SERENGETI 3: HUMAN WILDLIFE INTERACTIONS

Chapter 13 :Land Use Economics in the Mara Area of the Serengeti Ecosystem

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The northern part of the Serengeti/Mara ecosystem falls within the two Kenyan districts of Narok and Trans Mara. Within these two districts major land use changes have been clear for quite some years. Specifically, the spread of both large scale, mechanised and small scale agriculture (Norton-Griffiths 1996, Homewood *et* al. 2001, Serneels 2001, Serneels and Lambin 2001a and b); the concentration of settlements and livestock around the Maasai Mara National Reserve (Lamprey and Reid 2004); the transition of land tenure from group or communal ownership to individual ownership (Thompson 2002, Thompson and Homewood 2002); all leading to the alienation of land previously used by both resident and migratory wildlife and to the gradual loss of wildlife abundance and diversity (Broten and Said 1995, Norton-Griffiths 1995, Norton-Griffiths 1996, Otichello 2000, Said *et* al. 1997, Serneels and Lambin 2001a).

The importance of the Mara portion of the Serengeti ecosystem as a critical source of dry season grazing for the Serengeti migratory wildebeest population has long been noted (Hilborn and Sinclair 1979, Mduma *et* al. 1999, Sinclair and Norton-Griffiths 1992, Sinclair 1995, Sinclair *et* al. 1985). Indeed, with wildebeest being limited primarily by the supply of food in the dry season, any loss of dry season habitat could have an inordinate effect on this population which is in itself the main driving force of the Serengeti ecosystem (Sinclair *et* al. Chapter 2). Previous work (Hilborn 1995, Norton-Griffiths 1996, Sinclair 1995) indicates that loosing what are called the group ranches that surround the Maasai Mara National Reserve and the Mara Triangle could cause a permanent loss of perhaps 20% of the migratory wildebeest, which in turn could trigger major changes in the Serengeti ecosystem itself.

These changes in land use are perplexing in view of the large revenues generated from wildlife tourism which should encourage investment in conservation on the part of landowners rather than land development. This Chapter examines the apparent contradiction between the revenues generated by wildlife on the one hand and the land use changes initiated by the Maasai on the other. Our objective is to describe the economic conditions of the Mara portion of the Serengeti ecosystem within which individual economic agents – Maasai households – are making decisions about land use investment and development.

Our perspective is that conservation outside of Protected Areas, in the sense of maintaining viable populations of large ungulates and their predators, is a matter of land use economics driven by the differential returns from the alternative land uses which are open to Maasai landowners, namely agricultural, livestock and wildlife production, under conditions of a (mostly) free market economy and private land tenure.

THE STUDY AREA

The circa 12,800 km^2 area selected for this study (Map 1) falls within the Mara River valley, from the highlands of the Isuria escarpment to the North West to the Loita Hills in the south east, and from Narok town on the Loita plans to the north east to the Kenya/Tanzania border to the south west. It includes two protected areas (the Maasai Mara National Reserve and the Mara Triangle, from now together referred to as the Mara Reserve) and the Group Ranches surrounding the Mara Reserve. For the purposes of this study this is now referred to as the Mara Area.

Descriptions of the topography and vegetation of the Mara area abound (Epp and Agatsiva 1980, Dublin 1995, Serneels 2001). Of specific relevance to this study is the marked rainfall and gradient from the c. 500mm annual rainfall on the dry south-eastern plains of Siana to the 1200 mm annual rainfall to the north-west.

LAND USE CHANGES IN THE MARA AREA SINCE THE '70s

Agricultural Rents in Kenya

One of the key concepts to understanding the dynamics of agricultural land use change is that of *agricultural rents* which are defined as the net returns to land from all agricultural activities, both large scale and small scale (Norton-Griffiths 1996, Norton-Griffiths and Butt 2006, Norton-Griffiths and Southey 1993). These net returns are strictly financial, in that they represent the ***net cash returns*** to landowners from their agricultural activities. They are, so to speak, cash-in-the-bank at the end of the season, or at least cash-in-the-pocket, once all the ***direct expenses of production and marketing have been met***. Agricultural rents are therefore something quite different to agricultural revenues which represent the gross returns from agricultural production before deducting the expenses of production and marketing.

Agricultural rents for Kenya have been derived from a series of aerial point sampling surveys (Norton-Griffiths 1988) dating from the '80s which covered 20 districts and some 150,000 km^2 of Kenya; from highland areas receiving in excess of 2000mm of annual rainfall to low lying arid areas receiving less than 200mm (Norton-Griffiths and Southey 1993).

Some 27,500, georeferenced 35mm large scale (1:6000) sample aerial colour photographs were taken in the course of these surveys. Percent cover, equivalent to hectares per square kilometre, were measured from on each sample photograph at an interpretation scale of 1:600 for all crops and crop combinations (ESL 1987). Standard GIS methods were used to associate each georeferenced photograph with a wide range of physical, administrative, environmental and other spatially organised data.

Net returns from each agricultural land use were derived from the PARM crop budget methodology as applied by the Tegemeo Institute of Edgerton University, Kenya (Monke and Pearson 1989, PARD 1991, Sellen 1991). For any given agricultural activity, for example "small scale pure maize in agro-ecological zone UH3" (Jaetzhold and Smith 1982), all indirect and direct costs are itemised, including labour, land preparation, machinery and other inputs and, where appropriate, costs of transport, marketing and sales. Not included are the costs of acquiring or converting land, of land mortgages, of depreciation, or of taxes (apart from local cess where appropriate).

Any individual crop budget may be based on up to 50 farmer interviews for a given district and agro-ecological zone. Budgets reflect the range of variation from "good", "average" and "bad" years, from intercropping and from double cropping. In the final crop budget gross revenues were found by multiplying yields per hectare per season by contemporary (mid '80s) farmgate prices, and net returns were found by subtracting from them the itemised costs of production and sales. Finally, agricultural rents were derived from the individual net returns of every crop and crop combination by averaging the data from the sample photos falling within individual 5km UTM grid cells (6-7 samples per cell in the high potential areas, 2-3 samples in the low potential areas). For this study all values were discounted to a base year of 2002 and expressed as US$ per hectare per year (\$ $ha^{-1}y^{-1}$).

Agricultural rents reflect long term net returns to land rather than the net returns in any specific year, much in the same way that climate reflects long term averages rather than the actual weather experienced ay any specific time. Agricultural rents are closely related to mean annual rainfall, rising sharply up to 1000mm after which they plateau and then decline in the face of the lower temperatures found at the higher altitudes in Kenya (Norton-Griffiths and Southey 1993).

Agricultural Rents in the Mara Area

The relationship between agricultural rents and mean annual rainfalls up to 900mm is given by Norton-Griffiths and Butt (2006) as:-

$$\ln(y) = 0.836 + 0.00474X \qquad \text{Eq. 13.1}$$

where ln(y) is the natural log of the agricultural rents in \$ $ha^{-1}y^{-1}$ and X is the mean annual rainfall in millimetres (n = 958, adjusted multiple $r^2 = 0.29$, t = 14.98, p = 0.000).

For the Mara Area (Map 1), mean annual rainfalls were derived from the AWhere-ACT Kenya Database (Mudsprings Inc. 1999) on a 5.5 by 5.5 km grid. A topographically dependent climate surface was fitted to the point data and interpolated at a 1km resolution using elevation. Agricultural rents within the Mara Area were then derived by applying Eq. 13.1 to each interpolated point, but were set at \$240 $ha^{-1}y^{-1}$ for annual rainfalls above 900mm which lay outside the range of the regression line (Norton-Griffiths and Butt 2006). Finally, the surface for agricultural rents was then sub-divided within a GIS environment into bands of higher and lower rents (Table 13.1A).

After adjusting for the land conserved within the Mara Reserve, there is a total of 1.139 million hectares available for use and cultivation within the Mara Area. The great majority of this land remains undeveloped for agriculture. Nonetheless, the agricultural rents which are potentially available for capture (by developing the land for cultivation) are worth some \$181 million. These rents are not distributed evenly but are concentrated in the areas of higher potential; for example, the highest band of >\$200 $ha^{-1}y^{-1}$ covers only 34% of the land area but provides 52% of the potential rents.

Capture of Agricultural Rents in the Mara Area

The magnitude of the agricultural rents available for capture, some \$460m in Narok district as a whole and \$181m in the Mara Area, creates strong incentives for landowners to capture these rents by developing their land for cultivation. Irrespective of how good an individual might be at farming, or whether they farm the land themselves or rent it out to entrepreneurs, the incentives are there to develop the land, especially the land with high potential rents. Equally, incentives are there for outsiders to alienate the land from its traditional owners, the pastoral Maasai.

The District Agricultural Reports for Narok district suggest that this is indeed the case, for the area under cultivation has been expanding at an average rate of 8.5% pa over the last 30 years (Figure 13.1) with some 120,000 hectares under cultivation by 2001 (see also Homewood *et* al. 2001, Thompson 2002). Narok is no different in this respect than any other of the 19 ASAL (arid and semi arid lands) districts in Kenya, all of which report similar significant expansion of cultivation over the last 30 years (Norton-Griffiths 1998, Norton-Griffiths and Butt 2006). However, these district level data cannot be disaggregated to the level of the Mara Area, neither do they distinguish between large scale and small scale cultivation.

