Effects of human–livestock–wildlife interactions on habitat in an eastern Kenya rangeland

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Abstract

Human–livestock–wildlife interactions have increased in Kenyan rangelands in recent years, but few attempts have been made to evaluate their impact on the rangeland habitat. This study identified drivers of increased human–livestock–wildlife interactions in the Meru Conservation Area between 1980 and 2000 and their effects on the vegetation community structure. The drivers were habitat fragmentation, decline in pastoral grazing range, loss of wildlife dispersal areas and increase in livestock population density. Agricultural encroachment increased by over 76% in the western zone adjoining Nyambene ranges and the southern Tharaka area, substantially reducing the pastoral grazing range and wildlife dispersal areas. Livestock population increased by 41%, subjecting areas left for pastoral grazing in the northern dispersal area to prolonged heavy grazing that gave woody plant species a competitive edge over herbaceous life-forms. Consequently, open wooded grassland, which was the dominant vegetation community in 1980, decreased by *c.* 40% as bushland vegetation increased by 42%. A substantial proportion of agro pastoralists were encountered around Kinna and Rapsu, areas that were predominantly occupied by pastoralists three decades ago, indicating a possible shift in land use in order to spread risks associated with habitat alterations.

Key words: habitat change, human–livestock–wildlife interactions

Résumé

Les interactions hommes-bétail-faune sauvage ont augmenté dans les pâturages kényans ces dernières années, mais il y a eu peu de tentatives pour évaluer leur impact sur cet habitat. Cette étude identifie quelles ont été les raisons sous-jacentes de ces interactions dans l'Aire de Conservation de Meru entre 1980 et 2000, et leurs effets sur la structure de la communauté végétale. Les raisons étaient la fragmentation de l'habitat, le déclin de la surface libre pour le pâturage pastoral, la perte d'aire de dispersion pour la faune sauvage et l'augmentation de la densité de population du bétail. L'envahissement agricole a augmenté de plus de 76% dans la zone ouest touchant les fermes de Nyambene et l'aire sud de Tharaka, réduisant substantiellement l'étendue du pâturage pastoral et les aires de dispersion de la faune sauvage. La population du bétail a augmenté de 41%, soumettant les étendues laissées au pâturage pastoral dans la région de dispersion nord à un pâturage intensif prolongé qui a donné aux espèces végétales ligneuses un avantage sur les formes herbeuses. Par conséquent, la prairie arborée ouverte, qui était la communauté végétale dominante dans les années 1980 a diminué de près de 40% alors que la végétation de broussailles a augmenté de 42%. Une proportion substantielle d'agropastoralistes se rencontraient autour de Kinlla et de Rapsu, des zones qui étaient principalement occupées par des pasteurs il y a trois décennies, ce qui indique une évolution possible de l'utilisation des sols afin de disperser les risques liés à l'altération des habitats.

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Introduction

Kenya's rangelands make up 87% of the country's total land area (Pratt & Gwynne, 1977). These areas support over 25% of the country's human population, 52% of the

total livestock population and 90% of wildlife resources (Maalim, 2001). With more than 4 million Kenyans engaged in full-time pastoralism and several more millions deriving their sustenance from livestock production, rangelands are important in supporting both rural and urban livelihoods (Wekesa, 2001). The total value of livestock in Kenyan rangelands is currently estimated at about US$ 1 billion, which accounts for *c.* 90% of the pastoral economy and 10% of the country's Gross Domestic Product (Wekesa, 2001). Rangelands are also important for the country's tourism industry, through which Kenya earns about US$ 0.8 billion annually, based largely on viewing of wildlife in protected areas (Herlocker, 1999).

