A landscape model of grassland decline in Kinangop Plateau, Kenya: Implications for conservation of Sharpe's Longclaw *Macronyx sharpei*

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A landscape model of grassland decline in Kinangop Plateau, Kenya: Implications for conservation of Sharpe’s Longclaw *Macronyx sharpei*

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**Abstract**

The Kinangop highland grasslands, the world stronghold of the endangered Sharpe’s Longclaw (*Macronyx sharpei*), consist almost entirely of privately-owned land. As human population in the grasslands increases, the mean acreage of land holdings are decreasing and more grassland is being converted to other uses. I used 11-year (1984 to 1994) land subdivision information, existing human population data, and current land use data from a subset of 162 farms to extrapolate the past and future extent of Sharpe’s Longclaw’s habitat throughout the grassland landscape on Kinangop Plateau. I also assessed the importance of various on-farm variables in determining the quality of grasslands as the longclaw’s habitat. Farm size emerged as a key determinant of grassland cover within individual farms. I estimated that, in 2000, grasslands covered 50% of the area, but only half of this was likely to be tussock grasslands, the preferred habitat of the longclaw. Large farms are rapidly being subdivided, and more than half of the remaining tussock grasslands were likely to be found on farms that are not large enough to support very large longclaw territories. I predict that within the next decade tussock grasslands will cover only one-sixth of Kinangop, and all farms that are large enough to act as longclaw reserves are likely to have been subdivided to smaller sizes. Land subdivision and intensive use of small farms presents a major challenge for conservation of Kinangop grasslands. I propose urgent prioritisation of a network of large farms (>30ha) for conservation action.

**Key words:** Grassland, Kinangop, landscape, land subdivision, Sharpe’s Longclaw
1. Introduction

Population decreases of grassland birds due to conversion and fragmentation of their habitat is a widespread problem (Jansen et al., 1999; Temple et al., 1999; Vickery and Gill, 1999; Vickery et al., 1999). Sharpe's Longclaw *Macronyx sharpei*, an endemic resident restricted to the highland grasslands of Kenya (Stattersfield et al., 1998), is threatened by loss of its grassland habitat. It occurs almost exclusively on privately-owned grasslands, which are under severe conversion pressure from agriculture. The continued loss of the longclaw's habitat through conversion and fragmentation has led to its being listed as 'Endangered' (BirdLife International, 2000).

The highland grasslands on Kinangop Plateau are the stronghold of Sharpe's Longclaw (Bennun and Njoroge, 1999). Originally, the habitat was open tussock grassland, grazed by large ungulates and with numerous tussock bogs along drainage lines (Bennun, 1999). The land was initially under the ownership of white settlers before Kenya gained independence in 1963. Settlement by smallholder agriculturalists started following independence in the 1960s, and the area is now densely settled. Native grasslands in the area are threatened by conversion and fragmentation resulting from a complex combination of demographic, environmental and economic factors (Bennun and Njoroge, 1999; Rayment and Pisano, 1999). Human population is increasing rapidly leading to pressure on land. Crop production is now being favoured over livestock rearing due to unreliable payments by large-scale milk purchasers and climate changes that have reduced frost occurrence (Bennun and Njoroge, 1999; Rayment and Pisano, 1999). Reduction in the area of semi-pristine grassland, especially tussock, has been rapid. The grasslands that remain are increasingly fragmented (Muchai, 1998). This negatively influences Sharpe's Longclaw (Lens et al., 2000) and other birds that depend on these grasslands.

The Sharpe's Longclaw has very specific habitat requirements (Section 2.2) making accurate predictions about its population trends based on habitat models possible (Cowley et al., 2000). The extent and quality of its habitat throughout Kinangop Plateau have not been documented, but there are data on land subdivision and human population growth, major factors that drive grassland fragmentation. As human population is increasing steadily and mean acreage of landholding is decreasing, more grassland is being converted on virtually a daily basis (Muchai, 1998; Lens et al., 2000).

This study investigates the influence of farm size on the extent and quality of the longclaw's habitat within individual land holdings, and how mean farm size is affected by human population growth. It further sets out to predict future changes in the extent of suitable habitat throughout Kinangop Plateau by use of a simple deterministic model. The model makes use of past land subdivision (1984 to 1994) and human population (1969 to
1999) data, together with information on land use patterns within a subset of the farms in Kinangop, to make predictions of grassland cover for a time span of 16 years (1995 to 2010). Finally, possible conservation measures that will stem the loss of Sharpe's Longclaw habitat are considered.

