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Identification of Plant Species along the Riparian Corridor of the Iguameti Stream in Laikipia County Kenya

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Abstract
This study presents the first characterization of riparian vegetation on Iguameti Stream as well as a description of anthropogenic activities within the riparian corridor. Study points fell within the upper reaches of the stream within Laikipia University and lower reaches with a high density of human settlements and farming activities. Sample plots (30m×10m) in the upper and lower reaches of the stream were selected in the phytocoenoses of the study area in such a way that each sample plot was visually homogenous and that all floristic variation in the area was sampled. Based on physiognomical classification, three types of vegetation formations were identified: afromontane forest, woodland and swamp vegetation. Human activities include: introduction of exotic species; timber harvesting; damming; stream channelization; livestock grazing; and land tillage. The upper reaches exhibited minimal disturbance, a detailed vertical stratification with ample canopy, understory, shrub, herb layer, and ground cover dominated by indigenous vegetation. *Trichocladus ellipticus*, *Allophylus* sp., *Teclea* sp, *Dombeya goetzinii*, *Ficus natalensis*, *Rhus natalensis*, *Pavonia urens* and *Cyathula cylindrical* were dominant, while in the lower reaches, *Pittosporum viridiflorum*, *Cupressus* sp., *Eucalyptus* sp., *Crotalaria agatiflora*, *Rhus natalensis*, *Hibiscus fuscus*, *Hypoestis verticillaris* and *Rubus* sp. were dominant. Species loss was reported in the lower reaches where the buffer strips <5m on the left and right banks compared to >20m in the upper reaches. Steam damming has caused replacement of riparian vegetation with wetland plants like *Crassula schimperi*, *Hydrocotyl* sp., *Oenanthe palustris*, *Sphaeranthus steetzi*, *Rorippa* sp., *Polygonum pulchrum*, *Typha* sp. and sedges mainly *Cyperus* spp. and *Fimbristylis* sp. Canopy cover decreased from >90% in the upper reaches to < 60% in the lower reaches. Riparian vegetation loss in the upper reaches may cause habitat loss for *Colobus guereza kikuyuensis* and *Aonyx capensis*. Urgent strategic multi-disciplinary management of the riparian zone is needed to limit biodiversity loss.

Keywords: Biodiversity conservation, climate change, Laikipia County, riparian vegetation, species loss

Introduction

The global increase in human population and the resultant effect on aquatic ecosystems (Masese et al., 2009) continues to concern natural resource stakeholders. Anthropogenic impacts on aquatic ecosystems pile pressure specifically on freshwater sources whose composition is only 2.5 percent of the total global water mass with about 68.7 percent of this being locked up in ice caps, 29.9 percent in ground water, and only 0.26 percent occurring in lakes and reservoirs (M'Erimba et al., 2014). In Kenya, the distribution of freshwater resource is limited both spatially and temporally

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imposing immense strain on the already scarce resource (Masese et al., 2009; M'Erimba et al., 2014). On the other hand, these are delicate ecosystems which have increasingly lost their integrity and health due to immense anthropogenic utilization pressures (Masese et al., 2009). Rivers and streams integrate effects of land use practices hence suffer impacts of activities in their drainage basins, and they therefore provide a perfect platform to evaluate the environmental health of the drainage basin (Masese et al., 2009). The environmental health of the streams and rivers thus becomes an issue of utmost concern.

The health of a river is measured in terms of its ability of the ecosystem to support and maintain key ecological processes and a community of organisms with a species composition, diversity, and functional organization as comparable as possible to that of undisturbed habitats within the region (M'Erimba 2014). Key land use activities in drainage basins that negatively affect the health of rivers and streams include rapid expansion of farmlands, and degradation of natural forests and wetlands (Masese et al., 2009; M'Erimba et al., 2014). These activities affect the hydrology of the stream and rivers, the quality and quantity of water, and the riparian vegetation through nutrient enrichment, pesticide contamination, sedimentation, destruction of the riparian vegetation among others (Mathooko, 2001; Mathooko and Kariuki 2001; Masese et al., 2009; M'Erimba et al., 2014).

Riparian vegetation is critical to the existence of a river as it provides both physical and biological aspects that determine river health (Oruta et al., 2017). The vegetation is important for the hydraulic, hydrologic, water quality and life support functions in the riparian corridors (Davis et al., 1996; Oruta et al., 2017). The physical and biological functions of the riparian vegetation ensure stabilization of the stream flow, stream morphology and hydrology which in turn attenuates floods. On the other hand, the vegetation plays an important role in providing food, refuge, nesting, areas, habitats and corridors for a great diversity of terrestrial and aquatic fauna (Davis et al., 1996; Oruta et al., 2017). Loss of riparian vegetation leads to destabilization of the stream morphology, alteration of hydrology, poor water quality and loss of related aquatic and terrestrial fauna (Davis et al., 1996; Oruta et al., 2017). Riparian strips are faced with a variety of disturbances, usually natural and human induced perturbations which consequently affect the plant community structure and composition. While the ability of riparian vegetation to recover from spates of natural disturbances like flooding is well reported (Swanson, 1994), the anthropogenic disturbances usually have a long-term negative impact.

