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The Effects of Adjacent Land use Practices on the Structure and Diversity of Riparian Vegetation along River Kibwezi, Makueni County Kenya

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ABSTRACT

Woody vegetation is an important component of riparian habitat which performs important ecosystem functions such as preserving river biodiversity and providing a range of environmental goods and services. However, the integrity of riparian ecosystem is being compromised by adjacent land use type as well as anthropogenic activities which are not well understood. These ecosystems are among the rarest and most sensitive habitat in semi-arid and arid land of Kenya which has not been intensively studied and yet it plays an important role of food security and provision of scarce water resource. The present study was contacted in order to describe and analyse riparian woody plant species floristic composition and how they are influenced by adjacent land use along the upper ecosystem of river Kibwezi. Three transects each with five sampling points were established in each site. A total of 15 sampling plots from each site were systematically selected and sample. A total of 103 plant

species were sampled from the three sites. Canopy cover, tree density, diameter at breast height species diversity and evenness were significantly different ($p<0.05$). Partially protected site had higher woody plant species diversity than the protected or community settled areas. This implies that involving local communities in natural resources conservation could be beneficial to riparian ecosystem which fits well in the principle of sustainable natural resource use. However protected area had higher tree density and covers and mature trees than the community and partially protected habitat. Thus involving local communities in conservation of riparian habitat should be accompanied by proper policy structure to ensure that people understand why they are preserving the resources. Overall, these findings suggest that riparian vegetation in protected habitat had more structural and compositional diversity than any other land use areas. Thus protection of riparian habitats is important in trying to reverse the negative impacts of land use practice on streams and river Kibwezi is not unexception.

Key words: *Riparian, Kibwezi, sustainable, woody plant species, landuse, community*

Background Information

Riparian habitat consists of vegetations that develop along water courses and they are most threatened by human activities (Allan, 2004, Mligo, 2017). These woody vegetation, which form an ecotone between terrestrial and aquatic systems (Malason, 1993), plays an important role in the maintenance of a range of ecosystem services such as, control of riverbank erosion, heat regulation of river water, filtration and retention of nutrients, maintenance of water quality and quantity and provision of esthetic and recreational resources (Mligo, 2017, Meyer et al.; 2007, Hubble et al:. 2009, McNcish et al; 212). Woody plant species (trees, shrubs and vines) plays an important role in improving the provision of these services. Clagget et al;.(2010) noted that the clearing of riparian vegetation for agriculture and urban development especially upstream contributes to significant degradation of downstream riparian ecosystem. A well-protected upstream riparian habitat may provide stable water downstream while maintaining important habitat rich in biodiversity (Brimson, 1996). Riparian habitats contain many different plant species making it biodiversity hot sport (Corbacho et al. 203) which infiltrate the surface runoff (Dillaha, et al., 1989) from terrestrial land, stabilizing stream banks and improving moisture in riparian soils as well as improving water quality (Mligo, 2007

Even though riparian ecosystem is key in provision of ecosystem goods and services, the impacts of human activities is poorly understood in most of the rivers in Kenya and river Kibwezi is not an exception. Thus a few studies have determined the effects of adjacent land use on the riparian woody vegetation characteristics (Burton et al;. 2005), although such information is key in developing strategies that contribute to the conservation, restoration and sustainability of riparian vegetation in ecosystems which is dominated by anthropogenic activities such as riparian ecosystem along river Kibwezi. Mligo, (2017), noted that most rivers don't have a history of riparian dynamics that could aid in understanding of disturbances caused by human activities.

The objective of this study was to determine how adjacent land use may impact on riparian woody plants structure, composition and diversity indices along river Kibwezi. This is an important issue considering that there is rapid land use change occurring specifically in community settled area. These riparian ecosystems also are among the rarest and most sensitive habitat in semi-arid and arid land of Kenya which plays an important role of food security. Riparian woody plant species serves important roles in maintaining water quality, quantity and biodiversity. Understanding on land use change affects them is crucial because any disturbance on such ecosystem can result in drastic changes in the ecosystem dynamics.