Large Scale, Mechanised Cultivation: Serneels (2001) mapped the spread of large scale, mechanised cultivation (mainly wheat, farmed by contractors with short term land leases) for the years '75, '85, '95 and '00, and again in '03 using satellite imagery and ground control (Table 13.1B). There was an initial strong growth over the 20 years from 1975 to 1995 from 4,000ha to 40,000ha, clearly concentrated in the areas of highest agricultural rents. Subsequently there was a marked decline to around 25,000ha, especially in the more marginal areas of lower agricultural rents.

This decline was due to a combination of factors including lower rainfall, falling prices and rising costs (as subsidies were removed), and especially the sub-division of land so contractors were faced with negotiating leases with many individual agents (the owners of smaller land parcels) rather than with just a few agents acting on behalf of entire group ranches. The decline was accompanied by the removal of fences to allow livestock to move back onto land that had been previously cultivated (Homewood *et* al. 2001, Thompson 2002, Thompson 2005).

More recently, better rainfalls and stronger prices in both 2004 and 2005 have led to an increase in the hectares under mechanised farming, but with smaller enterprises many of which are now farmed by individual Maasai landowners themselves.

Nonetheless, despite the vagaries of climate, prices, subsidies and tenure, it is clear that the areas of higher agricultural rents were developed sooner, more completely and more permanently than were the areas of lower agricultural rents (Thompson *et* al. 2002, Thompson 2005).

Total Area Under Cultivation (Africover): There are extensive areas of small scale cultivation within the Mara Area apart from the large scale, mechanised cultivation mapped by Serneels, for example along the Isuria escarpment where some 16,000 hectares were described in the mid '80s (ESL 1985). The Africover Project (Africover 2003) mapped all land uses, including both large scale and small scale cultivation, across the whole land area of Kenya for the base year of 2000 using a combination of satellite imagery, aerial photography and extensive ground control. Potentially, therefore, the Africover data base could be used to find the total extent of cultivation within the Mara Area. However, unlike Serneels *et* al. (2001), Africover does not map the actual hectares cultivated but rather the area within which certain types of cultivation occurs. For example, a typical polygon in the Africover database might have the description "*…isolated (in natural vegetation or other) rainfed herbaceous crop (field density 10-20% polygon area)…..*" along with an estimated area of the polygon. Clearly the Africover areas had to be adjusted.

In the areas analysed and mapped by Serneels (2001), the relationship with Africover (Table 13.1C) was:-

$$y = -221.88 + 0.373X \qquad \text{Eq. 13.2}$$

where y are the hectares of mechanised cultivation mapped by Serneels (*op. cit.*) and X are the hectares of large scale cultivation as mapped by Africover (n = 5, adjusted multiple r^2 =

0.95, p=0.001). Equation 13.2 was then used to correct the Africover estimates of large scale cultivation in the Mara Area as a whole.

For small scale cultivation, which Serneels did not map, the general relationship between small and large scale cultivation mapped by Africover in the whole Mara Area was:-

$$y = 4392.78 + 0.443X \qquad \text{Eq. 13.3}$$

where y are the areas of small scale cultivation and X the areas of large scale cultivation mapped by Africover (n = 5, adjusted multiple $r^2 = 0.735$, p = 0.018). Equation 13.3 was used to estimate the hectares of small scale cultivation from the corrected hectares of large scale cultivation mapped by Africover.

The areas of agricultural land use for the Mara Area, including both large scale and small scale cultivation, were extracted from the Africover data base and converted to hectares using equations 13.2 and 13.3 (Table 13.1D). By the year 2000, a total of some 92,000 hectares had been cultivated within the Mara Area, capturing some $18.2 million of agricultural rents, the great majority of which are in the band of highest rents. This represents only some 10% of the total agricultural rents available for capture, so clearly the process of land conversion is still at an early stage.

Time Perspective: A third regression (Eq. 13.4) relates the total area under cultivation in the Mara Area in 2000 to the area mapped by Serneels in 2000.

$$y = 882.44 + 3.479X \qquad \text{Eq. 13.4}$$

where y are the corrected estimated areas of large and small scale cultivation mapped by Africover in 2000 and X are the areas of mechanised cultivation mapped by Serneels in 2000 (n= 5, adjusted multiple $r^2 = 0.98$, p = 0.000).

Equation 13.4 was used to estimate the total area under cultivation in the Mara area from the areas mapped by Serneels in each of the five surveys (Table 13.1B), expressed in Table 13.1E as cover density (ha km^{-2}, equivalent to percent cover). All these data suggest that the areas of higher agricultural rents are being taken up sooner and more completely than are the areas of lower agricultural rents, and that the greater proportion of the land that has been converted to cultivation lies in the areas of higher agricultural rents (Serneels and Lambin 2001a, b, Serneels *et* al. 2001).

Livestock Rents in the Mara Area

As with agricultural rents, livestock rents are defined here as the net returns from livestock operations expressed as \$ $ha^{-1}y^{-1}$ for the base year of 2002. Norton-Griffiths and Butt (2006) derived an empirical relationship between the net returns to livestock and mean annual rainfall (Eq. 13.5) from the analysis of 14 livestock operations in Kenya; ranging from intensively managed livestock embedded within high potential, high rainfall agricultural areas to extensively managed livestock in arid pastoral rangelands. The 14 studies covered annual rainfalls from 1,200mm to 200mm.

$$\ln(y) = -0.943 + 0.00542X \qquad \text{Eq. 13.5}$$

where ln(y) is the natural log of the livestock rents in \$ $ha^{-1}y^{-1}$ and X is the mean annual rainfall in millimetres (n = 13, adjusted multiple $r^2 = 0.699$, t = 5.368, p = 0.000).

Livestock rents within the Mara Area were derived by applying Eq. 13.5 to the rainfall surface, and then dividing into bands of increasing livestock rents. After adjusting for the areas conserved within the Mara Reserve, the livestock rents potentially available within the same 1.139m hectares of available land amount to some $35 million (Table 13.2), 20% of the potential agricultural rents (Table 13.1A). There is a slight tendency for livestock densities to be higher in the areas of higher rents, especially in the >\$50 $ha^{-1}y^{-1}$ band, otherwise they are distributed evenly across the rent gradient.

Census data from the Mara Area suggest relatively stable livestock numbers over the last 30 years (Broten and Said 1995, Norton-Griffiths 1995, 1996, 1998, Lamprey and Reid 2004). However, District Livestock Reports suggest that while cattle sales are rising year on year, smallstock sales are in decline (Figure 13.2). Narok district is again similar in this regard to the 19 ASAL districts in Kenya all of which demonstrate, over the last 30 years, a similar strong growth in cattle sales but a fall in smallstock sales with relatively stable populations of both (Norton-Griffiths 1998, Norton-Griffiths and Butt 2006).

For smallstock, these falling sales possibly indicate an increasing use for home consumption and for local trade and barter. With cattle, however, the rising sales indicate perhaps a fundamental shift in production strategy away from extensive, subsistence production towards more intensive, market oriented production.

Wildlife Rents in the Mara Area

In principle, wildlife rents can be defined in the same way as can agricultural and livestock rents, namely as the net returns to landowners from the provision of wildlife goods and services expressed as \$ $ha^{-1}y^{-1}$ for the base year of 2002. The situation is, however, a bit more complicated as far as wildlife rents are concerned, primarily from major distortions within the market for wildlife goods and services.

First is a policy distortion which denies to landowners highly profitable sources of wildlife rents from consumptive utilisation, including sport hunting, cropping, bird shooting, and the capture and sale of wildlife. The impact of this is not just lost revenues, but lost revenues specifically in areas which cannot support wildlife viewing. Before the ban on consumptive utilisation in 1977 it was possible to generate wildlife revenues throughout Narok district for all of the land was divided into hunting blocks. In contrast, wildlife viewing today is confined to some 5% of the district around the Mara Reserve.

Further distortions arise from the actions of the tourism cartels which control the supply of clients. First, these cartels divert the greater proportion of wildlife rents away from the producers of the resource, the Maasai landowners, to tourist agents and to the providers of transport and accommodation services. As a result, landowners find it difficult to capture more than 5%-10% of wildlife rents (Norton-Griffiths and Butt 2006). Furthermore, the market is highly inefficient especially with respect to the flow of information between bargaining parties resulting in marked discrepancies between the rents obtained for essentially the same services: for example, while one land parcel might receive \$40 $ha^{-1}y^{-1}$ for granting access to tour operators a second, perhaps only a few kilometres away, might receive \$5 $ha^{-1}y^{-1}$. Second, by erecting barriers against local landowners becoming involved in the tourism industry except at a trivial level (e.g. guiding), these cartels restrict the capacity of landowners to capture a greater proportion of the available wildlife rents by, for example, becoming involved in the transport sector of the industry.

