, Invasive Species Specialist Group. IUCN.

Kamau P (2004). Forage diversity and impact of grazing management on rangeland ecosystems in Mbeere District, Kenya. LUCID Working Paper, no. 36. Nairobi (Kenya): ILRI

Kewessa L. Tiki L, Molla A (2015). Effects of Hypericum revolutum (Vahl) tree on major soil nutrients and selected soil physico-chemical properties in Goba district, Oromia, Ethiopia. J. Agric. Res. 4: 006-013.

Kindt R, Coe R (2005). Tree diversity analysis. A manual and software for some common statistical methods for biodiversity and ecological analysis. World Agroforestry Centre (ICRAF), Nairobi.

Kumar A, Singh A (2012). Review on Hibiscus rosa sinensis. Intern J Research Pharm Biomed Scie 3: 534-538.

Liu J, Liang SC, Liu FH, Wang RQ, Dong M (2005). Invasive alien plant species in China: regional distribution patterns. Divers Distrib. 11: 341-347. http://dx.doi.org/10.1111/j.1366-9516.2005.00162.x

Maina JG (2013). Mainstreaming sustainable land management in agropastoral production systems of Kenya, Narok project target area baseline survey report. United Nations Development Programme (UNDP), Nairobi, Kenya.

Maundu P, Tengnäs B (2005). Useful trees and shrubs for Kenya. World Agroforestry Centre Eastern and Central Africa Regional Programme (ICRAF-CEA), Nairobi, Kenya.

Monteiro A, Cheia VM, Vasconcelos T, Moreira I (2005) Management of the invasive species Opuntia stricta in a Botanical Reserve in Portugal. Weed Res. 45:193-201. http://dx.doi.org/10.1111/j.1365-3180.2005.00453.x

NEMA (2009). Narok District Environment Action Plan 2009-2013. National Environment Management Authority (NEMA), Nairobi, Kenya.

Niemiera AX, Von HB (2009). Invasive plant species and the ornamental horticulture industry. Manage Invasive Weeds 9: 167-187. http://dx.doi.org/10.1007/978-1-4020-9202-2_9

Nürk NM (2011). Phylogenetic analyses in St. John's wort (Hypericum) inferring character evolution and historical biogeography. Dissertation, Freien Universität Berlin, Germany.

Obiri J F (2011). Invasive plant species and their disaster-effects in dry tropical forests and rangelands of Kenya and Tanzania. J Disaster Risk Stud. 3: 417-428. http://dx.doi.org/10.4102/jamba.v3i2.39

Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A (2009). Agroforestree database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/)

Pauchard A, Alabark PB (2004). Influence of elevation, land use and landscape context on patterns of alien plant invasion along roadsides in protected areas of South-Central Chile. Conserv Biol 18: 238-245. http://dx.doi.org/10.1111/j.1523-1739.2004.00300.x

Raddad EY, Salih AA, El Fadl AA, Kaarakka V, Luukkanen O (2005). Symbiotic nitrogen fixation in eight Acacia senegal provenances in dryland clays of the Blue Nile Sudan estimated by the 15N natural abundance method. Plant and Soil, 275: 261-269. http://dx.doi.org/10.1007/s11104-005-2152-4

Rahman HM, Akter M (2013). Taxonomy and Medicinal Uses of Euphorbiaceae (Spurge) Family of Rajshahi, Bangladesh. Res. Plant Sci.1: 74-80.

Reed DN, Anderson TM, Dempewolf J, Metzger K, Serneels S (2009). The spatial distribution of vegetation types in the Serengeti ecosystem: The influences of rainfall and topographic relief on vegetation patch characteristics. J. Biogeo 36: 770-782. http://dx.doi.org/10.1111/j.1365-2699.2008.02017.x

Rizk AM (2008). The chemical constituents and economic plants of the Euphorbiaceae. Bot. J. Lin. Soc. 94:293-326. http://dx.doi.org/10.1111/j.1095-8339.1987.tb01052.x

Sankaran KV (2015). Lantana camara Asia - Pacific Forest Invasive Species Network, Food and Agriculture Organization of the United Nations (FAO) and USDA Forest Service.

Shannon CE, Wiener W (1963). The Mathematical Theory of Communication. University of Illinois press, Urbana. pp. 1-117.

Stadler J, Trefflich A, Klotz S, Brandl R (2000). Exotic plant species invade diversity hot spots: the alien flora of northwestern Kenya. Ecography 23: 169-176. http://dx.doi.org/10.1111/j.1600-0587.2000.tb00272.x

Tiwari S, Siwakoti M, Adhikari B, Subedi K (2005). An inventory and assessment of invasive alien plant species of Nepal. IUCN - The World Conservation Union, Nepal.

Vila` M, Burriel JA, Pino J (2003). Association between Opuntia species invasion and changes in land-cover in the Mediterranean region. Global Change Biol. 9: 1234-239. http://dx.doi.org/10.1046/j.1365-2486.2003.00652.x