There exists a wide diversity of anthropogenic disturbances on the riparian vegetation ranging from damming of river channels, constructing levees, stream channelization, vegetation, clearing and conversion of the riparian vegetation with crops, livestock grazing, development of recreational facilities, sewage discharge, toxic chemical spills among others (Mathooko, 2001). These anthropogenic disturbances are responsible for denying water to the riparian corridor which in turn leads to shrinkage of the riparian corridor, reducing canopy cover, a shift in composition of the riparian vegetation structure and function, soil erosion and compaction, non-native plant invasions, and loss of riparian vegetation related wildlife (Smith et al., 1991; Richardson et al., 2007; M'Erimba et al., 2014).

The interest to study Iguameti stream is premised on the fact that the stream flows through Laikipia County which is described as a water scarce county with human-human and human-wildlife conflicts over water resources being a common occurrence (Butynski & De Jong, 2018). In addition, human activities in the riparian zone like deforestation, cattle grazing, farming among others have led to its destruction and decline compromising its function (Butynski & De Jong 2015; Butynski & De Jong, 2018). This study considered Iguameti Stream a very significant aquatic ecosystem in Laikipia County and in its provision of ecosystem services in the watershed. We surveyed the riparian vegetation on Iguameti stream with an intent to determine the structure and composition of the riparian vegetation, the width of the riparian buffer strips and to establish the existing anthropogenic induced natural perturbations.

Materials and Methods

The study was conducted on Iguameti Stream located in Nyahururu Sub-County of Laikipia County, Kenya (GoK, 2013). Laikipia County is located in the semi-arid region of the Rift valley with a mixed zone of low-lying drier areas suitable for arid pastoralism and higher, wetter areas that are suitable for high potential farming (Bond, 2014). The County is bordered by Mt. Kenya to the east and southeast and the Aberdare ranges to the southwest as well as the Rift Valley (Butynski & de Jong 2015; Evans & Adams, 2016). Iguameti Stream flows through Laikipia University, through Shamanek Forest that was part of the Marmanet Forest then joins Waseges River which flows towards Lake Bogoria that is found in the neighbouring Baringo County. In the upstream, the stream flows through Laikipia University, where there is minimal anthropogenic impact on the riparian zone. Downstream, the stream flows through privately owned human settlements. There is no data to show whether Iguameti is a seasonal or permanent stream but during the whole duration of the study, the stream flowed consistently. The stream is characterized by silty sediments within its series of pools and ripples, while some artificial impoundments on the stream within and without the University have led to replacement of the riparian vegetation with wetland plants.

The study area and sample points are presented in Fig 1 while the study points and their GPS coordinates are presented in Table 1. A total of 9 study sites were selected to fall within two distinct zones: an upstream with relatively intact riparian buffer strip zones falling within the protected Laikipia University land (T1, T2, T3, CF, DE and WWT) and a downstream section, outside the University boundaries which was characterized by disturbed riparian zones and increased direct human interaction with the stream (W1, W2 and KD). T1 and T2 were points on two ephemeral tributaries that join the Iguameti Stream in the upstream. T3 is the uppermost accessible point on Iguameti Stream. CF was a point at the confluence of the three streams while DE was a study point before the stream joins the first impoundment within the Laikipia University. WWT was a study point located close to a construction site of a waste water treatment plant. W1 and W2 and KD were study sites close to impoundments downstream of the stream. KD was also located close to an unplanned settlement of temporal structures built very close to the stream.