Norton-Griffiths and Butt (2006) analysed 63 examples of wildlife rents received by landowners in Kenya (from 22 sources, and Lamprey 2006, Thompson and Homewood 2002). Rents from Public conservation include protected area revenue sharing schemes with the Kenya Wildlife Service (e.g. the revenue sharing schemes around Amboseli National Park) and with County Councils (e.g. the 19% of revenues disbursed to nine group ranches by the Narok County Council); and revenues from NGO and private community conservation programmes. Rents from Private conservation include both non consumptive and consumptive utilisation of wildlife. Non consumptive utilisation included concession and/or access fees with tour and lodge/camp operators (including bed night fees, local employment etc), and fees from simple camp sites, cultural bomas etc. Consumptive utilisation included bird shooting and wildlife cropping, both of which are now banned by the Kenya Wildlife Service.

The statistical distribution of the wildlife rents was highly skewed, with the great majority being less than \$1 $ha^{-1}y^{-1}$ (Table 13.3). Converting rents to natural logs made the distribution more normal, with median and mode acceptably close. On average, wildlife rents received by landowners in Kenya are \$5.83 $ha^{-1}y^{-1}$ with 95% confidence limits falling between \$6.73 $ha^{-1}y^{-1}$ and \$2.28 $ha^{-1}y^{-1}$.

It was clear from the data that there were marked differences between rents from different sources, for example concession fees compared with wildlife cropping. However, after much testing only two groups could be consistently distinguished from one another, concession and access fees on the one hand and on the other rents from "all other sources", including simple camp sites, cultural bomas, bird shooting, cropping, revenue sharing schemes etc. (Table 13.4). At \$10.21 $ha^{-1}y^{-1}$, rents from concession and access fees are some 19 times higher than are the average rents of \$0.53 $ha^{-1}y^{-1}$ from all other sources.

Although the average wildlife rents captured by landowners in the Mara are quite low, some rents are in fact very much higher. However, these seem to be both unreliable and highly variable, especially in response to fluctuations in tourist numbers. For example, in the good tourist years of 1999 and 2003, the wildlife rents received by the Narok and Trans Mara County Councils averaged \$52 ha^{-1} (Lamprey 2006, Thompson and Homewood 2002) compared with \$11 ha^{-1} ten years previously. Similarly, wildlife rents on some well organised Group Ranches ranged from \$35–\$45 ha^{-1} in these same years, while on others it was some \$2 ha^{-1}.

In general, however, the wildlife rents available for landowners, including the County Councils, in the Mara Area are both modest and highly variable. The total wildlife rents available on the Group Ranches could be as high as \$57 million at the highest recorded rents, or as low as \$11.6 million at the average rents for concession and access (Table 13.5). For the protected areas rents vary between good and bad years from \$11.7m to \$1.5m. This variability and uncertainty are all indicative of a poorly functioning and inefficient market. As a result, total wildlife rents on the Group Ranches compare quite unfavourably with the \$35m from livestock and the \$181m from agriculture (Thompson 2005).

Settlements

Lamprey and Reid (2004) mapped settlements (occupied *bomas*) from aerial photographs within an 1,827 km^2 study area to the north and east of the boundary of the Mara Reserve. Six coverages were analysed between 1950 and 1999, with a seventh in 2003. For this study, occupied *bomas* were recounted within 10km, 20km, 30km and >30km bands from the boundary of the Mara Reserve, and converted to densities (Table 13.6).

With an overall annual rate of increase of occupied *bomas* between 1950 and 2004 of 5.25% (from 0.02 km^2 to 0.26 km^2), it is clear that the rates of increase are faster, and the densities higher, nearer to the Mara Reserve than further away. These same trends are also seen in the % of occupied *bomas* at different distances from the reserve (Table 13.6). For example, during the 54 years between 1950 and 2004 the proportion close to the Mara Reserve started low (<10%) and rose rapidly to c 30%, while far from the Mara Reserve the proportion started high (>50%) but fell rapidly to <20%.

Lamprey and Reid (op cit) interpret the increase in occupied *bomas* in terms of population growth, water availability and immigration of Maasai into the area once certain constraints to settlement, specifically infestation by the *tsetse* fly, had been lifted. However, the concentration of *bomas* and the higher rates of increase closer to the Mara Reserve are good examples of the "Galapagos Effect" in which settlement is attracted by enhanced economic activity and opportunities, in this case the expansion of tourism facilities, private camps, small lodges etc. over the last 15 years around the Mara Reserve itself.

Sub-Division of land

A major and fundamental change throughout the Mara Area is the rapid transformation of land tenure from group or communal ownership to individual ownership by the sub-division of communally owned land into small parcels each with an individual title deed (Homewood *et* al. 2004, Thompson 2002, Thompson *et* al. 2002, Thompson and Homewood 2002). The process started in the Mara Area in the mid '80s and has been riven by protracted boundary and entitlement disputes, often ending in complex court battles. Following a Presidential Pronouncement in the '90s it is now government policy that group ranches should be subdivided. and the process is now some 90% complete.

Of the many factors that contributed towards the incentives to subdivide perhaps the most pervasive was security of tenure (Homewood *et* al 2004): from local and central government and their "big men", from immigrant settlers and from the possible expansion of the Mara Reserve itself. Indeed, the first group ranches to subdivide (in the north west of the Mara Area) did so in response to perceived threats from immigrant settlers who were able to acquire land by dealing directly with group ranch committees; while nearer to the Mara Reserve there were perceived threats to enlarge the size of the protected area from KWS, the County Council and from the NGO conservation community.

Other incentives were more directly economic in nature, especially the evident dilution of each members' share of the communal resources in the face of population growth and the increasing number of young people attaining the age at which they could become registered members of a group ranch in their own right. There was also widespread dissatisfaction with the inequitable distribution of revenues from land leases for large scale cultivation, and from tourism, with members of group ranch committees and other elites being perceived to be the main beneficiaries (Thompson 2002, Thompson and Homewood 2002).

Added to which there was a general change in lifestyles and aspirations among the communities, following better education, enhanced job opportunities, wider economic horizons and greater exposure to the world at large; all cumulating in the wish to manage more completely their own future and economic well being. Sub-division was seen to be the key process through which individuals could capture for themselves and their immediate family the potential land rents, be they from agriculture, livestock or wildlife; while the clear benefits accruing to individual families in terms of capturing such revenues on already sub-divided land added further incentives.

From a sample of five group ranches that have completed sub-division (Table 13.7), the original five land holdings under communal tenure were transformed into 6,521 individually owned land parcels of 34.2 hectares on average (sd = 19.1ha). From this sample, once the processes of sub-division is complete the original 38 communal landholdings within the Mara Area (Map 1) of on average 33,000 hectares each (se = 5,500ha) will be transformed into some 33,000 individually owned parcels of land. This will have, and is having, major impacts on both land use and land values.

One immediate effect of sub-division is the intensification of both agricultural and livestock production. Small parcels are not well suited to large scale cultivation, and access to livestock resources is now becoming constrained. Mobility, especially in droughts, has become increasingly difficult, and while kinship remains critical to access scarce resources such as water, salt licks and pastures, a livestock owner now has to seek permission from many families to move to a new area.

Land values invariably rise after sub-division both from the intensification of production and because it is now available in bite sized chunks rather than in huge swathes. In the Mara Area, there was initially an expansion of settlement as new owners moved onto their parcels, often before they were formally adjudicated, although many new owners were slow to move mainly for a lack of capital to develop their land and their farm. This had the side effect of forcing families which had settled but which had never been registered as members of a particular group ranch to relocate elsewhere as they were no longer welcomed or tolerated by the new landowners.

Perhaps because of this land sales became rampant, initially among the former group ranch members themselves, but later to outsiders - immigrants, tour operators and the owners of large scale farms. Land prices increased sharply from $35 to $1,300 per hectare as new investors flooded into the (previously) group ranch areas. Increased investment in land has clearly followed land sub-division, for building permanent houses and livestock pens, for clearing and preparing land for cultivation, and for water development.

One significant development has been that of neighbouring landowners grouping themselves into more or less formal wildlife associations, especially near to the Mara Reserve, to create conservation areas where in principle human settlements are not allowed and livestock use is regulated (Thompson 2005).

The members of these wildlife associations have three incentives to keep their land undeveloped for wildlife. First, they can capture the wildlife rents for themselves directly from tour operators rather than though group ranch committees. Second, they are creating more opportunities to establish new tourism facilities, either permanent or semi-permanent. Third, the wildlife rents are providing the capital to develop other land.

IMPACTS OF DEVELOPMENT ON THE SERENGETI/MARA ECOSYSTEM

The gradual attrition of the numbers and diversity of wildlife in the Mara Area and the Mara Reserve has been noted in a number of studies (Broten and Said 1995, Norton-Griffiths 1995, Norton-Griffiths 1996, Ottichilo 2000, Said *et* al. 1997, Serneels and Lambin 2001a). Here we relate these losses of wildlife specifically to the economic process of capturing agricultural rents by developing land for cultivation.