2. Methods

2.1 Study area

The Kinangop montane grasslands (0°42'S; 36°34'E) have been described by Bennun and Njoroge (1999). They fall in the Central and (a small portion) Rift Valley Provinces of Kenya, at an altitude of between 2400-2700 m asl on the Kinangop plateau, covering approximately 77000 ha. The plateau is bounded by the Aberdare Mountains to the east and a steep scarp along the 2400m contour, dropping to the Rift Valley floor, to the west. Rainfall is around 1000 mm per year, the southern part being wetter than the north, which lies in the rain-shadow of the Aberdares (Republic of Kenya, 1997; Bennun and Njoroge, 1999). It is part of the Kenya Mountains Endemic Bird Area (Stattersfield et al., 1998), and has been identified as one of the 60 Important Bird Areas (places of international significance for the conservation of birds) in Kenya (Bennun and Njoroge, 1999). The present study was carried out within 13 settlement areas distributed throughout Kinangop Division, the small administrative region that covers most of Kinangop Plateau.

Kenya human population census of 1999 estimated a population density of about 160 people km⁻² for Kinangop (Republic of Kenya, 2000). Although, this density is higher than the national density (50 people km⁻²), it is lower than the density of Central Province (280 people km⁻²), the administrative region within which most of Kinangop Plateau lies. The Kinangop Plateau is rich farming land that has attracted farmers from within and outside Central Province. The main inhabitants are the agriculturally based Kikuyu people, whose livelihoods revolve around small-scale crop farming. Food crops (mainly potatoes, cabbages, peas, and maize) and a few cash crops (mainly pyrethrum, wheat, and flowers) are grown. Although food production is the main agricultural occupation of the people in Kinangop, dairy farming is the predominant enterprise. As tussock grass is unpalatable to livestock, tussock grassland is being ploughed up, re-seeded and converted to cultivation at an alarming rate (Lens et al., 2000).

2.2 Habitat use by Sharpe's Longclaw

Sharpe's Longclaw occurs only in grassland; it is never found in cultivated fields or woodlots (Bennun, 1999; Lens et al., in press). Within grassland, it shows a strong
preference for short grass with tussocks (Muchai, 1998; Lens et al., 2000), where it occurs at densities of around 1.2 birds ha\(^{-1}\) (Bennun, 1999). It nests in tussocks, forages around tussock bases, and retreats into tussocks when threatened (Muchai, 1998; Bennun, 1999). In the absence of tussocks, tall grass areas (density 0.8 bird/ha) are preferred over short grass areas (0.4 birds ha\(^{-1}\)) (Muchai, 1998; Bennun, 1999, Lens et al., 2000). Tall grass is associated with lower grazing pressures (Bennun, 1999). Sharpe's Longclaws are sedentary and group territorial, forming permanent groups of two to seven individuals, with larger groups in higher quality areas (Lens et al., in press; Muchai et al., in press). Estimates of territory size range from 0.4 to 5.6 ha (mean size: 1.7 ± 0.4 ha; Muchai, 1998). Individuals use home ranges sizes of approximately 0.5 ha (Muchai, 1998), with the home ranges being negatively related to tussock cover (Lens et al, 2000). Longclaw densities are strongly related to the size of particular grassland patches, and remain low (<0.20 birds ha\(^{-1}\)) in patches of <20 ha, no matter what the grassland type (Bennun, 1999, Lens et al., 2000). Grasslands >20 ha are likely to support high densities of the species, and may therefore serve as good 'source' reserves for other grasslands.

For the purpose of this study, I identify four categories of grassland patches based on the known ecology of the study species.

A. Grasslands at least 20 ha in size, which may serve as good 'source' reserves for other grasslands.
B. Grasslands between 5.6 and 20 ha in size, which are large enough to support at least one longclaw territory of the maximum size recorded.
C. Grasslands between 0.5 and 5.6 ha in size, which are large enough to support one longclaw home range.
D. Grasslands less than 0.5 ha in size, which are too small to support a single longclaw home range.

These categories are later used to classify farms into four suitability classes, depending on the area of continuous grassland patches the farms are likely to support.

2.3 Land subdivision and human population

Information on past land subdivision on the Kinangop Plateau was obtained from a sample of land subdivision maps that plot farm boundaries. The study area is subdivided into multiple settlement 'schemes', for each of which a set of maps are compiled by Survey of Kenya at a scale of 1:10,000. These maps are updated regularly to reflect date and type of farm boundary amendments (subdivision, interchange or merging). Sample maps were obtained from 12 settlement schemes that lie within the longclaws' range. From the set of maps of each scheme, a sample map covering the greatest area was
selected. Two maps were, however, selected for one of the schemes, resulting into 13 sample maps (Figure 1, Table 1). The selected maps were examined, and details regarding dates of land amendments and resultant numbers of farms recorded for each year (1984 to 1994). A list of the original sizes of all farms before subdivision was obtained and used to estimate the average size of the resultant farms after subdivisions for each year.