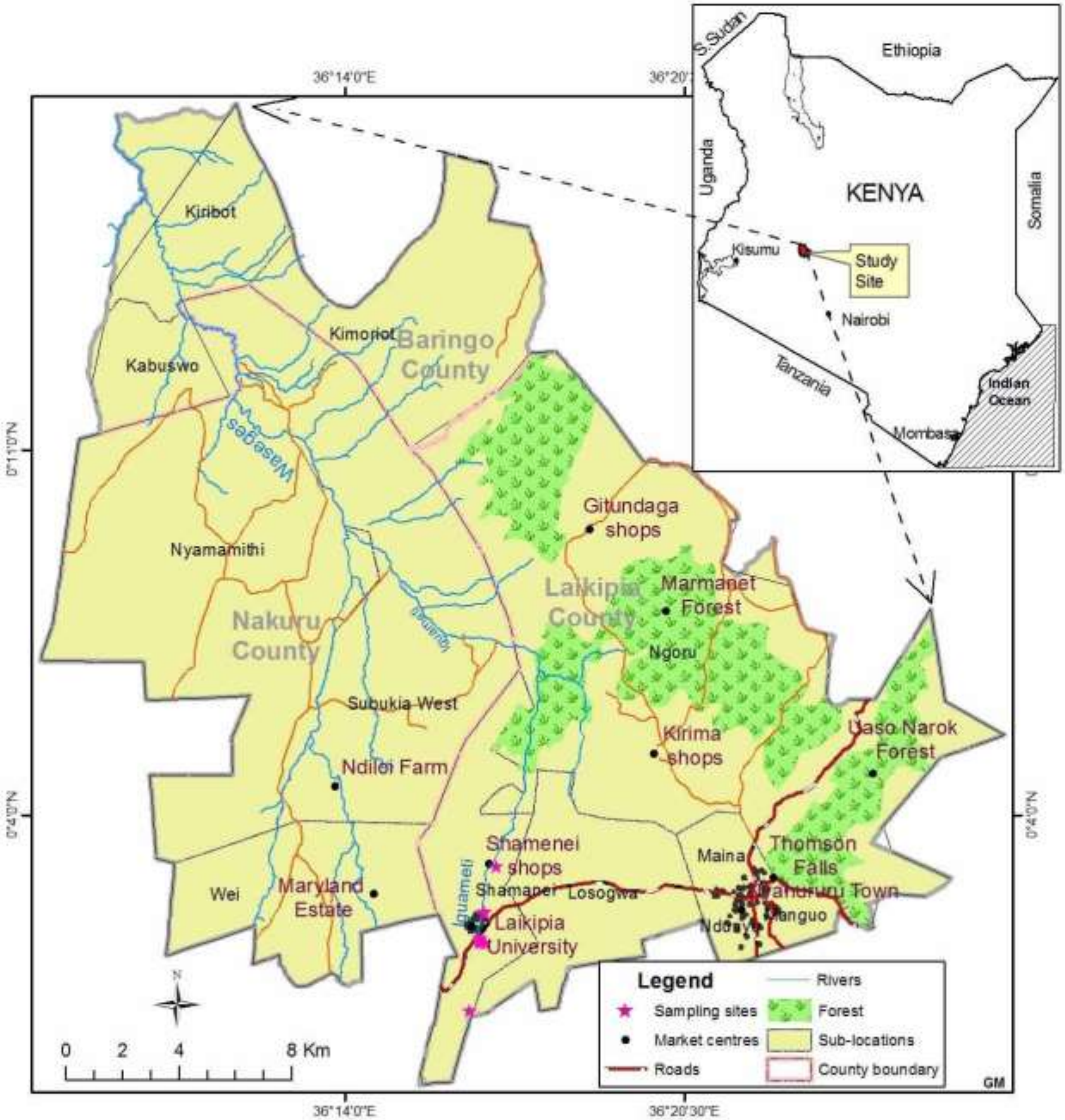

Fig. 1: Study Area and Sampling Sites

Table 1: Study Sites, GPS Coordinates and Altitude

Sites	Co-ordinates	Altitude (m)
Upstream		
T1	N00° 01.568’, E036° 16.680’	2372
T2	N00° 01.575’, E036 16.599’	2368
T3	N00° 0.264’, E036° 16.378’	2364
CF	N00° 01.604’, E036° 16.560’	2361
DE	N00° 01.667’, E036° 16.582’	2343
WWT	N00° 02.144’, E036° 16.667’	2325
Downstream		
W1	N00° 02.152’, E036° 16.659’	2315
W2	N00° 03.039’, E036° 16.901’	2304
KD	S 00° 26.122’, E 035° 58.361’	2295

Key: T1-Tributary 1; T2-Tributary 2; T3 Tributary 3; CF- Confluence; DE- Dam Entry; WWT- Waste Water Treatment; W1- Wetland 1; W2- Wetland 2; KD-Kamukunji Dam.

The study was carried out between September 2014 and September of 2015. Sample plots (30m×10m) were chosen in the phytocoenoses of the study area in such a way that each sample plot was visually homogenous. All floristic variation in the area was also sampled. Sampling was done at the end of the raining season when most plant species are flowering and producing fruits hence are recognizable. Based on physiognomical classification, the types of vegetation formations were identified. The plants were identified using the handbook by Maundu and Tengnas (2005) and a field guide by Dharani (2002) which combine pictorial images of plants, distribution of plants, plant morphological descriptions, and the plant names in Kenyan dialects and their scientific names.

Although not the original objective of the study, some mammals were identified to associate with the riparian zone. As such, a photographic guide (Stuart & Stuart, 2014) was used to help identify the mammals. Most of the plants were identified on-site, while those that could not be accurately identified were collected for further morphological examination at the Botany Laboratory in Egerton University, Njoro in Kenya. In addition, plant samples were sent to the National Museums of Kenya for confirmation of the species types. Plant press and secateurs were used to collect plant samples. Plant leaves, flowering twigs and fruits where possible were collected, fitted well in the press and labelled.

The cover-abundance values of plant species within each sample plot area were done based on the Braun-Blanquet scale as follows:

R - Very rare with a negligible cover (usually a single individual)
+ - present but not abundant with a small cover (<1%)
1- Numerous but covering 1-5%
2 - Covering 5-25%
3 - Covering 26-50%
4 - Covering 51-75%
5- Covering 76-100%

Canopy cover above stream and ground cover by percentage were also estimated in each site. The size of the riparian buffer strips was also measured landward laterally from the river bank. Species richness within each quadrat was determined by counting the total number of different species recorded. The above stream canopy cover, ground cover and height of trees were given as approximations through on-site observation, by averaging the observations of three different people. The Shannon-Wiener diversity index (*H'*) (Brower et al., 1990) was used to assess diversity as shown below:

$$H'=\sum((n/N) \text{ x } \mathrm{In}(n/N))$$

The study team also carried out monthly observations for evidence of anthropogenic impacts on the riparian vegetation and buffer strips; for instance, introduction of exotic species, loggings/clearing of the riparian vegetation, grazing of livestock, and farming within the riparian buffers strip. The importance of the riparian vegetation as refugia for unique organisms was also investigated.

Results

Results on the above stream canopy cover, tree canopy height and buffer strip width at all the study sites is presented in Table 2. The dominant vegetation growth forms are presented in Table 3. In the upstream, indigenous vegetation dominated the study sites and a dense afromontane forest was exhibited where it was composed of *Allophylus africanus-Trichocladus ellipticus* and *Teclea* spp.