MATERIAL AND METHODS

STUDY AREA

Upper riparian habitats on river Kibwezi is located in Makueni county eastern part of Kenya. It covers an area of 37.2 km^2 and extends from latitude 2°20'23.341"S to latitude 2°24'14.513"S and longitude 37°58'47.611"E to longitude 38°4'30.756"E and an average elevation of 810 meters (2657.48 feet's).

The climate of Kibwezi is typical semi-arid characterized by low and unreliable supply of enough moisture for plant growth (Mganga et al., 2010). The average annual rainfall is 600 mm (Musimba et al., 2004). This area receives a bi-modal rainfall pattern with the long rains expected between April-May and short rains between November-December.

Kambas are the largest community in the area who practice agro-pastoralism as their mainstream economic activity. Crops grown include a variety of drought tolerant grains like maize, sorghum, millet, beans and pigeon peas. Tomatoes, water melons, cabbages and kales are grown under irrigation using water from river kibwezi. Livestock kept consist of local breeds mainly the Small East African Shorthorn Zebu cattle, Red Maasai sheep and the Small East African Goat (Nyangito et al., 2009).

DATA COLLECTION

Structure and composition of vegetation communities adjacent to different land use was determined. A stratified systematic random sampling procedure was used to collect vegetation attributes. Three riparian strata were defined according to level of disturbance, namely, (a) protected riparian habitat (b) partially protected riparian habitat where grazing by livestock is allowed (c) settlement/farming habitat . Data collection was conducted in the month of October 2016. The collected vegetation variables were specifically for woody vegetation i.e. trees shrubs and vines. Data collected helped in the analysis of *plant species diversity, evenness, canopy cover, density and diameter at breast height* of woody plants. A total of three transects (replicates) with five sampling plots (3x 30m) were sampled in each site (total of 15 sampling plots per site/treatment). Data from the five sampling on each transect were pulled together.

Figure 1: Sampling woody vegetation characteristics along different transects

DATA ANALYSIS

Data on vegetation density and cover were analysed for ANOVA using GenStat thirteenth Edition. Means were separated using Duncan.

Species diversity in the three types of adjacent land use habitats was determined by using the Shannon diversity index (Shannon and Weaver 1948) based on the following equations.

Diversity Index (H^0)= $\sum_{i}^{\infty} pihipi \ldots\ldots (eq-1)$

Evennes (E) = $\frac{H\acute{\imath}}{InS}$……(eq -2)

Where;
H= Shannon Weaver Index
S= Total number of species at a site

The differences in vegetation composition and structure were tested using One-way Analysis of variance at 5% level of significance using GenStat statistical package

RESULTS AND DISCUSSION

Woody Vegetation Structure and composition in the three different land uses

A total of 103 woody plants species (29.7% trees , shrubs 64.5% and vines 5.8%) from thirty two (32) families, were sampled and assessed from the three study sites. Woody vines were mostly found in protected area. Large to giant tree species encountered were; *Dalbergia lacteal* (60.4%), *Ficus cycomorus* (7.7%), *Combretum heroreonse* (7.6%), *Lannea schimperii* (7.1%), *Acacia xanthophlea* (3.6%), *Acacia robusta* (3.6%), *Lecaniodiscus flaxinfolia (3.6%)* and *Gardenia volkansii* (3.6%). Notable among the large trees species was *Dalbergia lacteal* with 119 trees/ha

Table 1: Tree canopy cover and density of woody plants species

	Site A	Site B	Site C	LSD	% cv
Canopy cover (%)	73.56±4.33b	59.9±3.98b	22.61±2.21a	32.74	32.4
Density (No of plants/ha)	200.3±6.5b	222.3±4.8b	136.6±5.2a	55.5	44.4

Means followed by different letters along the row are significantly different at Duncan's $p \leq 0.05$.