Data on human population density for Kinangop Plateau was obtained for the years when there have been Kenya human population censuses. The data for Kinangop Division was available for 1969, 1979, 1989, and 1999. The data on human population density for these census years were used to project inter-census population densities based on an inferred annual population growth rate. Human population growth in the future years was projected using growth rates arising from three scenarios. Under these scenarios, population was assumed to grow (1) exponentially at the 1989/99 growth rate, (2) linearly at the 1989/1999 growth rate; or (3) exponentially at the 1969/99 average growth rate. Based on the existing data, a functional regression between human population density and proportion of land under farms of different size categories was established and used for future projections.

2.4 Grassland cover and quality within farms and schools

A random sample of 6 small (<6 ha) and 6 large (>6 ha) farms selected from each of the study maps (Table 1) was visited between 21 September and 15 October 2000. Farm size, overall grassland cover, tussock grassland cover, tussock density, number of human residents on the farm, and number of grazing livestock were recorded for each of the farms visited. I suspected that the often steep, shallow-soiled areas near river valleys had more grasslands because they were unlikely to be cultivated. Distance of farm boundary to the nearest river or stream valley was therefore recorded. Grasslands were broadly classified as ‘tussock’ (if tussock density ≥5%) or ‘non-tussock’ (c.f. Muchai, 1998; Lens et al., in press). In a more quantitative assessment, tussock density was classified as 0 (none, or almost no tussocks), 1 (a few scattered tussocks, up to 5% of area), 2 (moderate tussock cover, 5% to 30% of area), 3 (considerable tussock cover, from 30-60% of area) or, 4 (dense tussock cover, greater than 60% of area). Grass height is also an important variable that affects Sharpe’s Longclaw densities (Lens et al. in press), but prolonged drought prior to the study meant that most areas had only short grass. Under usual conditions grass height on Kinangop is associated with grazing pressure, so grazing intensity was used as a surrogate for estimating grass height. Relative grazing intensity was estimated as the density of large animal units (LAU), expressed as LAU per ha of
grasslands. One LAU is defined as being equivalent to one cow or five sheep, and represents the metabolic equivalent of a 454 kg cow (Owen-Smith and Danckwerts, 1997; Jansen et al., 1999). The nearest distance between the boundary of grassland patches within an individual farm and other grassland outside the farm also was recorded. Correlation tests were done to establish which variables within individual farms were best related to the following grassland characteristics that are important for Sharpe’s Longclaws: (i) total grassland area, (ii) area of tussock grassland, (iii) tussock density and (iv) grazing intensity (as a surrogate of grass height).

Thirty-four public primary and secondary schools (2 or 3 per settlement scheme) were also visited to assess their potential as longclaw reserves (c.f. Bennun and Njoroge, 1999). The amount and quality of grasslands remaining in their compounds was assessed as in farms. A head teacher was also interviewed in each school.

2.5 Predicting landscape grassland cover and suitability of individual farms

Regressions were used to derive functional relationships between farm size and grassland (tussock and non-tussock) cover from the 162 farms that were actually visited. These relationships were to be used later in estimating grassland cover on farms whose size history data was obtained from maps. Farm size data obtained from land subdivision maps was classified into seven size classes of <2, 2-5, 5-10, 10-15, 15-20, 20-30 and >30 ha. Estimates of proportion of area covered by each class for the years 1984 to 1994 were made, and regression models derived for estimating percentage cover of each of the classes as a function of human population density. Individual farms within each class were assumed to have a constant size lying halfway between the class range. Estimates of grassland cover within the farms were obtained from a regression model relating grassland cover to farm size. For each of the seven classes, The percentage area covered by grasslands in each class was estimated by the equation:

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\% \text{ Grassland cover (overall or tussock)} = \frac{\{(\text{Grassland cover estimate per farm}) \times (\text{number of farms in that class} \times 100)\}}{\text{overall area sampled}}.
\]

Grass cover estimates within farms of different sizes formed the bases for classifying farms into four broad suitability categories. Farms that were estimated to support grasslands patches of categories A, B, C, and D of section 2.2 above, were classified as ‘highly suitable’, ‘suitable’, ‘poor’ and ‘unsuitable’, respectively.
3. Results