Table 2: Above Stream Canopy Cover, Tree Height and Buffer Strip Width in the Study Sites

Sites	Canopy cover (%)	Tree height (m)	Buffer Strip (m)
Upstream			
T1	95	15-40	Right & Left › 20
T2	60	30-50	Right & Left › 10
T3	80	10 - 25	Right 2; Left ›5
CF	85	30-40	Right & Left › 10
DE	60	20-30	Right & Left › 5
WWT	80	20-40	Right 3; Left 2
Downstream			
W1	10	5-15	Right 2; Left 2
W2	0	10-30	Right 3; Left 4
KD	60	10-20	Right 2; Left 3

The composition of vegetation forms at the study sites is presented in Table 3. The sites showed a detailed vertical stratification where from top to bottom, the site exhibited a defined canopy, a canopy, an understory, and shrubs.

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Table 3: The Dominant Vegetation Growth Forms and Representative Plant Species in the Study Sites

Site	Trees	Shrubs	Herbs	Grass	Climbers	Epiphytes	Sedges/Cattails
	Upstream						
T1	*Trichocladus elipticus; Teclea spp., Allophylus sp.*	*Maytenus senegalensis , Phytolaca dodecandria*	*Cyathula cylindrical, Pavonia urens, Ferns*	*Leersia hexandra, Pennisetum clandestinum*	*Cissus sp. Periploca linearifolia*	*Loranthus sp.*	
T2	*Cupressus spp., Rhus natalensis.,*	*Phytolaca dodecandria*	*Polygonum pulchrum., Crotalaria agatiflora, Cyathula cylindrica*	*Pennisetum clandestinum . Agrostis stolonifera*	*Periploca linearifolia, Momodica foetida, Zehneria sp.(*		*Cyperus rotundus*
T3	*Allophylus sp, Ficus natalensis, Eucalyptus globulus*	*Vernonia lasiopus*	*Circium sp., Crassula schimperi, Hydrocotyl sp.*	*Cynodon dactylon*	*Rhynchosia sp*		*Cyperus sp. Cyperus rotundus, Fimbrystilis sp.*
CF	*Allophylus sp., Cupressus lusitnica Dombeya sp.*	*Phylanthes forcesi, Phytolacca dodecandria , Rubus sp.*	*Oenanthe palustris., Pavonia urens, Triumfetta romentosa*	*Panicum sp.*			*Cyperus rotundus, Fimbrystilis sp.*
DE	*Dombeya goetzinii, Rhus natalensis,*	*Maytenus senegalensis*	*Oenanthe palustris, Rorripa sinuate, Polygonum pulchrum*	*Pennisetum clandestinum , Typha domingensis, Cynodon dactylon*	*Basella alba, Cissus sp.*		*Cyperus papyrus, Typha domingensis*
W WT	*Pittosporum sp., Rhus natalensis, Trichocladus elipticus*	*Erythrococca bogensis, Rhamnus staddo*	*Crotalaria agatiflora, Oenanthe palustris, Hypoestes verticillaris*	*Leersia hexandra, Panicum sp.*	*Momodica foetida, Periploca linearifolia, Zehneria sp.*	*Orchids*	*Cyperus sp. Typha domingensis*
Downstream							
W1	*Cupressus lusitanica, Pittosporum sp., Rhus natalensis*	*Hibiscus diversifolius, Maytenus senegalensis , Rhamnus staddo*	*Polygonum sp., Oenanthe palustris, Ferns*	*Pennisetum clandestinum*	*Momodica foetida*		*Cyperus rotundus, Cyperus sp., Typha domingensis*
W2	*Cupressus lusitanica, Eucalyptus globulus, Rhus natalensis*	*Helichrysum sp., Rhamnus staddo, Maytenus senegalensis*	*Sphaeranthus sp., Crassula schimperi, Comelina sp.*	*Pennisetum clandestinum*	*Cissus sp. Rhynchosia sp.*		*Fimbrystilis sp., Cyperus rotundus, Cyperus sp.*

KD	*Cupresssus lusitanica, Dombeya sp.*	*Rubus sp., Plectranthus barbatus., Hibiscus sp.*	*Oenanthe palustris, Crotalaria agatiflora, Senecio montuosum*	*Pennisetum clandestinum*	*Periploca linearifolia, Cissus sp.*		*Cyperus rotundus, Fimbrystilis sp.*

Human activities in the riparian zone and the observed and potential impacts were observed. The potential impacts of the human impacts are described in table 4.

Table 4: Description of Human Activities in the Riparian Zone of Iguameti Stream

Site	Human activities and observed/potential impacts on the riparian zone
Upstream	
T1	[1]Livestock grazing; [2]picnicking,
T2	Livestock grazing; Picnicking, [3]Land tilling/Crop farming
T3	Livestock grazing; Picnicking; Land tilling/Crop farming
CF	Livestock grazing
DE	Livestock grazing; [4]Stream crossing
WWT	[5]Construction of waste water plant, Land tilling/Crop farming
Downstream	
W1	[6]washing laundry; [7]Fish farming [8]Livestock grazing and watering; Land tilling/Crop farming
W2	[9]Channelizing of stream; [10]Charcoal burning; [11]Water harvesting for domestic and irrigation; Land tilling/Crop farming
KD	[13]Unplanned human settlement (houses); Water abstraction, laundry washing