Impact of Cultivation on Resident Wildlife and Livestock

Between 1977 and 2002 the Kenya Rangeland Ecological Monitoring Unit (KREMU), now the Department of Remote Sensing and Resource Surveys (DRSRS), carried out 21 aerial surveys of wildlife and livestock within the Mara Area and the Mara Reserve when the Serengeti migratory wildebeest population was clearly not present. The densities of wildebeest (the Loita population), of all wildlife (expressed in Tropical Livestock Units) and of all livestock (also expressed in TLUs) were first calculated from each of these 21 surveys within the five bands of agricultural rents used in Table 13.1A before averaging within each successive decade corresponding to the Serneels' surveys. These decadal averages were then regressed against the crop cover density:-

$$y = a + b*X_1 + c*\ln(X_2) + d*(X_1 * \ln(X_2)) \qquad \text{Eq. 13.5}$$

where y = was the density of wildlife or livestock, X_1 was the decade ('70s, '80s, '90s and '00s), and X_2 was the natural log of the crop cover density for each decade/band (Table 13.1E).

The densities of the Loita wildebeest and of all wildlife both showed significant negative trends through time and stronger negative associations with cultivation density (Table 13.8). As expected, the cross product terms (decade * ln(crop cover)) are positive showing that both wildlife densities and crop cover are relatively higher in areas of high agricultural rents. In contrast, livestock densities show no significant trend through time nor any significant effect from increasing cultivation.

It is clear that the Loita population of wildebeest, and all wildlife in general, are being displaced by the process of capturing agricultural rents by converting land to cultivation. Livestock show no such effects and are being absorbed into the developing matrix of mixed agricultural and livestock land use (Homewood *et* al. 2001, Serneels and Lambin 2001a).

Impact of Land Development on the Serengeti Migratory Wildebeest

The numbers of Serengeti migratory wildebeest have been monitored consistently since the mid 1960s (Mduma *et al* 1999; TWCM 1999). In contrast, their migratory movements have been studied in three main phases: in the early '70s in the course of 28 monitoring flights covering the Serengeti National Park and some of the Kenyan Maasai Mara area; since 1977 in the Mara area by the KREMU/DRSRS; and more recently through following GPS collared individuals (Thirgood *et* al. 2004). For this analysis we have used the series of population censuses, the early '70s monitoring data and 11 of the KREMU/DRSRS censuses between 1979 and 1996 when the Mara Area was flooded by migrants from the Serengeti.

The size of the migratory population grew strongly in the early '70s and by 1977 had established an equilibrium where the population fluctuated around a mean of some 1.3 million (Figure 13.3). In the early '70s when the population was low relatively few moved into Kenya during the dry season, but the numbers increased substantially during the early '80s until a precipitous drop in 1984 that never reversed. The numbers moving to Kenya dropped by 65% after 1984 (Table 13.9), from an average of 0.866 million (68% of the population) to 0.307 million (27% of the population).

Of the migratory wildebeest moving to Kenya, the numbers using the Mara Reserve were high during the mid '80s but declined sharply after 1984 (Figure 13.4), from an average of 0.612 million to 0.229 million (Table 13.9). While the numbers using the group ranches outside the Mara Reserve have shown a more gradual decline (Figure 13.4), numbers dropped from an average of 0.254 million before 1984 to 0.078 million after (Table 13.9). Simple trend analysis confirms these impressions: from 1970 to the late '90s, the densities both inside and outside the Mara Reserve declined significantly, as did the overall density within Kenya (Table 13.10).

On the group ranches outside the Mara Reserve there is absolutely no rainfall signal whatsoever that can be associated with the decline in wildebeest numbers (Figure 13.5A, Reid *et* al 2000 Figure 3, and Table 13.9). However, the spread of cultivation is having a clear effect, with migratory wildebeest being selectively squeezed out of the areas of high agricultural rents (>$150 $ha^{-1}y^{-1}$) where land use development is most advanced (Figure 13.6). Multiple regression analysis confirms this impression.

$$y = 0.964 + 32.231X_1^{***} + 0.010X_2 - 1.129(X_1*X_2)^{***} \quad \text{Eq. 13.6}$$

where y = density of the Serengeti migratory wildebeest, X_1 is a dummy variable distinguishing between areas of high agricultural rents (>$150 $ha^{-1}y^{-1}$ dummy variable = 1) and low agricultural rents (<$150 $ha^{-1}y^{-1}$ dummy variable =0) and X_1 is the year since 1970 (multiple adjusted $r^2 = 0.760$, n = 54).

The dummy variable X_1 is highly significant (p = 0.000) and expresses the higher densities of wildebeest found in the areas of high agricultural rents. The time variable X_2 is not significant on its own but shows a highly significant negative value (-1.129, p = 0.000) in the cross-product term. This demonstrates clearly that wildebeest densities are falling significantly in the areas of high agricultural rents.

Inside the Mara Reserve different explanations must be sought for the drop in utilisation by the migratory wildebeest. As with the group ranch areas, there is no rainfall signal to account for the change (Figure 13.5B and Table 13.9), except that there are perhaps more very dry years since 1984 than in previous years. Other factors that could be important include the "ring fencing" by pastoral settlements (and tourist facilities) around the Mara Reserve which, at 0.34 km^{-2}, are approaching critical values for excluding wildlife (Figure 13.8). The ever increasing incursions of livestock, the increasing use of the Mara by tourists, poaching activities and vegetation change (Dublin 1995, Lamprey and Reid 2004, Serneels and Lambin 2001a,b) may all be playing a part as well.

In summary: use of the Mara Reserve and the Mara Area by the Serengeti migratory wildebeest population has dropped by some 65% since 1984, from 866,000 animals a year on average to 307,000 animals. In the absence of any evidence for a major change in rainfall, other explanations must be sought. The evidence is most clear cut on the group ranches outside the Mara Reserve, where the drop in utilisation can be associated with the explosive growth, especially in the mid '80s, in large scale (mechanised) and small scale cultivation land sub-division and the concentration of both pastoral settlements and tourist facilities around the Mara Reserve. The drop of utilisation within the Mara Reserve itself requires different interpretations.

Impact of Land Sub-Division

Data from ranches in Laikipia district (Figure 13.7) demonstrate clearly that both the density and diversity of large wildlife decline with ranch size. This would suggest that the sub-division of land in the Mara Area into smaller parcels is enough on its own to influence negatively the densities and diversity of wildlife. The formation of wildlife associations, where neighbouring landowners co-operate by leaving their (sub-divided) land undeveloped to make larger areas for capturing wildlife rents could act against this trend.

Another potential impact of land sub-division is the proliferation of settlements as land parcels are developed into a farming homesteads. This could increase the overall density of settlements from the current 0.17 km^{-2} reported by Reid *et* al. (2003) to 0.34 km^{-2} if every land parcel were so developed (note from Table 13.6 that this is the contemporary density of settlements within 10km of the boundary of the Mara Reserve). Reid *et* al. noted the strong negative relationship between the densities of occupied settlements and wildlife density (Figure 13.8). The relationship between the densities of wildlife and occupied bomas (Figure 13.8) reported by Reid *et* al. (2003 Figure 7) is:-

$$\ln(y) = 4.172 - 1.438{*}X \qquad \text{Eq. 13.7}$$

where y is the density of wildlife in natural logs and X is the density of occupied *bomas* (n = 15, adjusted multiple $r^2 = 0.85$, p= 0.000). An increase in the density of occupied *bomas* from 0.17 km^{-2} to 0.34 km^{-2} would reduce wildlife densities from 50.8 km^{-2} to 39.8 km^{-2}.

Time Horizons to the Elimination of Wildlife

A simple equation relating the total hectares cultivated (as estimated in Table 13.E) to the number of years since cultivation started and the agricultural rent can be used to calculate time horizons.

$$y = 5.208 + 0.0014 * (X_1 * X_2) \qquad \text{Eq. 13.8}$$

where y is the estimated cover density of crops (in ha km^{-2}), X_1 is the number of years since crops were first grown (the first occurrence of a crop being taken as year 1) and X_2 is the agricultural rent in \$ $ha^{-1}y^{-1}$ (n = 21, adjusted multiple $r^2 = 0.341$, t = 3.367, p = 0.003).

While it is never advisable to extend a regression analysis beyond the limits of the available data, the regressions of wildlife on crop cover density (Table 13.8) suggest that wildebeest will be effectively eliminated at a crop density of 25% while wildlife in general will be eliminated at around 40% crop density. If the rates of land development remain the same then these critical crop cover densities will be achieved in 30-60 years (Figure 13.9 from Equation 13.8). However, if most landowners start to develop small farms on their sub-divided plots then the rate of conversion of land to cultivation and intensive livestock management, along with fencing, must inevitably become faster than that currently observed. Time to the elimination of wildlife would be shorter, possibly within a decade or so. Much depends upon how quickly landowners act optimise their net returns to land.

OPTIMAL LAND USE CHOICES FOR LANDOWNERS

The agricultural rents within the Mara Area (Table 13.11) clearly outcompete those from either livestock or wildlife. The total available for capture are $181 million of agricultural rents, $35 million of livestock rents and anywhere between $12 and $57 million of wildlife rents. However, since both agricultural and livestock rents are a function of rainfall (equations 13.1 and 13.5), the optimal selection by a landowner will depend upon their differential returns along the rainfall gradient compared with those from wildlife.