3.1 Grassland cover and quality within individual farms

I visited a total of 162 study farms ranging in size from 0.5 acres to 130 acres (0.2 to 52.6; mean 9.6 ha) in the 13 settlement schemes of Kinangop Plateau (Table 1). ‘Small’ (<6 ha) farms (mean 2.0 ha, n=76) covered 9.8% of the sample area. Tussock grasslands covered 23.0% of the area on small farms while non-tussock grasslands covered 23.6%. ‘Large’ (>6 ha) farms (mean size 16.4 ha, n=86) covered 90.2% of the sample area. Tussock grasslands covered 37.4% of the area on large farms while non-tussock grasslands covered 22.2%. Crops, woodlots and residential structures mostly covered the rest of the area.

Farm size was positively correlated with total grassland area, tussock grassland area and tussock density, and negatively correlated with grazing intensity and distance to river valleys (Table 2). Tussock grassland area was most strongly correlated to total grassland area. Tussock density was weakly correlated with both farm size and grassland area.

The functional relationships of overall grassland cover and tussock grassland cover to farm size and overall grassland cover, respectively, were established (Figures 2 and 3). There was little tussock cover in some large grasslands that had originally been used as wheat or barley plantations by white settlers, or whose local geological and topographical conditions did not favour tussock growth. This led to an apparent dichotomy of large grasslands with very little tussock cover and large grasslands that were almost entirely covered by tussocks (Figure 3).

According to the farm size - grassland size relationship, grasslands of the size 0.5, 5.6, and 20 ha (in reference to categories of Section 2.2) could be expected on farms of the sizes 2.1 ± 1.4, 9.2 ± 2.0 and 29.2 ± 3.8 ha (95% CI) respectively. Farm sizes of 2, 10, and 30 ha, were therefore, set as thresholds for classifying farms as ‘unsuitable’ (<2 ha), ‘poor’ (2 to 10 ha), ‘suitable’ (10 to 30 ha) or ‘highly suitable’ (≥30 ha) for Sharpe’s Longclaw (Figure 4).

3.2 Human population growth and land subdivision

Human population density (people km\(^{-2}\)) in the Kinangop Plateau almost doubled from 93 in 1969 to 160 in 1999 (Republic of Kenya, 1970; 2000). The latest inter-census (1989-99) annual population growth rate of 3.75% has been the highest compared to the 1969-79 and 1979-89 inter-census population growth rates of 1.00% and 0.78% respectively (Republic of Kenya, 1970; 1981; 1994; 1997, 2000). Based on the three
population growth scenarios (section 2.3), population density for the year 2010 was projected to range between 195 and 239 persons km$^{-2}$ (Figure 5). A total of 1582 residents occupied 156 of the farms (residence information was not provided in six farms) that were sampled (mean number of residents per farm = 10.1 ± 7.3), at a density of 5.0 ± 5.1 (n=72, SD) and 1.0 ± 0.7 (n=84) persons per ha in small and large farms, respectively.

Based on the sample maps, the number of farms occupying the entire Kinangop Plateau are estimated to have almost doubled from 6470 in 1984 to 12550 in 1994. Correspondingly, average farm size halved from 12 ha to 6 ha. Further increases of up to 30350 farms and decreases in average farm size to 2.5 ha in 2010 are projected if human population is to increase exponentially as in the recent years (Figure 6). Estimates for the year 2000 show that over 70% of Kinangop Plateau is currently under farms <10 ha in size. Area under larger farms is rapidly decreasing, and the percentage area covered by ‘highly suitable’ (>30 ha) farms halved between 1984 and 1994 from 18% to 9% (Table 3).

3.3 Predicted grassland cover and suitability for Sharpe’s Longclaw

Grasslands were estimated to cover 50% of Kinangop Plateau in the year 2000. Only 25% (half of the grasslands) of the plateau was estimated to be covered by tussock grasslands, the preferred habitat of Sharpe’s Longclaw (Figure 7). Most (57%) of the tussock grassland, were estimated to be found within farms that are unlikely to support many or very large territories (2-10 ha or ‘poor’ farms). Only about 5% of tussock grasslands was estimated to be found in farms large enough to support grasslands that could act as ‘source’ reserves for the longclaw (>30 ha or ‘highly suitable’ farms). It is predicted that by the year 2010, the current tussock area will have dropped by 50% to cover 12 to 20% (about one-sixth) of the entire plateau. Almost all of the tussock grasslands will be on farms classified as ‘poor’ (Figure 7). Virtually all farms that have potential for holding grasslands big enough to serve as ‘source’ reserves for longclaws (‘highly suitable’ farms) will have been subdivided.