Key: Description of the observed and potential impacts of activities in the riparian zone:
[1]loss of plant species, destruction of plant structure, defecation by livestock;
[2]Waste disposal (organic and inorganic), trampling on plants
[3]Species loss, disturbance of vegetation
[4]Interferance with riparian vegetation growth; waste disposal;
[5]Loss of riparian vegetation, disposal of sediments in the riparian zone; interference with soil structure in the riparian zone;
[6]Introduction of inorganic wastes from detergents; interference with riparian vegetation growth; [7]species loss, interference with soil structure, interference with plant growth;
[8] trampling, species loss, interference with soil structure and root structure
[9]Species loss, interference with soil structure;
[10]Species loss
[11]Species loss & disturbance, inorganic contamination with oils & greases, interference with soil structure
[12]Reduced riparian zone, species loss, interference with soil structure, introduction of alien species [13] Species loss, interference with soil structure, defecation

The study reported human activities in the riparian zone or close to the riparian zone both in the upstream and downstream as already shown in Table 4. Livestock grazing, human crossing the stream and picnicking were noted to be the activities that directly impacted the riparian zone in the upstream. A comparison of the human activities in the riparian zone during the wet and dry season is presented in Table 5.

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Table 5: Dominant Human Activities Influenced by the Dry and Wet Seasons of the Year

Activity	Wet season	Dry Season	Sampling site
Livestock grazing	√	√	T1, T2, T3,
Picnicking		√	T1,T2
Laundry washing		√	W1,W2,KD
Channelization		√	W1,W2
Stream crossing	√	√	DE, W1, W2, KD
Fish farming	√	√	W1
Water abstraction		√	W1,W2, KD
Tilling/farming	√	√	T1,T2, W1,W2,

Results on canopy cover and vegetation types are presented in Fig 2 and Fig 3 respectively. Except for W1 and W2, the rest of the study sites had more than 50 percent canopy cover. The reduced canopy cover at W1 and W2 can be attributed to the site being a wetland.