Comparing agricultural, livestock and wildlife rents along the rainfall gradient we see that agriculture always provides better net returns compared with livestock (Figure 13.10) while wildlife rents from concession and access fees ($10.27 $ha^{-1}y^{-1}$) can offer an alternative and/or supplement to livestock rents only at lower rainfalls, below 600mm: relatively little (14%) of the Mara Area receives less rainfall than this. In contrast, the highest wildlife rents of $50 $ha^{-1}y^{-1}$ seem quite competitive against both crops and livestock and could offer landowners a genuine alternative to land sub-division and development.

These differentials between agricultural rents on the one hand and livestock and wildlife rents on the other go a long way to explaining the observed conversion of land to cultivation, especially in areas of higher agricultural rents. However, other factors must also be taken into account especially rainfall, for these differential returns will vary in normal versus drought years.

Norton-Griffiths and Butt (2006) modelled the optimal choice for landowners between agricultural, livestock and wildlife production in the pastoral areas of Kajiado district, Kenya. Parameters included agricultural and livestock rents as a function of rainfall (equations 13.1 and 13.4), drought years were defined as one standard deviation below average rainfall, livestock:wildlife interactions were taken into account (wildlife reduce livestock returns by 30%); and wildlife rents were set at the average for access and concession fees. When applied to the Mara Area (Table 13.12) it is clear that no single production system, e.g. only agriculture, does as well in terms of net returns as mixed production systems. Furthermore, defining the "optimal" selection of production systems as that giving highest net returns in both normal and drought years, an agriculture and livestock system where livestock returns are maximised by eliminating all wildlife are optimal in the wetter areas while a livestock and wildlife production system is optimal in the drier areas. Dry areas are absent from the Mara Area; and landowners are clearly opting for the agriculture and livestock system with elimination of wildlife.

This optimal selection depends upon the relative returns to the different production systems, and it is clear that the selection would change if the relative differentials between them were to change. In southern Africa for example, where returns to agriculture are falling (ABSA 2004), landowners are opting instead for livestock:wildlife or even wildlife only production systems.

In Figure 13.11 we model the critical wildlife rents at which the livestock:wildlife production system becomes the optimal choice in terms of providing highest net returns in both normal and drought years. Also shown are the contemporary average wildlife rents of \$10.2 $ha^{-1}y^{-1}$ from access and concession fees and the highest Mara Area rent of \$50 $ha^{-1}y^{-1}$. This high wildlife rent is effective for influencing land use choices at around 600mm – 650mm of rainfall, roughly where the wildlife associations and similar initiatives are currently struggling for survival in the Mara Area. Wildlife rents of between \$100-\$150 $ha^{-1}y^{-1}$ are required for wildlife to survive on significant areas of the Mara Area.

CONCLUSIONS

ECONOMIC DRIVING FORCES

We see four main economic driving forces that are influencing the land use decisions of the pastoral Maasai in the Mara Area. These are the differential returns to land uses and production systems; the incentives to sub-divide land; the macro and micro economic conditions that are in turn influencing these differential returns; and policy and market distortions with respect to the provision of wildlife goods and services.

Differential Returns to Land Uses

The differential returns to agricultural, livestock and wildlife production in the Mara Area (Table 13.11) are so great that agricultural returns overwhelm those from either livestock or wildlife. These differentials create incentives to develop rather than conserve land, and alone are adequate to explain the contemporary patterns of land use change. In the areas of higher agricultural rents, land is becoming developed for agricultural and livestock production and resident and migratory wildlife are being eliminated. In areas of lower agricultural rents, livestock:wildlife production systems maintain a precarious foothold.

Incentives to Sub-Divide Land

The most important incentives to sub-divide land are firstly, security of tenure -- from in-migration, and from land alienation by political elites, government or even NGOs (Homewood *et* al. 2004); secondly, to avoid the dilution of the value of communal resources from population growth; and finally to capture the benefits of agricultural, livestock and wildlife production at the family level rather than through group ranch committees or other agencies (Thompson and Homewood 2002). The process of sub-division in itself sets off significant changes: land values tend to rise, and along with them the values of agricultural and livestock rents as production strategies shift from extensive to more intensive methods.

Macro- and Micro- Economic Factors

From the perspective of the individual landowner, at the macro-economic scale domestic and international markets are expanding, there are real gains in producer prices, ever increasing opportunities for off-farm jobs and investment, and a wider availability and choice of goods and services. At the micro-economic level the landowner sees improved market and transport networks, improved information networks about market conditions, and improved access to financial services. All of these create additional incentives for landowners to increase returns to land by investing in land development and production.

Policy and Market Distortions

At the policy level, the perverse policy environment since 1977 bans sport hunting and other high value sources of wildlife revenues and, indirectly, restricts wildlife revenue generating activities to the small (c 5%) of the land that can support wildlife viewing. This denies to landowners many sources of wildlife rents.

Market distortions are created through the actions of the tourism cartels which firstly create barriers to landowners entering fully into the market for wildlife rents; and secondly divert the greater proportion of the wildlife rents away from the wildlife producers. At best landowners can trap 10%-15% of wildlife rents, the remainder going to the service provider side of the industry. It is interesting here to note that in southern Africa, where the market for wildlife goods and services is essentially free of major distortions, landowners and communities typically own and manage wildlife operations themselves, rather than act as simple concessionaires -- as is the case in Kenya -- and accordingly capture a larger proportion of the wildlife rents.

OPPORTUNITIES FOR MITIGATION AND INTERVENTION

Conservation values are clearly being lost throughout the Mara Area as landowners justifiably improve their social, political and financial status by realising the potential of their land. The strategic problem to be addressed is how to maintain such conservation values in the face of these major and fundamental changes in land use and land tenure. We see two major areas for positive interventions. First, to improve wildlife rents so they become more competitive against the returns from cultivation and livestock and second, to support the intensification of agricultural and livestock production on land with higher agricultural potential to reduce pressure on land as yet undeveloped.

Improving Wildlife Rents

Moves to implement a policy change at Government level to reintroduce high value sources of wildlife revenues through consumptive utilisation, while beneficial in the longer term, would probably have little impact in the Mara Area within the time horizons discussed above. A policy change in Kenya of this magnitude will require a long consultative process; it will be highly controversial and will generate heated debate. Meanwhile, the expansion of land conversion will proceed unabated. No improvement to wildlife rents in the short term will be realised from such a policy change, even if cropping and bird shooting were to be reintroduced.

The one positive feature of the sub-division process is where owners of adjacent land parcels are forming Wildlife Associations in which they co-operate in keeping their land undeveloped so they can benefit from wildlife rents (Thompson 2005). These associations are now found on the (former) Koyaki, Lemek and Siana group ranches, and while they are still somewhat fluid in terms of composition and membership they offer an excellent opportunity to strengthen the commercial relationship between the suppliers of wildlife on the one hand and the suppliers of clients to view the wildlife on the other. Many of these members of wildlife associations have plots elsewhere on these former group ranches and use their wildlife rents as capital for farm development. This should in turn reduce, at least in the short to medium term, the pressure to develop the land currently devoted to wildlife.

This process should be encouraged and supported by all involved in the conservation and tourism industries as it offers one of the few positive opportunities to maintain conservation values.

However, the decision to create and maintain a Wildlife Association is essentially an economic one and its success will depend ultimately on the economic returns realised for the co-operating landowners. The economics of such decisions have been explored elsewhere (Norton-Griffiths 2000) and the key, as we have seen earlier, lies with the wildlife rents. The wildlife fees paid by tourism cartels to landowners must be raised significantly to make it economically worthwhile for the landowners to keep land free of development. Most of these associations are found on land with rainfalls around 700mm where rents of some $100-$120

$ha^{-1}y^{-1}$ or more are required to keep the wildlife option sustainable in the medium to long term (Figure 13.11). To meet this target, concession areas fees and fees for access and bed nights must all be raised, along with the wages to locally recruited staff. This will in turn require extensive negotiations with the tourism cartels, who will naturally offer strong resistance.

It is even more important for landowners to become more directly involved in the tourism industry for only then can they capture larger proportions of the wildlife rents. An initial entry has been through the employment of local guides trained to accepted standards – but this is trivial. Transport provides a much better opportunity, and wildlife associations should insist that only their vehicles, drivers and guides are used on their land – as already occurs on some concessions in Tanzania. This of course requires management skills, expertise and capital – but none of these are insurmountable. Later, the wildlife associations can enter into the ownership and provision of accommodation services, which in turn requires additional skills.

Improving Agricultural and Livestock Rents

Land use in the MPSE is undergoing a rapid transformation from pastoralism to agro-pastoralism, and then to settled mixed agricultural and livestock production. Such a transformation requires capital to develop farm infrastructure and new husbandry skills in intensive as opposed to extensive production; including the selection of appropriate crop mixes and livestock breeds, the adoption of new methods of crop and livestock husbandry, and the development of new marketing skills.

Today there is an almost complete lack of agricultural and livestock extension services to assist pastoralists make this transition from extensive production on communal land to intensive production on small, individually owned parcels of land. This too often results in poor land management and poor returns, increases incentives to convert even more land, and fuels land alienation by sales to outsiders.