3.4 Grasslands in neighbouring farms

Grasslands within 76% (111 out of 146) of the farms that had grasslands on them were adjacent to other grasslands on neighbouring farms. Only 4% (6/146) of the grasslands within individual farms were at a distance greater than 50 m from the nearest neighbouring grassland in the adjacent farms. Even in these cases, none of the nearest neighbouring grassland was at a distance greater than 700 m away. However, the
adjacent grasslands often differed in tussock quality, with only 27% (30/111) of the adjacent farms falling in the same tussock density category.

3.5 Grasslands in schools

A total of 34 public (27 primary and 7 secondary) schools was visited. Their compounds ranged from 0.9 to 16.2 ha (mean 4.8 ± 3.8). Most (n=23) of the schools were on land of less than 6 ha. Unlike privately-owned farms, schools plots were rarely subdivided. Only 2 schools had subdivided their plots since they acquired them, whereas 10 had increased the size of their land through acquisition. Grasslands covered about 75% of school plots (mean 3.5 ± 3.3 ha per school). However, most were playgrounds where tussocks had been removed. Only 4 of the 34 schools had grasslands with > 5% tussock density. These tussocks occurred in small patches except for one school that had 10.5 ha of dense tussock. Twenty (59%) of the school head teachers interviewed thought that it would be possible for their schools to set aside some land for the conservation of Sharpe’s Longclaw.

4. Discussion

4.1 Effect of farm subdivision and size on grasslands

Extent of suitable habitat is important in predicting Sharpe’s Longclaw numbers (Lens et al., in press). However, grasslands in Kinangop have been highly transformed, the effect being worsened by land subdivision. This study shows that extent and quality of grasslands within individual farms reduce with decreasing farm size. Also, grazing intensity increases with a reduction in farm size, further degrading the remnant patches. At certain farm size thresholds (mostly below 1 ha), grasslands drop out (cf. Figure 4). The residents of Kinangop are subsistence farmers, their priority being to make a living from their farms. Within small farms, cultivation is therefore understandably given a priority over retaining small areas of grassland. Also, higher human population density on small farms led to more pressure on the remnant grasslands and the need to convert larger portions of the farm for cultivation.

Members of the household usually provide the labour force (for cultivation and fodder provision), and most farming activities are not mechanised. Dairy farming requires less labour, especially if more pasture is retained. Consequently, owners of large farms prefer to retain larger pastures. Capital and labour limitations, as well the ability of the large pastures to meet the livestock needs, discourage pasture improvement in large farms, resulting in the retention of larger tussock grassland patches.
Tussock density tended to differ between adjacent grasslands of neighbouring farms, probably due to existence of independently managed patches that faced different levels of degradation. Apart from reducing grassland patch area, land subdivision apparently results in loss of continuity in grassland quality for the longclaw. With increasing human population, progressively smaller land subdivisions occur leading to further loss of continuity in grassland habitats and pressure on the remnant grasslands. Indeed, this study suggests that the remaining tussock grasslands cover only about a quarter of Kinangop Plateau, most of them being found on farms that are relatively small to hold grassland patches that can support large-sized longclaw territories. This scale of habitat loss and fragmentation is likely to have serious implications for the longclaw and other highland grassland biota of Kinangop Plateau.

4.2 Kinangop Plateau: a special challenge

Conservation of Sharpe’s Longclaw and other grassland biodiversity on Kinangop Plateau presents a challenge. Landholdings in Kinangop are minuscule compared to threatened habitats found on agricultural land in grasslands elsewhere in the world. For example, in Mpumalanga Province of South Africa, populations of birds in the mostly privately-owned highland grasslands are threatened by afforestation, annual burning and high stocking rates (Jansen et al. 1999). However, compared to Kinangop’s mean farm size of 6 ha in 1993, mixed farming units in Mpumalanga had an average size of 670 ha (Agri SA, 2000), i.e. more than two orders of magnitude larger.

In Kinangop, high population density, lack of alternative sources of income, and the culture of land succession have led to rapid land subdivision and intensive use of the already small landholdings.

In addition to having rich farming land, Kinangop is surrounded by regions that have substantially higher human population density. It is, thus likely to be a destination for people moving from other areas. In fact, the human population growth rate in the entire Central Province (in which Kinangop is located) is quite low (1989/99 growth rate = 1.7%; Republic of Kenya, 2000), compared to Kinangop’s 3.75%. The price of land in Kinangop is now high by Kenyan standards (USD 4500 ha⁻¹). This is due to the increased demand for land by immigrants and the traditional need to own individual pieces of land. Most new entrants therefore can only afford to buy small farms. A further complicating factor is that an increase in the number of landholdings presents a challenge to conservation initiatives due to the increase in the number of stakeholders to be dealt with.