Over the past two decades, however, the country's rangelands have increasingly experienced land use diversification and habitat alterations associated with agricultural encroachment (Said *et al.*, 1997). Areas most targeted for crop production are those with favourable soil and water conditions, which also happen to be critical for livestock and wildlife as water points and grazing reserves, particularly in the dry season (Ekaya, 2001; Serneels, Said & Lambin, 2001). The situation has led to a reduction in the pastoral grazing range and loss of wildlife dispersal areas (UNEP and Kenya Wildlife Fund Trustees, 1988). This has caused a decline in the wildlife-livestock resource base and an increase in human–wildlife–livestock interactions and associated conflicts (Herlocker, 1999). Given the agricultural limitations of rangelands in Kenya (Pratt & Gwynne, 1977; Jaetzold & Schmidt, 1983), the continued encroachment of land use practices more suited for the humid highlands is likely to cause intense resource competition among wildlife, livestock and agriculturalists. This may lead to habitat degradation, loss of biodiversity, a decline in the per capita pastoral livestock holding and increase in poverty levels among rangeland communities (Ellis & Swift, 1988; Rutten, 1992; Hoag & Clements, 1993; Southgate & Hulme, 1996). This study was, therefore, designed to identify the drivers of increased human–livestock–wildlife interactions in the Meru Conservation Area (MCA) between 1980 and 2000 and to determine the effects of these interactions on the vegetation structure and the likely impact on livestock production and biodiversity conservation. The results would provide policy makers, natural resource managers, wildlife interest groups and pastoral communities with information useful for sustainable management of rangeland ecosystems.

Materials and methods

The study area

The study was carried out in Meru National Park, Bisanadi National Reserve and the adjoining community land between June 2001 and July 2003. The area covers *c.* 3900 km^2. It lies between 0°20′ and 0°10′S, and 38°0′ and 38°25′E. It experiences a bimodal rainfall pattern with the long rains coming in March through June and the short rains in October through December. The area rises from an altitude of 300 m and a mean annual rainfall of 380 mm at the park's south-eastern boundary to an altitude of 850 m and a mean annual rainfall of 1000 mm on the western boundary where the park borders Nyambene ranges. The MCA is a protected area with wildlife management as the principal conservation activity. The major economic activities of communities bordering the protected area are subsistence crop cultivation and livestock keeping.

Evaluation of drivers of increased human–livestock–wildlife interactions

Focus group discussions were held with local leaders and community members to introduce the study to the area. Available documents describing aspects of human–livestock–wildlife interactions in the area, such as human–wildlife conflicts, were distributed among community members for discussion. A survey was carried out among 80 households out of *c.* 1000 households occupying the western, southern and northern buffer zones of the conservation area. The survey employed a stratified random sampling method (Dawson & Trapp, 2001) to determine land use patterns, human, livestock and wildlife population dynamics, human settlement patterns and indicators of human–livestock–wildlife interactions between 1980 and 2000. The *t*-test for paired proportions (Sokal & Rohlf, 1995) was used to test for the significance of the variation in human, livestock and wildlife populations as follows:

$$t_{\mathrm{df}} = \frac{|X_0 - X_t|}{\sqrt{(\mathrm{SE}_0)^2 + (\mathrm{SE}_t)^2}}$$

where X_0 is the sample population mean in 1980, X_t is the sample population mean in 2000 and SE is the standard error of the population mean.

Determination of habitat changes

Two, 30 m resolution Landsat TM satellite images of 1987 and 2001 were used to determine changes in land cover and vegetation structure. The images were geo referenced with the aid of topographic maps (1 : 50,000) using prominent landmarks located on both the maps and satellite images as reference points. Using standard image interpretation and supervised classification techniques (Wilkie & Finn, 1996; Leica Geosystems, 2003), an inventory of land cover features and vegetation life form categories (woody, shrubby and herbaceous cover) was taken for each of the satellite images. The spatial coverage of the various land cover features and vegetation life-forms was determined by quantifying the cumulative area under each respective spectral signature. The two sets of satellite images were analysed for significance in differences in spatial coverage for the various land cover features and vegetation life-form categories using the *t*-test of one sample set (Sokal & Rohlf, 1995).

$$t_{df} = \frac{|X - \Pi|}{SE},$$

where X is the sample mean, Π is the expected mean and SE is the standard error.

Results

Increase in human population

There was a significant increase in human population ($t = 158$; $P < 0.05$) in the buffer zones surrounding the conservation area between 1980 and 2000. Human population increased by over 83%. About 70% of the increase was attributed to the migration of people into the area from other parts of the country. Approximately 43% of the migrant households were agriculturalists from the more humid areas of the Mt. Kenya region, 12% were pastoralists from the drier zones of northern Kenya, whereas 45% were agro-pastoralists who migrated from districts bordering the conservation area.