While in general terms the technology to effect this transition is available throughout Kenya, the transfer of this technology to these new farmers is proving problematic. Normally, farmers look to the Government for extension services, but this need not be the case, especially today when the Government has other priorities in mind. Effective technology transfer can also be achieved by mobilising local expertise, and expertise available from the commercial suppliers of agricultural and livestock services. Whichever, here is an opportunity for a positive intervention to maintain conservation values by increasing production and profits on already converted land thus reducing pressures to develop unconverted land.

A second opportunity to assist in this transformation is to develop new marketing networks, marketing skills and especially ways of providing better market information to the producers. Remote producers achieve a ridiculously low proportion of the final enduser price for their products (Norton-Griffiths and Butt 2006) and are often at the mercy of middlemen. Breaking this stranglehold will increase returns to land.

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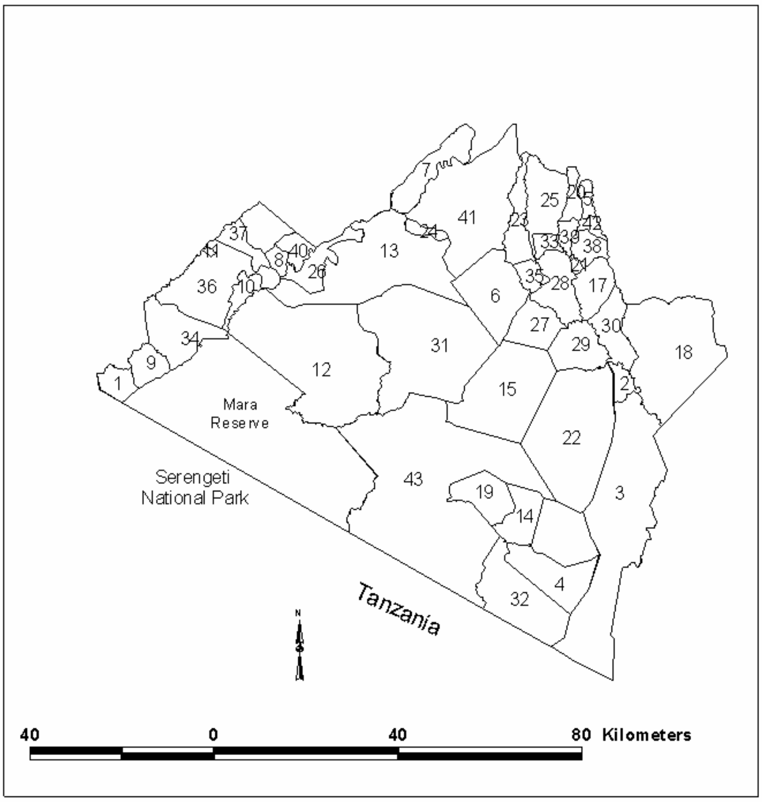
Map 13.1 Map of the Mara Area



Code	Group Ranch
1	Ang'ata Barrekoi
2	Enatamatishoreki
3	Enkutoto Elang'at' enterit
4	Entakesera
5	Eorr Enkitok
6	Ewaso Ngiro
7	Ilmotiok
8	Intulele
9	Kerinkani
10	Kimintet
11	Kimintet-a
12	Koyaki
13	Lemek
14	Leshota
15	Maji Moto
16	Morijo Loita
17	Morijo Narok
18	Mosiro
19	Naikara
20	Naisoya
21	Narok Township
22	Narosura
23	Nkoben
24	Nkorrkorri
25	Nkareta
26	OlChoro-Oirowua
27	Oldonyo Orasha
28	Oleleishwa
29	Olenkuluo
30	Oletukat
31	Olkinyei
32	Olmesutye
33	Olaimutiai
34	Oloirien
35	Iloisiusiu
36	Oloonkoliin
37	Oloonkoliin
38	Olorroito
39	Oloroito
40	Olosakwana
41	Osupuko-Ololunga
42	Rotian
43	Siana

Numbers refer to individual group ranches

TABLES

Table 13.1
Capture of agricultural rents in the Mara Area

1A: Agricultural Rents[1]						
Bands	<$50	$50-$100	$100-$150	$150-$200	>$200	Totals
Mid point ($)	$25	$75	$125	$175	$249	
Hectares	27,109	336,343	191,950	202,593	530,722	1,288,717
Conserved hectares [2]	0	0	0	4,941	144,577	149,518
Available hectares [3]	27,109	336,343	191,950	197,652	386,145	1,139,199
Available rents ($millions)	$0.68	$25.23	$23.99	$34.59	$96.15	$180.64
1B: Large Scale Mechanised Cultivation (Serneels 2002)						
1975 ha	0	0	0	0	4,002	4,002
1985 ha	0	0	837	4,451	13,867	19,155
1995 ha	0	4,808	8,998	7,459	18,849	40,114
2000 ha	0	2,540	4,691	5,459	13,382	26,072
2003 ha	0	3,526	2,907	3,030	15,432	24,895
1C: Comparison between Serneels (2000) and Africover (2000)						
Serneels 2000 ha	0	2,540	4,397	5,315	14,207	26,459
Africover large scale (area)	0	9,044	20,666	12,046	31,054	72,810
1D: Total Area Under Cultivation in the Mara Area, 2000, from Africover [4]						
Total cultivation (hectares)	0	11,634	16,019	10,832	54,011	92,496
Rents captured ($ millions)	$0.00	$0.87	$2.00	$1.90	$13.45	$18.22
% Rents captured	0.0%	3.5%	8.3%	5.5%	14.0%	10.1%
1E: Estimated Total Crop Cover Density in the Mara Area (ha km^{-2} = % cover) [5]						
1975 ha km^{-2}	0.0	0.0	0.0	0.0	3.8	1.2
1985 ha km^{-2}	0.0	0.0	2.0	8.3	12.7	6.1
1995 ha km^{-2}	0.0	5.2	16.8	13.6	17.2	12.6
2000 ha km^{-2}	0.0	2.9	9.0	10.1	12.3	8.3
2003 ha km^{-2}	0.0	3.9	5.7	5.8	14.1	7.9

(1) from equation 13.1; (2) Maasai Mara National Reserve and Mara Conservancy, (3) for use by wildlife, livestock, settlements and agriculture; (4) corrected from equations 13.2 and 13.3; (5) hectares from equation 13.4, then converted to ha km^{-2} (equivalent to % cover)

Table 13.2 Livestock rents in the Mara Area						
Livestock rents	<$10	$10-20	$20-30	$30-50	>$50	Totals
Mid point ($)	$9	$15	$25	$40	$70	
Hectares	179,406	281,298	288,052	287,922	252,040	1,288,718
Conserved hectares	0	0	2,651	92,662	54,206	149,519
Available hectares	179,406	281,298	285,401	195,260	197,834	1,139,199
Available rents ($millions)	$1.61	$4.22	$7.14	$7.81	$13.85	$34.63
Mean livestock density	23.00	24.81	31.91	31.24	40.93	30.21
% total livestock	11.99%	20.28%	26.47%	17.73%	23.53%	
% land	15.75%	24.69%	25.05%	17.14%	17.37%	

Table 13.3 Wildlife rents in Kenya – basic statistics			
	Rents	Ln(rents)	$ ha^{-1}y^{-1}
Number cases	63	63	
Median	$5.83	1.763	$5.83
Mean	$16.96	1.365	$3.92
Standard error	$2.99	0.272	
95% CL upper lower		1.907 0.822	$6.73 $2.28
Skewness	1.584	-0.414	
Kurtosis	1.640	-0.781	
SE Kurtosis	0.595	0.595	

Table 13.4 Wildlife rents from concession and access fees versus "all others"				
Rents	n	Mean	SD	$ ha^{-1}y^{-1}
Concession and access fees	44	2.323	1.666	$10.21
All other sources	22	-0.640	1.486	$0.53
Pooled variance: t =7.053, df=64, p=0.000 Note: rents are logged				

Table 13.5 Potential wildlife rents in the Mara Area			
Mara Area	Wildlife Rents	Total Potential Rents ($ million)	
	$ $ha^{-1}y^{-1}$	Protected Areas	Group Ranches
Highest Mara	$50	$7.5m	$57.0m
Average for concession and access fees	$10.21	Na	$11.6m

Table 13.6 Density (and %) of occupied settlements around the Mara Reserve					
Distance from Mara Reserve	<10km	10km - 20km	20km-30km	>30km	Total
Area (km^2)	413	558	450	406	1,827
1950	-- --	-- --	0.03 (40.6%)	0.05 (59.4%)	0.02
1961	--	0.03 (30.5%)	0.03 (25.4%)	0.06 (44.1%)	0.03
1967	0.01 (6.7%)	0.03 (16.7%)	0.06 (31.1%)	0.10 (45.6%)	0.05
1974	0.04 (16.5%)	0.03 (16.5%)	0.08 (36.9%)	0.08 (30.1%)	0.06
1983	0.10 (22.2%)	0.07 (21.1%)	0.10 (22.2%)	0.17 (34.5%)	0.11
1999	0.32 (30.2%)	0.15 (19.7%)	0.19 (19.7%)	0.33 (30.4%)	0.24
2003	0.34 (29.0%)	0.23 (26.3%)	0.30 (27.5%)	0.20 (17.2%)	0.26
Rate of Increase (%pa)	9.14%	4.65%	4.49%	2.82%	5.25%