In addition to Sharpe’s Longclaw, Kinangop Plateau holds three other restricted-range bird species and a distinctive avifauna that includes localised species and large
numbers of Palearctic migrants that use the area on passage (Bennun and Njoroge, 1999). There is further possibility that the grasslands could be holding other unique highland grassland species. In fact, the frogs *Hyperolius montanus* and *Phrynobatrachus kinangopensis* and the Kenya Horned Viper *Bitis worthingtonii* are only known from Kinangop and a few other sites in the Kenyan highlands (Bennun and Njoroge, 1999). Continued loss of grasslands implies further threats to this unique biodiversity. Unlike Sharpe's Longclaw, the other highland grassland fauna of Kinangop Plateau have been little studied. However, the longclaw is distributed over most of the plateau, and its specific habitat requirements make it quite sensitive to changes in grassland cover and quality. The longclaw may therefore, serve as an umbrella species, since conservation of its habitat may bring many other species under protection.

The high rate at which the habitat of Sharpe's Longclaw is disappearing requires that the remaining habitat be quantified urgently at a landscape level. Collection of fine-grained data over extensive areas can be resource and time intensive. The approach used here serves as a good starting point for understanding the dynamics of future grassland loss on Kinangop Plateau at a landscape level. Environmental managers are placing increasing emphasis on landscape scales, since they reflect the cumulative effects of anthropogenic change (Cowley *et al.*, 2000; Ormerod and Watkinson, 2000). However, the approach used here has a number of possible weaknesses. Relying on farm size as the main predictor of grassland cover and quality fails to consider topographic and geological factors, or the economic considerations and individual behaviour of landowners. Nevertheless, since farm size is correlated to all grassland variables that are important for Sharpe's Longclaw habitat, it is assumed to be a good proxy for predicting the longclaw's habitat.

Apart from using a simple deterministic approach that does not take into account environmental and catastrophic stochasticity (Beissinger and Westphal 1998), the study faces the problem of extrapolating grassland cover from individual farms to wider areas. The extrapolated grassland cover may not be an accurate estimate of the actual cover. However, it should give an idea of the pace and scale at which the habitat of Sharpe's Longclaw and other grassland birds is declining in response to land use changes. Despite these potential weaknesses, I believe that the predictions of this study are realistic, if not conservative.

4.3 *The way forward: exploring options* 

Unless immediate action is taken, the cost of reversing the decline of the grassland habitat may become prohibitive. Lens *et al* (2000; in press) have suggested a need for a
spatial network of large, homogeneous patches of grassland that could form ‘source areas’ for the long term survival of Sharpe’s Longclaw. This would require land purchase, land management agreements, or a system of incentives for farmers to refrain from converting grasslands into cultivated fields (Bennun and Njoroge, 1999; Lens et al., 2000; Muchai et al., subm.) and not to subdivide their farms. Designation of potential small reserves on common land, or institutions such as schools has also been suggested (Bennun and Njoroge, 1999). Findings of this study make it doubtful that most of the school plots meet the grassland area and quality requirements that would qualify them as potential reserves for Sharpe’s Longclaw. Also there is no scope in the Kenyan legislation that makes available financial incentives for biodiversity conservation on private land, and property rates are rarely implemented in the Kenyan rural setting. Financial incentives that are commonly used elsewhere, e.g. tax concession or subsidies, (McDowell, 1986; Vickery et al., 1999; Langholz et al., 2000) are therefore almost impossible to apply in the Kinangop situation.

Large farms have the potential of providing large extents of suitable habitat that can serve as reserves or ‘source’ areas for the longclaw. Large farms are however, few and almost all of them are likely to be subdivided soon. As an urgent intervention, a “few-large farm reserves” approach may be more appropriate and cost effective in the short term. Incentives in form of rewards for not subdividing farms and refraining from converting grasslands into cultivated fields may be targeted to the few owners of the large farms under land agreements. Such an approach would avoid high initial and management costs that may be incurred by purchasing reserves. It also has the opportunity of integrating longclaw conservation with the productive land uses practised by the landowners, e.g. ‘grassland-friendly’ dairy farming.

Criteria for setting priorities among large farms is, however, needed because not all large farms are likely to have high tussock cover (c.f. Figure 3), and some farms have a high potential for future conversion. The criteria could include: (a) presence of large tussock area; (b) lack of immediate plans of removing tussocks, probably due to the need to spare them for pasture; (c) proximity to large grasslands in other farms; (d) few number of dependants; (f) presence of tussocks on infertile, shallow or steep land that has little potential for cultivation; (g) and sympathetic landowners’ attitudes to conservation of biodiversity.