Migratory trends indicated that agriculturalists migrated into the area throughout the two decades with majority of the households settling in the area between 1990 and 2000. Most of the pastoralists, on the other hand, migrated between 1980 and 1990.

Majority of the agro-pastoralists settled in the area between 1995 and 2000.

Approximately 10% of the migrant agro-pastoral households arrived in the conservation area as pastoralists, but took up agro-pastoralism while staying in the area.

Increase in livestock population

There was a significant increase in livestock population ($t = 48$; $P < 0.05$) in the conservation area. An overall livestock population increase of 41% was recorded between 1980 and 2000. However, analysis of livestock holdings by land use indicated that livestock population increased among pastoral households by 97%, but reduced among agro-pastoral households by 11%. The trend was similar in districts bordering the conservation area, with livestock population increasing in areas with marginal agricultural potential, but reducing in those with higher agricultural potential (Table 1).

Decline in wildlife population

There was a significant decline in wildlife population in the conservation area between 1980 and 2000. Partial wildlife population data obtained from the Kenya Wildlife Service (2002) indicated that the combined population of elephant, buffalo and giraffe declined from *c.* 7400 in 1977 to 2000 in 1992 before rising gradually to *c.* 3600 in 2002.

Human–wildlife conflicts

There was a significant increase in incidence of human–wildlife conflicts between 1990 and 2000. For instance, between 1997 and 2000, the number of human deaths directly caused by wildlife attacks increased by over 70%. Majority of the deaths occurred around Murera and Kinna on the western buffer zone, where agricultural encroach-

Table 1 Changes in livestock population in districts bordering the conservation area between 1979 and 1999

District	Agro-ecological potential	Livestock population in 1979	Livestock population in 1999	% change
Meru	High	1,998,856	448,822	−77.5
Kitui	Marginal	606,600	623,955	2.8
Isiolo	Highly marginal	632,100	775,200	22.6
Total		3,237,556	1,847,977	

Source: Central Bureau of Statistics (2001).

ment had taken up wildlife dispersal areas. Human injuries caused by wildlife attacks increased by *c.* 120% during the same period. There were numerous incidences of destruction of property by wildlife, majority of which went unreported.

Habitat changes

There was a significant reduction in the pastoral grazing range and wildlife dispersal areas as a result of agricultural encroachment in the conservation area between 1980 and 2000. The area under crop cultivation increased from *c.* 35,050 ha in 1987 (Fig. 1) to *c.* 61,850 ha in 2001, with average farm sizes of 2–3 ha. Most of the agricultural encroachment occurred in the more humid western zone bordering Nyambene ranges and the sub-humid southern Tharaka area (Fig. 2). Significant changes were observed in the spatial coverage of the herbaceous and shrubby lifeforms of the area's vegetation (t = 1987/2001; $P < 0.05$), particularly in the northern dispersal area. The area under open wooded grassland, which was the dominant vegetation community in the early 1980s, reduced from *c.* 136,360 ha in 1987 (Fig. 3) to *c.* 81,830 ha in 2001. The area under bushland vegetation increased from *c.* 64,860 to 92,590 ha during the same period.

Most of the changes in vegetation structure were observed in the expansive northern dispersal area, which was spared by agriculturalists because of its marginal agricultural potential (Fig. 4). Standard range management practices, such as regular burning of vegetation, were observed within the national park, but not in the pastoral grazing range.