Table 13.7 **Current status of land sub-division** **in a sample of 11 group ranches in the Mara Area**	
Number of ranches in sample	11
Total hectares	503,000
% of Mara Area	44%
Decade started	
'80s	2
'90s	4
'00s	3
not started	2
% complete (% area)	
100%	4 (22%)
>50%	2 (17%)
<50%	2 (41%)
not started	3 (20%)
# land parcels (sub-sample of 5 ranches)	6,521
Total Ha subdivided	222,782
Mean parcel size (hectares) St. dev.	34.2 19.1

Table 13.8
Influence of crop cover on resident wildlife and livestock in the Mara Area

	Constant	Decade	ln(Crops)	Decade * ln(Crops)	r^2
Wildebeest km^{-2}	46.75***	-4.74***	-14.66***	1.62***	0.89
All wildlife km^{-2}	82.01***	-8.11***	-22.70**	2.60**	0.93
All livestock km^{-2}	81.78**	-7.06	-27.34	3.71	0.25

All Wildlife and All Livestock densities as TLUs km^{-2}; decade = '70s, '80s, '90s and '00s; Crops = crop density as ha km^{-2}; df = 14; $p < 0.01$**, $p < 0.001$***

Table 13.9 Numbers of migratory wildebeest in Kenya 1972 – 1983 and rainfall 1969 – 2004					
A. Migratory wildebeest numbers	1972-83	1984-96	df	t	p
Migratory wildebeest population	1.279m	1.139m	9	1.912	0.088
Numbers in Kenya	0.866m	0.307m	9	-4.357	0.002
Inside the Mara Reserve	0.612m	0.229m	9	-3.768	0.004
Outside the Mara Reserve	0.254m	0.078m	9	-3.759	0.004
B. Rainfall in the Mara Area	1969-83	1984-04			
Group Ranches annual rainfall (mm)	855.3mm	861.7mm	34	0.488	0.629
Mara Reserve annual rainfall (mm)	990.6mm	897.1mm	34	-1.646	0.109
Pooled variance t tests					

Table 13.10 Trends in density of migratory wildebeest in the Mara Reserve and the Mara Area 1979-96			
	constant	Year	r^2
Densities "in Kenya"	92.3	-3.12**	0.40
Densities Inside Mara Reserve	548.7	-17.82*	0.32
Densities Outside Mara Reserve	33.5	-1.23***	0.45
Densities in # km^{-2}; df = 10; year since 1970			

Table 13.11 Rents from land use in the Mara Area		
	Mean \$ ha^{-1} y^{-1}	Total Rents \$m
Agricultural Rents	\$155.51	\$180.6m
Livestock Rents	\$30.40	\$34.6m
Wildlife Rents Mara high Mean concession & access	 \$50.00 \$10.27	 \$57.0m \$11.7m

Table 13.12
Optimal[1] landuse strategies in the Mara Area

	Rainfall	
Land Uses	700mm	300mm
Agriculture only, no livestock or wildlife		
normal year	$63.6	$7.6
drought year[2]	$26.8	$2.6
Agriculture with livestock, no wildlife		
normal year	**$89.2**	$10.6
drought year	**$34.3**	$3.9
Livestock only, no wildlife [3]		
normal year	$25.6	$3.0
drought year	$7.5	$1.3
Livestock with Wildlife		
normal year[4]	$27.5	**$12.2**
drought year	$15.3	**$11.1**
Wildlife Only		
average rents	$10.2	$10.2

(1) optimal choice is that giving best net returns in both normal and dry years; (2) drought year defined as one SD below normal rainfall; (3) net returns to livestock are 48% higher when wildlife are eliminated (Norton-Griffiths and Butt 2006); (4) livestock returns reduced by 30% in the presence of wildlife.

FIGURES

Figure 13.1 Increase in cultivation in Narok district, 1977 - 2001

Figure 13.2 Livestock sales ('000s) in Narok district 1977 - 2001

Figure 13.3 Size of the Serengeti migratory wildebeest population and the numbers moving into Kenya each year during the dry season (1970-99)

Figure 13.4 Numbers of Serengeti migratory wildebeest using the Mara Reserve and surrounding group ranches during the dry season (1970-96)

Figure 13.5 Annual rainfalls in the Mara Area, 1965 – 2005 (a) Group Ranches (b) Mara Reserve
Source: from PPTMAP, a computer program to create precipitation maps from point data. Input was monthly rainfalls at 20 stations in the northern Serengeti and Mara Area, 1960 to 2005. Interpolation used inverse distance weighting corrected for elevation differences between each interpolated point and the rainfall station. Numeric outputs and maps can be made for any required time period (month, years), for individual points or for "masked" areas. Figure 13.6A was masked for the group ranches of the Mara Area east of the Isuria escarpment; Figure 13.6B was masked for the Mara Reserve (Map 1).

Figure 13.6 Trends in the densities of migratory wildebeest in areas of high and low agricultural rents in the Mara Area (1977-96)

Figure 13.7: Wildlife density (numbers km^{-2}) and diversity (number of species on each ranch) on ranches of different size, Laikipia District, Kenya

Figure 13.8 Influence of occupied *bomas* on wildlife density

Figure 13.9 Predicted increases in crop cover (ha km^{-2}) 2010 – 2070 (from equation 13.8) as a function of agricultural rents (S $ha^{-1}y^{-1}$)

Figure 13.10 Returns to agriculture, livestock and wildlife in the Mara Area as a function of mean annual rainfall

Figure 13.11 Critical wildlife rents as a function of rainfall at which the livestock:wildlife option becomes optimal

Figure 13.1: Increase in cultivation in Narok district, 1977 - 2001

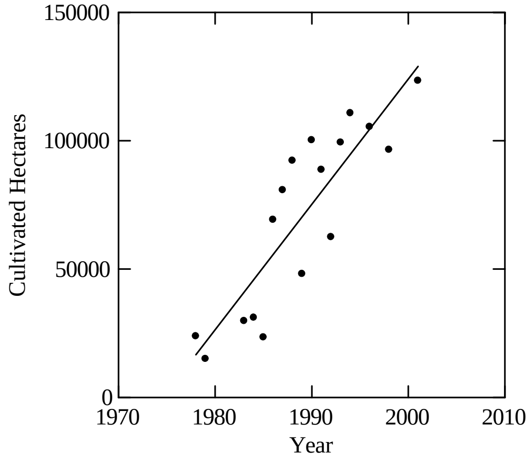


Figure 13.2: Livestock sales ('000s) in Narok district 1977 - 2001

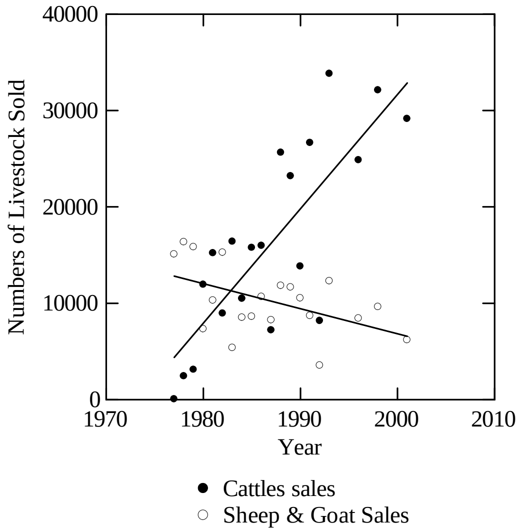


Figure 13.3: Size of the Serengeti migratory wildebeest population and the numbers moving into Kenya each year during the dry season (1970-99)

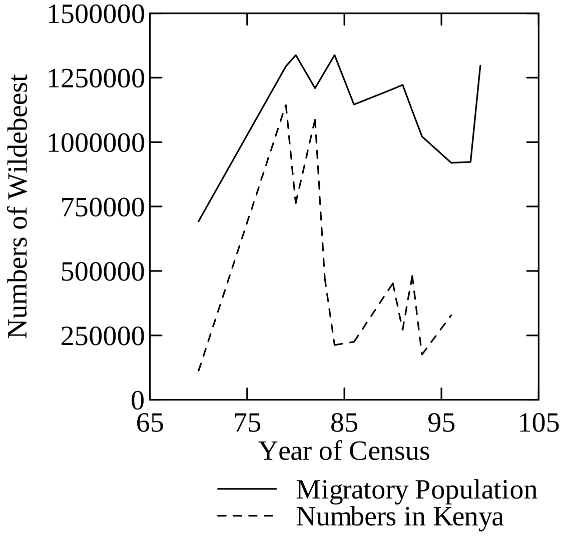


Figure 13.4: Numbers of Serengeti migratory wildebeest using the Mara Reserve and surrounding group ranches during the dry season (1970-96)