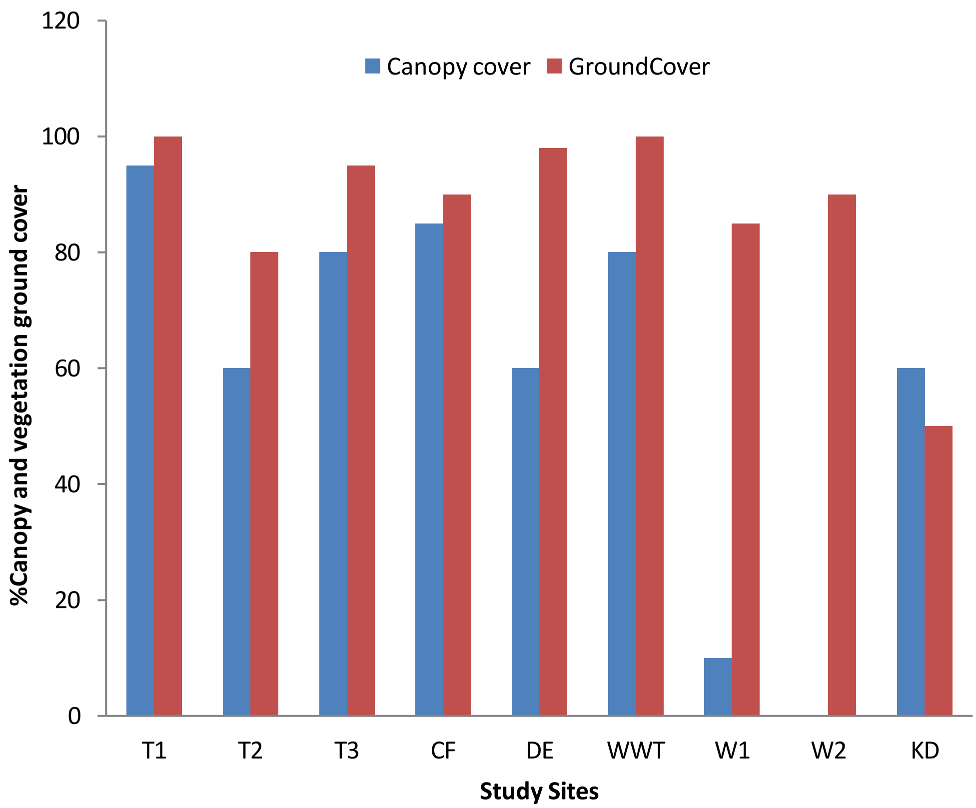

Fig. 2: Percentage Above Stream Canopy Cover and Percentage Ground Cover

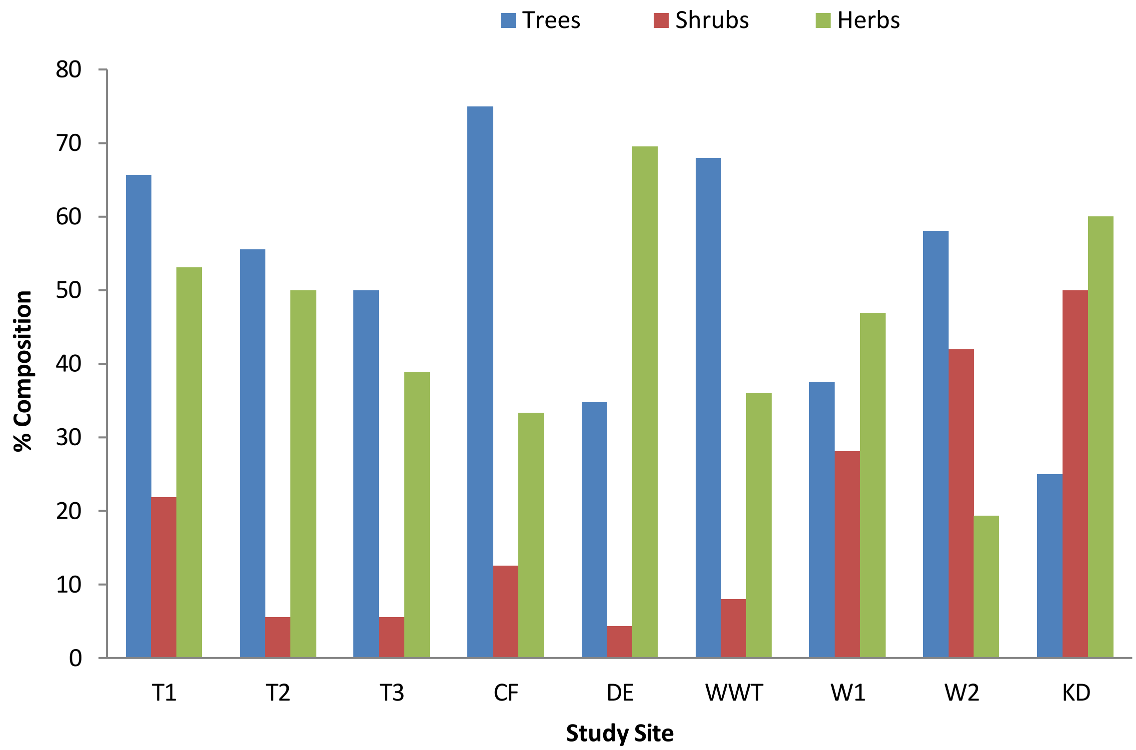

Fig. 3: Percentage Vegetation Type Composition at the Study Sites on Iguameti Stream

The comparison in species diversity Index (H') is shown in Fig 4. The highest diversity indices are recorded on the upper reaches at T1 where there is minimal alteration of the riparian vegetation.

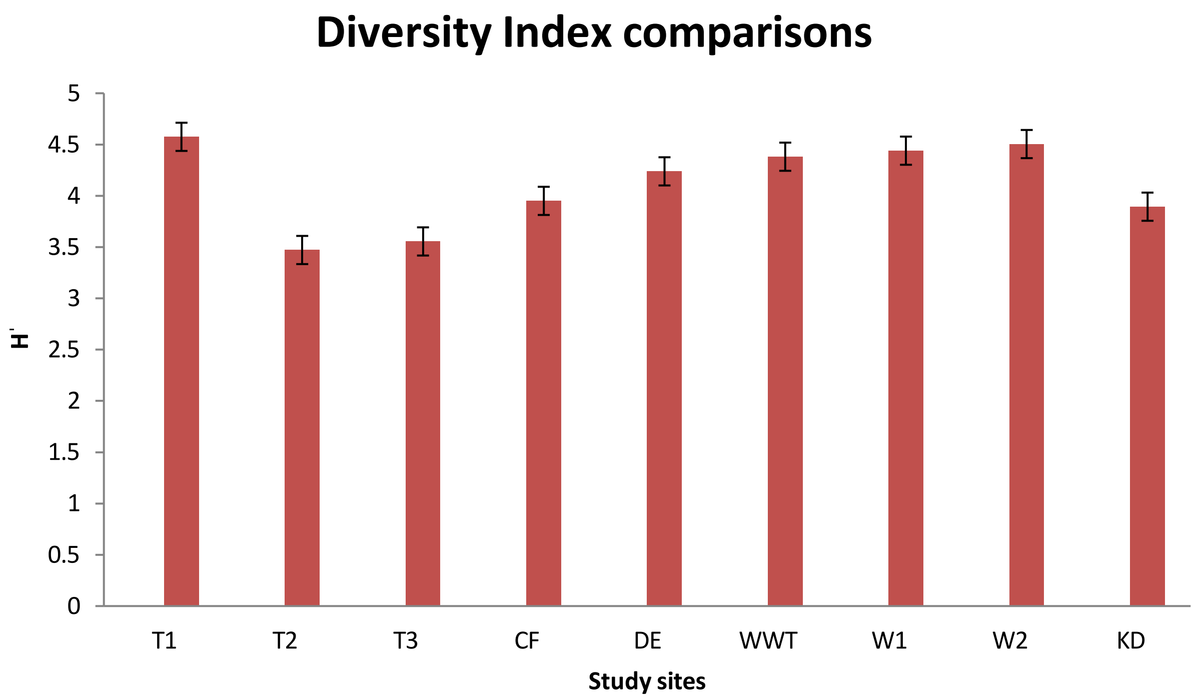

Fig. 4: Diversity index (H') comparison between sites

Discussion

Laikipia County is described to be in a transition zone for three major vegetation types: Somalia-Masai Semi-desert Grassland and Shrubland; Somalia-Masai Acacia-Commiphora Bushland and Thicket; and Afromontane Undifferentiated Montane Vegetation (Butynski & de Jong, 2015). Our study confirms the presence of the Afromontane vegetation as seen in the upstream study sites. Riparian vegetation on Iguameti Stream has an impact on the scarce but biologically important vegetation type in Laikipia County thereby contributing to the closed evergreen forest that is limited to the vicinity of rivers, deeper valleys and higher ground and forms about < 6% or <600km^2 of the county (Butynski & de Jong, 2014). The rich diversity of intact indigenous vegetation in the upstream and the biodiversity it supports is enough evidence of the critical importance of the riparian vegetation on this stream. The biodiversity includes both flora and fauna whose existence is threatened by habitat loss. However, in the midst of this, the riparian vegetation and the related biodiversity it supports is under threat. Except in the upstream where the riparian vegetation is near intact, there is great vegetation loss on the downstream. This is a scenario replicated in the rest of Laikipia County where change in land use has led to vegetation loss (Bond, 2014; Butynski & de Jong, 2014; M'mboroki et al., 2018).