The dynamics of remnant areas are predominantly driven by factors arising in the surrounding landscape. There is, therefore, a need to develop an integrated approach to landscape management that places the selected farm reserves in the context of the overall landscape (Saunders et al., 1991; Wiens, 1994), without creating a sense of alienation to
smallholder farmers. In the long term, an innovative approach that encompasses even the smaller farms should eventually be employed. Since students in the local schools are likely to represent almost every household, schools may serve as effective centres of spreading awareness to all landowners. The local community should be made aware of the unique biodiversity of the area, as well as the role of grasslands in maintaining watershed functions (water infiltration, purification, flow control, soil stabilization). Without such realisation, the local community is unlikely to be genuinely concerned about the future of the grasslands.

The goals of grassland conservation should also be harmonised with those of soil conservation and agriculture throughout the landscape. A local conservation action group ‘Friends of Kinangop Plateau’ is campaigning for an initiative that encourages production of food crops from small productive kitchen gardens. Such an idea may be pursued. The existing perception of introducing exotic as a soil conservation measure needs to be challenged.

Sharpe’s Longclaw and other grassland species on Kinangop Plateau are found in a country and place where people are generally poor and are in dire need of appropriate income. The people do not realise the global non-consumptive values that are attached to the species, and they may not be able to bear the costs of retaining its habitat. Major interventions, such as the ones proposed here would require substantial funds that may be beyond what local conservation NGOs can afford. International support is therefore of the essence.

Conclusions
Loss of grassland habitat in Kinangop is worsened by the existence of a large proportion of the remnant native grasslands in small landholdings that are likely to be intensively used. This reduces the chances of having grasslands that offer good habitat for Sharpe’s Longclaw and other highland grassland biota. From the simple predictive model of grassland loss on Kinangop Plateau, it is clear that immediate action needs to be taken. A delay of as little as ten years could result in 50 % decline in the current tussock cover, and subdivision of almost all farms that currently have the potential of being managed as longclaw reserves. It is thus imperative that conservation strategies should initially focus much of their efforts on the currently large farm units.
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References


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Figure 1: Location of Kinangop Plateau and sample areas selected.
Figure 2: Relationship between farm area and grassland area within individual sample farms. Regression equation: Overall grassland area = 0.718 x Farm area - 0.9774 (SE slope = 0.029, SE intercept = 0.403, $r^2 = 0.792$, p<0.05).

Not linear - bigger farms have relatively more grassland
Figure 3: Relationship between overall grassland and tussock grassland area.
Regression equation: Tussock grassland area = 0.660 x Overall grassland area - 0.465
(SE slope = 0.038, SE intercept = 0.376, \( r^2 = 0.659 \), p<0.05). There was a dichotomy of large grasslands with little tussock cover (ii) and, large grasslands that were almost entirely covered by tussocks (i).
Figure 4: Based on the relationship illustrated on Figures 2 and 3, the size of area covered by overall grasslands (a) and tussock grasslands (b) can be predicted from the size of individual land parcels at 95% confidence limits (boundaries shown by thin lines). Farm suitability categories are based on grassland patch size thresholds shown as (i) and (ii). The threshold for ‘unsuitable’ farms (0.5 ha) is not shown.
Figure 5: Human population density estimates in Kinangop based on the past four national censuses and projections until the year 2010. Projections are based on three growth rate scenarios: A - exponential at the 1989/99 growth rate; B - linear at the 1989/1999 growth rate; and C - exponential at the 1969/99 average growth rate.
Figure 6: (a) Past and projected mean farm size across the study area (b) Past and projected number of farms in the entire Kinangop Plateau. Projections based on three human population growth scenarios are shown.
Figure 7: Past and projected percentage overall and tussock grassland cover on: (a) the entire study area (b) ‘highly suitable’ (>30 ha) farms; (c) ‘suitable’ (10 to 30 ha) farms; and (d) ‘poor’ (2 to 10 ha) farms. Expected projections under the three human population growth scenarios are shown in (a). For the years for which land subdivision data was obtained, estimates of total grassland cover are represented by closed squares while tussock grassland cover is represented by open triangles.
### Table 1: Selected sample maps and farms that were visited in the various settlement schemes of Kinangop Plateau.