TREE COVER

The ANOVA analysis indicated that there is significance ($p<0.05$) difference in percent tree cover of riparian habitat under different land use. Protected riparian habitat had the highest tree cover while community settled area had the least (Fig. 1). This shows that protecting riparian area from anthropogenic activities promotes woody vegetation cover. Enhanced cover leads to healthy riparian habitat.

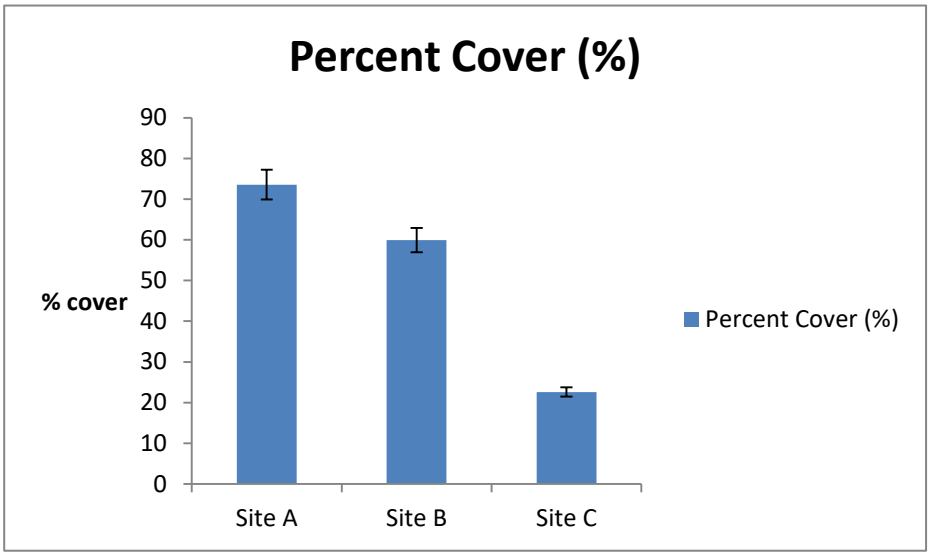

Figure 2: Bar gragh of percent cover from three riparian sites adjacent to different land use type

WOODY VEGETATION DENSITY

The ANOVA analysis indicted that there were significance difference between tree density in protected, partially disturbed and disturbed riparian habitats. The more the woody plant species in an the more the riparian ecosystem is likely to protected from effect of runoff as more water will percolate into soil profile.

DIAMETER AT BREAST HEIGHTWOODY PLANT SPECIES (DBH)/TREE SIZES

Figures in Table 2, show that community settled area had the lowest number of species per hectare. This could be attributed to anthropogenic activities such as burning of charcoal and harvesting of poles for construction work. The result agrees with the observation of Logheed (2000), who noted that cultivation, hydrological modification and landscape fragmentation has an impact on vegetation structure and composition. The observed results of low woody species density could be as a result of side effect and spillover of management of adjacent community settled area.

Table 2: The size and number of riparian woody species adjacent to different land use

	Regenerating seedlings <2.4cm. (DBH) trees/Ha	Sapling 2.5-24cm (DBH) trees/Ha	Small trees 25-37 cm (DBH) trees/Ha	Medium trees38-49 cm (DBH). trees/Ha	Large trees 50-75 cm (DBH) trees/Ha	>75cm (DBH) Giant trees/Ha
Protected riparian habitat	700 *(31.65%)*	501 *(51.86%)*	145 *(86.83%)*	118 *(100 %)*	52 *(88.14%)*	28 *(66.67%)*
Partially disturbed riparian habitat	1253 *(56.67%)*	422 *(43.69%)*	07 *(4.19%)*	00 *(0.00%)*	00 *(0.00%)*	07 *(16.67%)*
Disturbed riparian habitat in community settled area	258 *(11.67%)*	43 *(4.45%)*	15 *(8.98%)*	00 *(0.00%)*	07 *(11.86%)*	07 *(16.67%)*
Total from three sites	**2211 *(99.99%)***	**966 *(99.7%)***	**167 *(100%)***	**118 *(100%)***	**59 *(100%)***	**42 *(100.01%)***

Result of the study further reveal that, partially protected area has more younger woody plant species (56.67%) as compared to protected (31.65%) and disturbed areas (11.67%). This could be attributed to seed dispersion by grazing/browsing animals. The excess mulch is removed by grazing animals allowing seed to get in contact with the soil. The effect of animal hooves also makes small depression in the soil that is a favourable site for seedling germination and establishment. Absence of farming activities may promote seedling germination and establishment. Few seedling and sapling found in protected site could be explained by the shading effects which may influence negatively seeds germination and establishment.