Over time, much of Laikipia County's natural habitat has been degraded, fragmented, or lost as a result of over-grazing and over browsing by livestock, cutting trees, conversion to farmland and overharvesting of water (Butynski & de Jong, 2018). Studies have also shown that due to the rapid growth of population and the subsequent demand for common resources like water, this pressure may worsen with effects of climate change (Mmboroki et al., 2018). Specifically, Iguameti Stream flows partly through the Shamanek Forest Reserve located to the east of the Laikipia Escarpment/Eastern Rift Valley which has undergone extensive destruction in the recent past (Butynski & de Jong, 2014). The Shamanek Forest Reserve is part of the Marmanet Forest which overtime has witnessed encroachment and turning of land from the original forest land to agricultural farming with the major crop here being farming of Irish potatoes. In general, the Iguameti Stream watershed has undergone a lot of land degradation just like most parts of Laikipia County. There is scarce documentation of the anthropogenic impacts on riparian vegetation on Iguameti Stream. This knowledge gap creates challenges in the conservation and management efforts.

This study specifically noted that there continues to be adverse anthropogenic effects in the riparian vegetation on the Iguameti Stream attributed to increased human settlement and consequent change in land use activities. The extent of human disturbance is reflected in the composition of riparian vegetation, the forms, the width of the buffer strips, the species richness, the percentage of canopy cover and ground cover. The riparian vegetation on Iguameti Stream exhibits a unique composition specifically among the trees when compared to general description of riparian vegetation elsewhere in Laikipia County, perhaps due to the high altitude. Butynski and de Jong (2014) in their description of riparian vegetation in Laikipia County mentioned that these zones are dominated by tree species: *Acacia xanthophloea*, *Acacia gerrardii*, *Acacia gracilior*, *Syzigium guineense*, *Syzigium cordatum*, *Colodendrum capense*, *Warbugia ugandensis* and *Ficus spp* especially *Ficus sycomorus*.

The altitude in Laikipia County ranges from 1,260m asl to 2400m asl (Butynski & de Jong 2015) while the study points ranged between 2372m asl and 2295m asl which is within the higher points of the County. This explains the species composition specifically among the trees. The upper reaches of Iguameti Stream which have minimal disturbance show a composition that includes a domination of indigenous trees that include *Allophylus africanus*, *Tricholadus*, *Teclea spp*., *Polyscious kikuyuensis*, *Ficus natalensis* and *Dombeya goetzenii*. The tree layer decreases downstream and are replaced by exotic species like *Eucalyptus globules*, *Gravillea robusta* and *Cupressus lusitanica* that are mostly associated with human settlements hence confirming increased human encroachment, disturbance and depletion of the riparian zone.

The dominance of indigenous trees in the upper reaches depicts minimal disturbance in these reaches and therefore enhances a vertical stratification typical of forest ecosystems. In addition, the presence of abundant ferns at this site indicates the absence of or low levels of disturbance. Beukema and Noordwijk (2004) noted that species richness of terrestrial ferns and fern allies (Pteridophyta) may indicate forest habitat quality. Furthermore, the study also noted the presence of epiphytic wild orchids on trees in the riparian buffer strip. Kawaka et al. (2014) describe tropical wild orchids to be found exclusively in primary forests that are largely undisturbed. The authors further state that orchids are keystone species that can be used to monitor the general health of a wide range of habitats and furthermore, most of the orchids are classified in the International Union for Conservation of Nature (IUCN) red listing as Critically Endangered, Vulnerable, or Threatened. Although the team did not manage to identify the specific orchids as this was beyond the scope of study, it is worth noting that such species may be affected by loss of the host species. Threats to orchid existence have been attributed to increased population growth that has led to deforestation hence occasioning habitat destruction and fragmentation (Kawaka et al., 2014).

Despite the dominance of indigenous vegetation on the upper reaches of the stream, there is still however the presence of exotic tree species like *Cupressus lusitanica, Gravillea robusta* and *Eucalyptus globules* which have been introduced during tree planting initiatives in the upstream. Despite the well intended aim of such a strategy, it interferes with the original community structure and function. Exotic tree species like *Cupressus spp* and *Eucalyptus spp* have been found to limit growth of other vegetation through allelopathic activity. Richardson et al. (2007) noted that non-native plant invasions can cause changes to structure of riparian strips. Kawaka et al. (2014) in their study done on orchids found that most epiphytic orchids occurred on indigenous trees.

While the upstream of Iguameti Stream manifests what would have been of the riparian strip, the lower reaches depict the scenario exhibited in most parts of Laikipia County. Changes in land use have put pressure on water resources in Laikipia County due to competition from pastoralists, small and large scale farmers as well as wildlife and as a result, the riparian zone has not been spared (Bond, 2014). Compared to the upper reaches which fall in a protected area within Laikipia University, the lower reaches exhibit minimal or no management contributing to the destruction and declining of the riparian vegetation. In this zone, there is wanton encroachment and destruction of the riparian zone as shown by results where there is reduced buffer strip, river channel modification, reduced canopy cover among others.