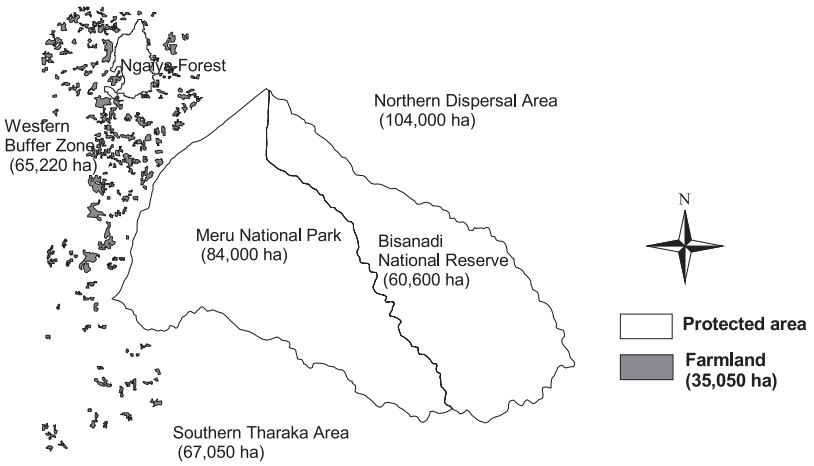

Fig 1 An illustration of the area under crop production in 1987

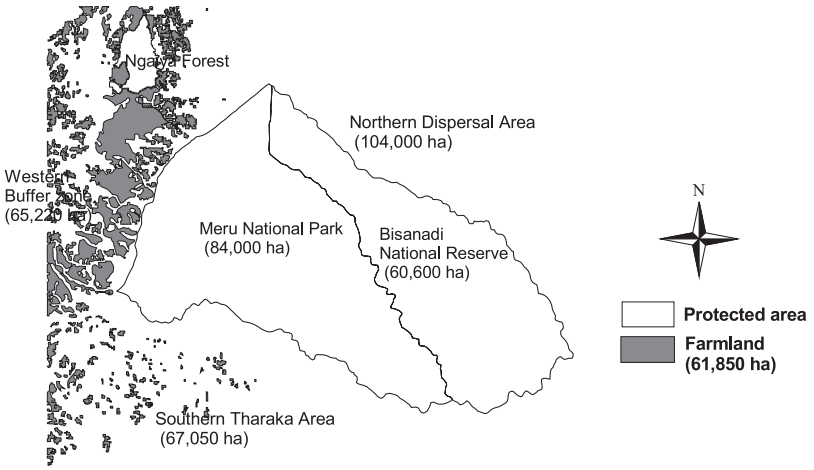

Fig 2 An illustration of the area under crop production in 2001

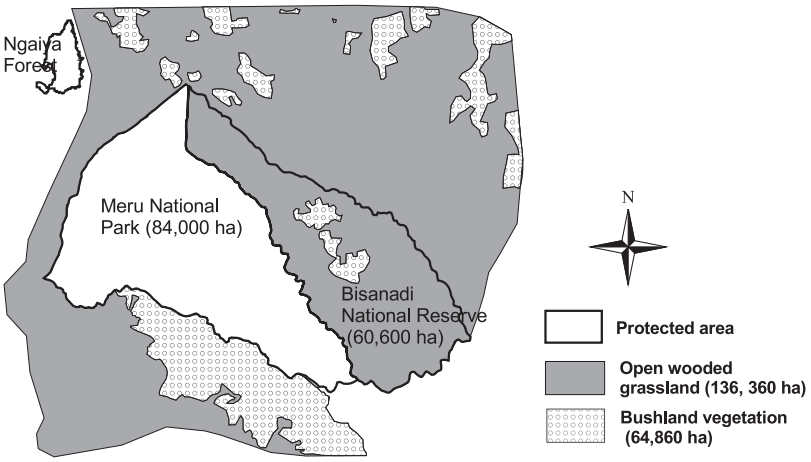

Fig 3 An illustration of the spatial coverage of dominant vegetation types in 1987

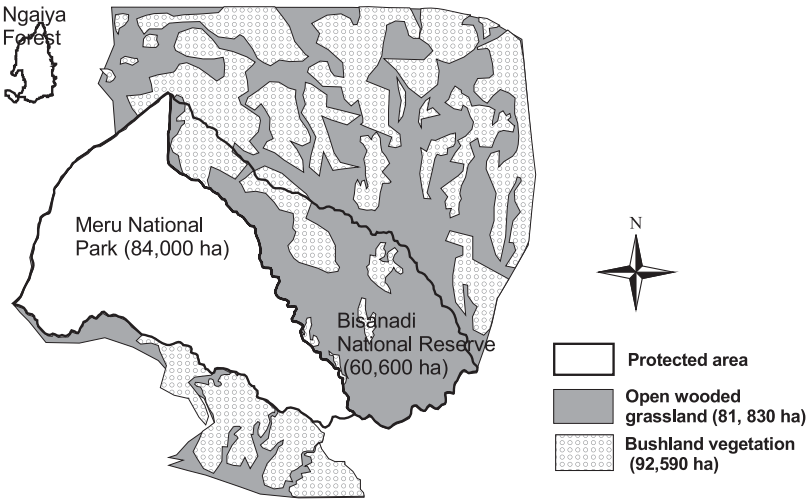

Fig 4 An illustration of the spatial coverage of dominant vegetation types in 2001