Across all the three sites, there are comparatively more younger trees and shrubs (seedlings and saplings) which indicates that population of trees and shrubs are building up. This could be attributed to people becoming aware of the importance of trees. Table 1 indicates that there are no medium or large trees in partially disturbed area (site B).

The low number of tree plant species in community settled area could be attributed to human activities such clearing land up to the river bank for farming and charcoal burning. This finding agrees with studies of Grijn (1994), Faulkner (2004), Aquiar and Ferreira (2005) and Villareal et al (2012) who separately argued that urbanization and agricultural practices is a leading cause of riparian ecosystem degradation. Matunda (2015) observed that riparian area has remained relatively unprotected from poor agricultural practice, residential and commercial construction and logging making it vulnerable to anthropogenic activities spillover from adjacent land use type. Watzen (2006) concluded that irrational anthropogenic activities on riparian vegetation could lead to this habitats being degraded

WOODY PLANT SPECIES DIVERSITY INDEX

Table 2 show that partially protected habitat is rich in terms of species composition although in protected habitat species are more evenly distributed (Table 3). A habitat with even distribution of species is more stable. From the forgoing discussion there is a possibly that grazing as a form of land use promotes species diversity and richness. However preserving a habitat from human and livestock activities may lead to a stable riparian ecosystem.

Table 3: Woody plant species diversity

Diversity measurement	**Protected habitat/control** Site A	**Partially disturbed through grazing** Site B	**Community settled/farming area** Site C	LSD	% cv
Species richness	38.12 ± 2.12b	41.22 ± 3.12b	16.03 ± 1.12 a	8.8	27.8
Evenness	0.818 ± 0.052a	0.814 ± 0.05a	0.939 ± 0.05a	0.23	19.5
Shannon Wienner index	2.603 ± 0.095a	3.023 ± 0.11c	2.977 ± 0.10bc	0.49	13.7

Means followed by different letters along the row are significantly different at Duncan's $p \leq 0.05$

Table 3, show that the partially protected area had higher woody plant species diversity than either protected or communal area making it a more stable ecosystem. An ecosystem that has many species is more stable and resilience to distubances (,,,,,,,,,,). This implies that riparian habitat should not only be protected to preserve the integrity of the river and continue to providing ecological and social services, but it can be used sustainably by

neighbouring communities. This can lead to participatory governance that is a precursor to sustainable riparian resource management ( ).

Although partially protected is more rich in species composition (Fig. 2), protected riparian habitat has even distribution of all woody plant sizes (Table 3). The high canopy cover is important in protecting river water from effect of sunlight and high ambient temperature that can lead to increased loss of water from the river through evaporation (Mligo, 2017) and rainfall velocity that may lead river bank erosion (,,,,,,,,)