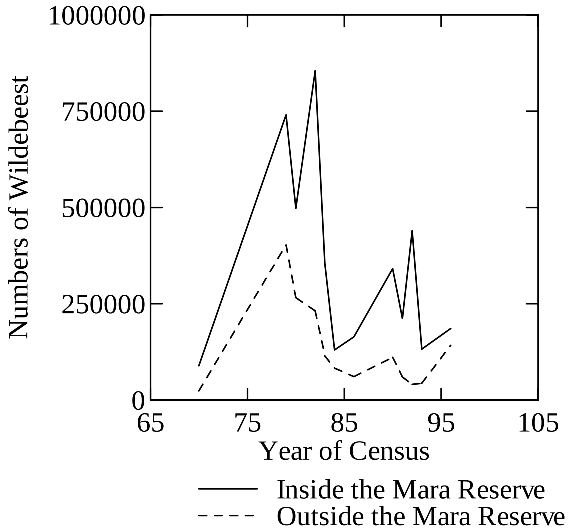
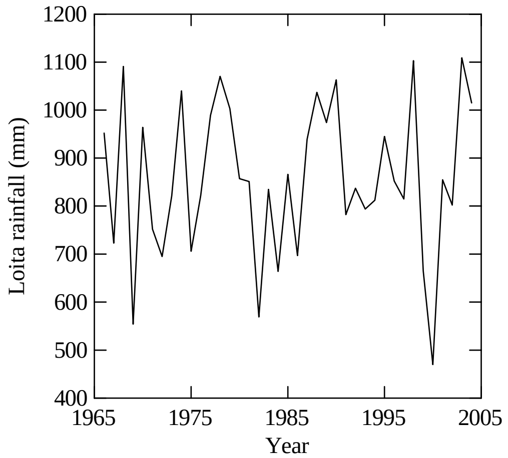
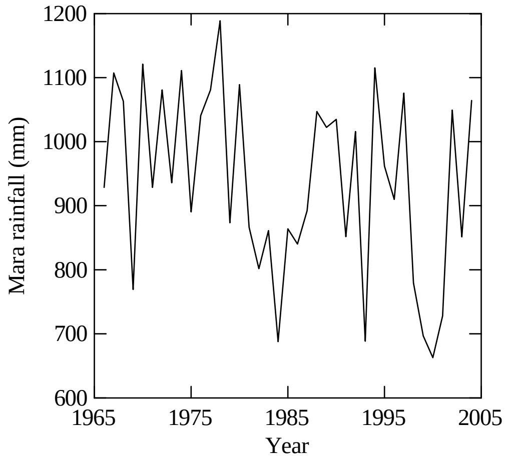


Figure 13.5: Annual rainfalls in the Mara Area, 1965 – 2005

(a) Group Ranches



(b) Mara Reserve



Source: from PPTMAP, a computer program to create precipitation maps from point data. Input was monthly rainfalls at 20 stations in the Mara Area, 1960 to 2005. Interpolation used inverse distance weighting corrected for elevation differences between each interpolated point and the rainfall station. Numeric outputs and maps can be made for any required time period (month, years), for individual points or for "masked" areas. Figure 13.6A was masked for the group ranches of the Mara Area east of the Isuria escarpment; Figure 13.6B was masked for the Mara Reserve (Map 1).

Figure 13.6: Trends in the densities of migratory wildebeest in areas of high and low agricultural rents in the Mara Area (1977-96)

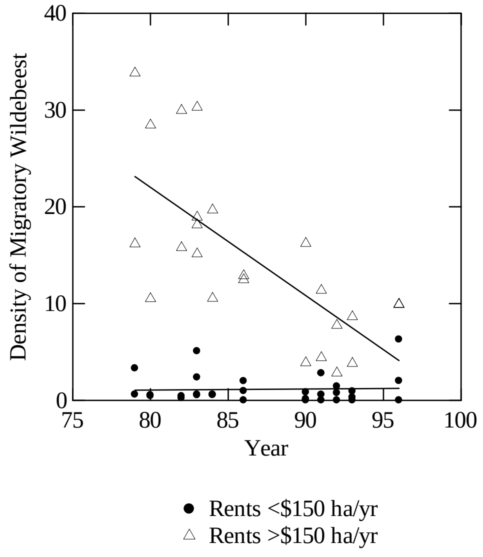


Figure 13.7: Wildlife density (numbers km^{-2}) and diversity (number of species on each ranch) on ranches of different size, Laikipia District, Kenya

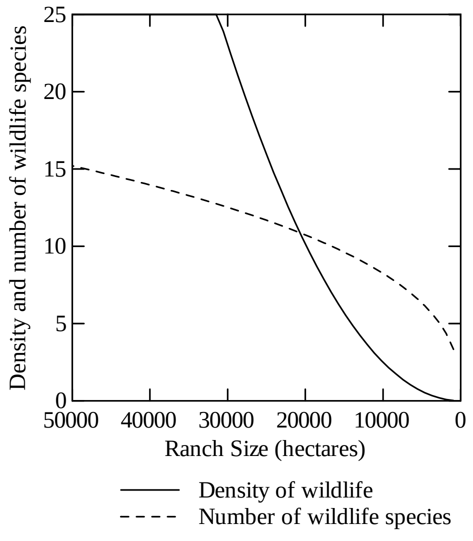


Figure 13.8: Influence of occupied *bomas* on wildlife density

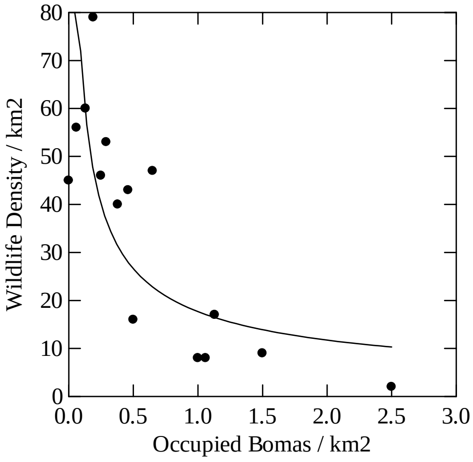


Figure 13.9: Predicted increases in crop cover (ha km^{-2}) 2010 – 2070 (from equation 13.8) as a function of agricultural rents (S ha^{-1}y^{-1})

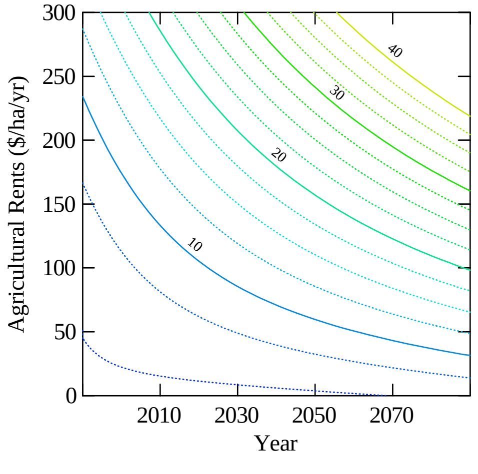


Figure 13.10: Returns to agriculture, livestock and wildlife in the Mara Area as a function of mean annual rainfall

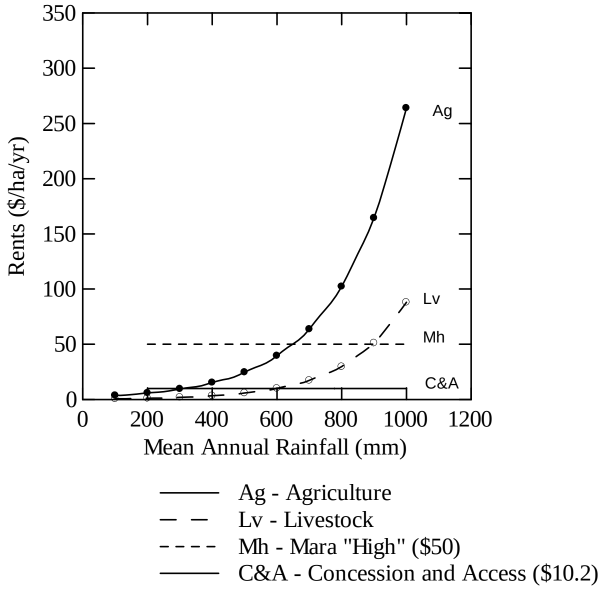
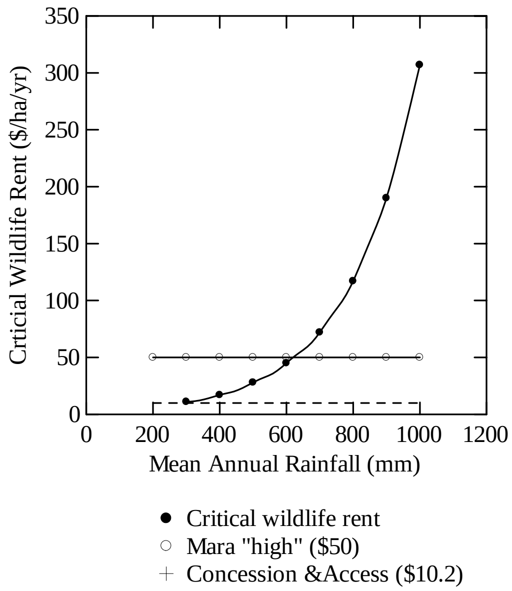


Figure 13.11: Critical wildlife rents as a function of rainfall at which the livestock:wildlife option becomes optimal



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