<table>
<thead>
<tr>
<th>Name of scheme</th>
<th>Area of scheme (ha)</th>
<th>% scheme area in selected map</th>
<th>% area of scheme covered by sample farms</th>
<th>No of sample farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Githioro</td>
<td>4375</td>
<td>42.6</td>
<td>3.6</td>
<td>12</td>
</tr>
<tr>
<td>Kahuru</td>
<td>6076</td>
<td>30.0</td>
<td>2.2</td>
<td>10</td>
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<tr>
<td>Karati</td>
<td>5957</td>
<td>29.9</td>
<td>1.5</td>
<td>12</td>
</tr>
<tr>
<td>Kitiri</td>
<td>5382</td>
<td>32.5</td>
<td>2.3</td>
<td>13</td>
</tr>
<tr>
<td>Mawingo</td>
<td>5199</td>
<td>32.9</td>
<td>1.0</td>
<td>10</td>
</tr>
<tr>
<td>Mkungi</td>
<td>2951</td>
<td>56.8</td>
<td>2.7</td>
<td>12</td>
</tr>
<tr>
<td>Mumui</td>
<td>1662</td>
<td>98.8</td>
<td>9.0</td>
<td>12</td>
</tr>
<tr>
<td>Muruaki*</td>
<td>6998</td>
<td>23.0</td>
<td>1.6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.5</td>
<td>1.7</td>
<td>11</td>
</tr>
<tr>
<td>Nandarasi</td>
<td>2943</td>
<td>52.6</td>
<td>2.7</td>
<td>11</td>
</tr>
<tr>
<td>Njabini</td>
<td>5206</td>
<td>29.1</td>
<td>1.9</td>
<td>12</td>
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<tr>
<td>Ol Aragwai</td>
<td>7240</td>
<td>20.5</td>
<td>2.5</td>
<td>14</td>
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<tr>
<td>Tulaga</td>
<td>4794</td>
<td>30.3</td>
<td>2.2</td>
<td>13</td>
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<tr>
<td>Turasha Ridge*</td>
<td>5051</td>
<td></td>
<td>1.7</td>
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</table>

*Two sample maps were selected from Muruaki Settlement Scheme and none from Turasha Ridge*
Table 2: Correlation coefficients, r among on-farm variables including the four grassland characteristics important in explaining the quality of Sharpe’s Longclaw habitat. All r values in the table are significant at \( p<0.05; n=162 \).

<table>
<thead>
<tr>
<th>Correlate on-farm variables</th>
<th>Overall grassland size</th>
<th>Tussock grassland size</th>
<th>Tussock density</th>
<th>Grazing intensity</th>
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</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>0.86***</td>
<td>0.68***</td>
<td>0.26**</td>
<td>-0.28**</td>
</tr>
<tr>
<td>Overall grassland size</td>
<td>0.78***</td>
<td>0.25**</td>
<td>-0.28**</td>
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<tr>
<td>Tussock density</td>
<td></td>
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<td>-0.20*</td>
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<tr>
<td>Grazing intensity</td>
<td></td>
<td></td>
<td>-0.21*</td>
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<tr>
<td>Distance to river valley</td>
<td>-0.19*</td>
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</table>

*Significant r at \( p<0.05 \)

**Significant r at \( p<0.01 \)

***Significant r at \( p<0.001 \)
Table 3: Percentage area of Kinangop Plateau covered by different farm size classes between 1984 and 1994. Estimates of number of farms covering the entire Plateau (77,000 ha) are also shown.

<table>
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<th>Year</th>
<th>% area of study area covered</th>
<th>Number of farms</th>
<th>Total</th>
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<tr>
<td></td>
<td>&gt;30 ha ('highly suitable')</td>
<td>&gt;30 ha ('highly suitable')</td>
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</tr>
<tr>
<td></td>
<td>10-30 ha ('suitable')</td>
<td>10-30 ha ('suitable')</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2-10 ha ('poor'))</td>
<td>(2-10 ha ('poor'))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;2 ha ('unsuitable')</td>
<td>&lt;2 ha ('unsuitable')</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30 ha ('highly suitable')</td>
<td>&gt;30 ha ('highly suitable')</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-30 ha ('suitable')</td>
<td>10-30 ha ('suitable')</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2-10 ha ('poor'))</td>
<td>(2-10 ha ('poor'))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;2 ha ('unsuitable')</td>
<td>&lt;2 ha ('unsuitable')</td>
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<tr>
<td>1984</td>
<td>18.7</td>
<td>365</td>
<td>6465</td>
</tr>
<tr>
<td>1985</td>
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<td>7003</td>
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<td>1986</td>
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<td>293</td>
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<td>1987</td>
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