Specifically, at W1 and W2 where there is encroachment onto the riparian zone to pave way for farming of maize, potatoes, vegetables and fruits, there is total destruction of the riparian vegetation. There is also the replacement of the indigenous trees with exotic ones, specifically *Eucalyptus globules* and *Gravillea robusta*. Human disturbance in the riparian zone is manifested at T2, DE, W1 and W2 where the herb layer hosts farm weeds like *Tagates minuta, Achyranthes aspera and Conyza sp* are present. These species are attributed to human disturbance specifically by land tillage as noted by Mathooko and Kariuki (2001) who attributed human disturbance to an abundance of *A. aspera* in the herb layer of the submontane *Acacia abyssinica* forest belt of the Njoro River. The dominance of the herb layer at KD can also be attributed to the disturbance and proximity to the unplanned human settlement known as Kamukunji. The unplanned settlement did not have access to piped water and sufficient lavatory facilities and hence the dwellers rely on the riparian zone for water abstraction, laundry as well as a site for open defecation.

The anthropogenic disturbance and human interference in the lower reaches also contributed to reduction in the buffer strip. The National Environment Management Authority of Kenya (NEMA) in its National Land Use guidelines recommends buffer strips of between 2m-30m width for rivers or streams depending on the width, water volume, and whether permanent or seasonal and the use of the water (NEMA, 2011). While the guidelines leave the identification and management of the riparian zones to the Water Resource Users Associations (WRUAs), the status of the riparian vegetation in downstream points to lapses or weaknesses in implementation of the NEMA guidelines. The wider buffer strips in the upstream can be attributed to proper management of the riparian zone which should be implemented in the downstream areas.

The Iguameti Stream riparian corridor serves great value given the diverse species of vegetation of great ecological and economic significance. The riparian corridor is rich in indigenous trees with diverse uses including fuel, fodder, flowers for bee foraging and traditional medicine (Dharani, 2002). On the other hand, the importance of Iguameti Stream Riparian as a refugia for different organisms is perhaps highlighted by the presence of two mammalian species. The African clawless otter (*Aonyx capensis*) and the Mount Kenya guereza *Colobus guereza kikuyuensis* were noted to be residents of the riparian zone on the Iguameti Stream.

The *Colobus guereza kikuyuensis* is one of the three primate species in Laikipia restricted to the closed evergreen forest above 1800m asl and endemic to the highlands of central Kenya (that includes the Aberdare Range, Mount Kenya, Ngong Hills and Nairobi) (Butynski & de Jong, 2014). On the other hand, otters are considered some of the top predators of aquatic ecosystems and keystone species of wetland environments. While the *Colobus guereza kikuyuensis* is considered Least Concern on the IUCN Red List (Butynski and de Jong, 2015), the *Aonyx capensis* is considered a near threatened species (NT) on the IUCN Red List for habitat loss (Jacques et al., 2015; Andarge & Balakrishnan, 2017). Maintenance of the riparian vegetation is critical to the survival of these two mammalian species.

Conclusion and Recommendations

Three types of vegetation formations; afromontane forest, submontane woodland as well as aquatic and swamp vegetation were identified. The composition of the riparian zone vegetation differed from that described along other rivers in Laikipia County. Various plant species and growth forms (trees, shrubs, herbs, climbers, epiphytes, grasses and sedges) were identified in the study sites. The riparian vegetation at the protected upstream of the stream has had minimal disturbance. Anthropogenic disturbances include: introduction of exotic species, water abstraction, watering of livestock, clearing of riparian vegetation to pave way for agriculture and aquaculture, modification of the stream channel, and conversion of flooding zone into aquaculture ponds. Anthropogenic disturbances were more pronounced during the dry season of the year. Quantification of riparian plant species richness and identification of the existing anthropogenic influence are important for future management of the vegetation and, consequently, the stream. The upper reaches of the riparian zone have played the role of a refugia for two mammalian species; the Mount Kenya Guereza *Colobus guereza kikuyuensis* and the clawless African otter *Aonyx capensis* which necessitates the protection of this unique area and opens up potential for studies into biodiversity supported by the riparian strip.

There are efforts in place to restore and conserve the riparian zone on Iguameti stream. For instance, Laikipia University which is an important stakeholder hosts the annual Laikipia University Marathon whose main theme has been to restore the Shamanek Forest through creation of awareness and tree planting. Such efforts should be supported by relevant stakeholder to ensure increased and guided tree planting, implantation of legal guidelines on riparian area use and management as well as identification mechanisms for sustainable use of the Iguameti Stream riparian corridor. On the other hand, there is need of an integrated approach in the management of the riparian vegetation by making community participation a key component of the management strategy. There is need for the WRUAs to implement the NEMA guidelines for riparian zone identification and management. Key areas to focus on would be restoration of the riparian vegetation in the lower reaches, identification and protection of related biodiversity and mitigation of climate change related effects on use of the Iguameti Stream. Given that this was the first study on the riparian vegetation on the stream, there is need for more research to understand the full ecological and economic value of the buffer strip. The study also recommends more research on the economic importance of the riparian vegetation on the Iguameti buffer strip as well as other biodiversity supported by the riparian zone. This will create opportunities for conservation of the vegetation.

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