Discussion

The drivers of increased human–livestock–wildlife interactions in the MCA were reduction of the pastoral grazing range, loss of wildlife dispersal areas and increase in livestock population density. However, the underlying cause of these interactions was land fragmentation, which was brought about by agricultural encroachment and subsequent land subdivision for crop production and human settlement. Although the area that came under crop production between 1980 and 2000 was only 11.3% of the conservation area, it had a profound impact on pastoral livestock production and wildlife conservation. This is because agricultural encroachment occurred in the more humid western and southern buffer zones that served as dry season grazing reserves and water points. The situation relegated pastoral livestock production and wildlife dispersal to the relatively drier northern dispersal area. This partly explains the significant increase in livestock population density during the period. The situation underscores the potential of crop production and land fragmentation to destabilize pastoral and wildlife coping strategies in rangelands (Herlocker, 1999; Ekaya, 2001).

The changes in vegetation structure reported in the northern buffer zones suggest that land use patterns that operated in the area between 1980 and 2000 may have given shrubby and woody vegetation a competitive edge over herbaceous life forms. This may have been caused by a reduction in the pastoral grazing range, increase in livestock population density and decline in the population

of wildlife, many of which are browsers. The situation was perhaps exacerbated by the 97% increase in livestock population among pastoralists during the same period. As illustrated elsewhere by Hoag & Clements (1993), the situation is likely to have subjected the predominantly herbaceous vegetation to prolonged heavy grazing in the absence of range management interventions, such as regular burning. In the process, shrubby and woody lifeforms are likely to have seized the opportunity to colonize the northern dispersal area.

The increase in livestock population among pastoralists and a decrease among agro-pastoralists that was reported in the conservation area was consistent with reports from the Central Bureau of Statistics, which indicated that livestock population increased in areas with marginal agricultural potential, but decreased in those with higher agricultural potential (Central Bureau of Statistics, 2001). This observation tends to support the argument by Bekure et al. (1991) and Coppock (1994) that risks and uncertainties associated with livestock production in rangelands may have compelled pastoralists to devise better coping mechanisms in livestock production and agro-pastoralists to lay more emphasis on crop production in recent times. However, the increase in the number of agro-pastoralists and the corresponding decline in the number of pastoralists in the conservation area from 1990 to 2000 suggest that some pastoralists may have taken up crop cultivation alongside livestock production to spread risks associated with land fragmentation. If this observation were to be confirmed, it would, support current thinking among some rangeland ecologists in eastern Africa that pastoral coping systems may be beginning to collapse as a result of sustained agricultural encroachment and land fragmentation (Ellis & Swift, 1988; Coppock, 1994; Ekaya, 2001). The situation is thought to be limiting the movement of pastoralists, thereby compelling some of them to settle for fairly sedentary sources of livelihood such as agro-pastoralism.

Conclusion and recommendations

The findings of this study indicate that habitat change is a primary indicator of a declining natural resource base in eastern Kenyan rangelands. The results suggest that further land fragmentation and subsequent reduction in the natural resource base are likely to disrupt livestock production and wildlife conservation in the conservation area. However, these habitat changes are not unique to the MCA, the results and recommendations given here apply to majority of rangelands in Kenya. Some of the measures required to mitigate further habitat fragmentation and disruption of livestock production and wildlife conservation include developing an integrated range management policy and promoting range management interventions such as regular burning of vegetation to control bush encroachment. We propose more studies to ascertain if indeed some pastora1ists are taking up crop production to spread their risks against uncertainties occasioned by land use change and land fragmentation in eastern Kenya rangelands.

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