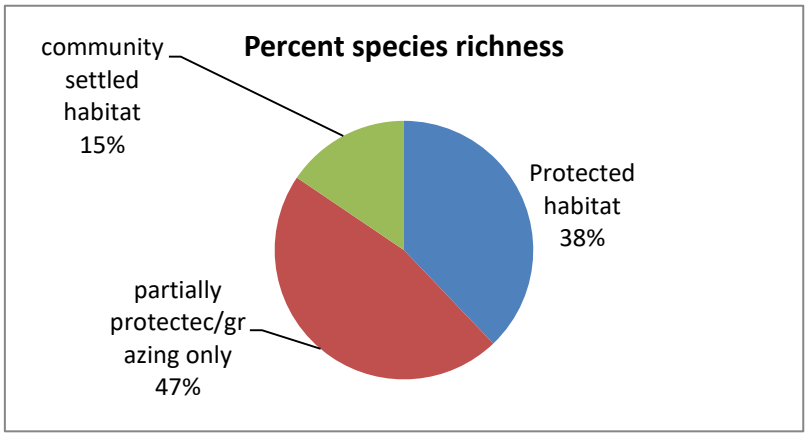

Figure 2: Shannon-Weaver index of diversity in percentage

Table 1 reveal that there are more regenerating tree seedlings in site B than either in control (A) and community/farming site C. These can be attributed to seed dispersion by the grazing/browsing livestock. Germination of some tree seeds is enhanced once the pass through the digestive system of the animals (,,,,). The effects on soil by hooves of the animals also create an environment conducive the germination of these seeds. With light grazing of riperian habitat as a form of land use can increase woody plant density, diversity and species richness, forming a better protector to river Kibwezi ecosystem in the long run.

The low riparian vegetation diversity in communal areas could be associated with increase in human population which has encroached into the riparian habitat and their high dependency on natural resources (eg. Charcoal burning and livestock grazing in dry season), for livelihood, resulting into the riparian ecosystem in community settled areas being the most modified habitat of the three. Holmes *et al*., (2005).in his study observed that riparian zone of most river systems in South Africa has been negatively impacted largely by agricultural activities, expansion of human settlements, as well as the invasion of alien plants species Rheinhard et al (2012), in his study, concluded that the stream integrity is often lowest in areas where agricultural and residential land use types are common. This results also agrees with findings of Lorion et al., (2009), Dudgeon, 2006) the of who asserts that, habitat alteration, along the river and its catchment, include over extraction of river water for irrigation, agricultural land clearing, and selective extraction of woodland resources for purpose such as fuel wood, construction material and charcoal burning. Greijn (1994) noted that land degradation is more pronounced in those land used for agriculture and settlement than land used for pasture production.

The shrinking of riparian vegetation habitat can lead to decreased canopy cover, species diversity and vegetation density (Bahuguna et al 2010) which in turn result in degradation of riparian ecosystem. Result of this study indicate that anthropogenic activities such as clearing woody plant species for agriculture and charcoal burning affects directly tree density, Cover and species diversity in riperian ecosystem. Grazing as form of land use can

promote species diversity although not evenly distributed. Best practice is to advice farmers to preserve riparian habitat.

The results also suggest that negative fundamental changes to riparian habitat have taken place in community settled area. The changes if not checked will lead to completely destroying riparian habitat.

CONCLUSION AND RECOMMENDATIONS

The determination of the effects of adjacent land use change on riparian woody plant vegetation density, cover and diversity in Kibwezi River ecosystem forms part of a few studies carried out in in Kenya to sensitize on the importance on the importance of conserving riparian habitat. The observed variation in woody plant density, cover and diversity between the three sites is due to difference in habitat qualities influenced by anthropogenic activities. Based on the above observation, participatory conservation where all actors including local communities, should be involved in the planning and sustainable management of riparian area of river Kibwezi with its watershed. This may minimize anthropogenic activities and reduce the ongoing disturbances and degradation of riparian habitat in river kibwezi ecosystem In general the result of the research has important implications for the planning and sustainable management of riparian ecosystems, since it provides some lights regarding the impacts of different land use on riperian woody plant community.

More studies on the structure, composition, and diversity of riparian woody plant communities should be undertaken which could help in understanding the ecological, anthropogenic and social factors that directly and indirectly affect this type of habitats. This is necessary since the characteristics of riparian woody plant communities are dependent upon a complex set of habitat factors (e.g., latitude and altitude) that are particular to each location and directly responsible for the biodiversity present in each area (Naiman and Decamps 1997. The results of these studies will guide in the formulation of sustainable management and conservation plans for the rehabilitation of upper habitat of river Kibwezi and other rivers basin in the country. The National government in collaboration with county should promote those land use practices that favors positive cumulative effects on the riparian ecosystem.

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