Integrated Modeling and Assessment for Balancing Food Security, Conservation and Ecosystem Integrity in East Africa

Narrative Summary

We are developing an integrated modeling and assessment system (IMAS) that integrates computer modeling, geographic information systems, remote sensing, and field studies to provide the information and understanding necessary to conserve biodiversity, wildlife, and ecosystem integrity while increasing pastoral food security. The IMAS quantifies the impacts of land tenure, enterprise scale, and conservation policy on four objective functions: livestock production, pastoral welfare, wildlife, and ecosystem integrity. The system will enable alternative policy and management strategies to be objectively explored, debated, implemented, and reassessed.

The IMAS includes an ecosystem model that spatially represents changes in plant and animal distributions and abundances over time, and the causal factors underlying livestock-wildlife interactions, in terms of plant growth and its responses to climate and grazing. Another model that describes cash-flow and dietary energy intake in pastoral households is being developed and linked to the ecosystem model to investigate scenarios and the impacts of economic and environmental changes, and to assess both ecological and socioeconomic impacts of interventions, particularly as these relate to household food security. An animal disease model is being developed to assess the risks of transmission between livestock and wildlife.

An application of the IMAS to the Ngorongoro Conservation Area, Tanzania was completed. Model experiments represented natural events or scenarios land managers might contemplate for NCA, and were selected in part to demonstrate the flexibility of IMAS methods. Questions addressed the effects of: 1) drought, 2) elevated livestock numbers, 3) improved veterinary care, 4) increased access to grazing lands, 5) changes in water supplies, and 6) growth in human populations and agriculture. The results of these analyses were demonstrated to project scientists, and modifications made where necessary.

Preliminary analyses suggest that the Maasai of the NCA are affected by wildlife conservation policies. However other factors such as landscape variation, distance to markets, and livestock disease incidence, etc. may also contribute to this human welfare variation. Wildlife is viewed as a potential source of disease to livestock. Although disease incidence varies with ecological setting, virtually all livestock are at risk from all wildlife diseases present in the NCA because of animal movements.

We are now conducting field studies of ecology, land use change, socioeconomic, and livestock-wildlife interactions in Kajiado District, Kenya. One study showed little evidence of severe competition for available resources between livestock and crops - if anything, there appears to be some degree of complementarity. Both crop and livestock

enterprises appear to give relatively high rates of return to capital, and most pastoralists and agro-pastoralists are able to derive their livelihood from the two enterprises. Another study documented land use trends such as: 1) sedentarization and government policies which favor a sedentary lifestyle; 2) conversion of dry season grazing areas to cultivation; 3) Privatization of land; and 4) displacement of pastoralists due to civil strife, drought, and cattle rustling.

Field and modeling studies of rangeland condition, livestock nutrition, and pastoral land use are thus providing the necessary information to assess disease, competition, and complementarity between pastoralists and wildlife for forage, water, and other resources. This information will be useful for developing more environmentally sustainable livestock systems in the wildlife rich areas of East Africa.

RESEARCH

Field Research

Socioeconomic Field Research in Ngorongoro Conservation Area (NCA), Tanzania (Galvin, Magennis, Lynn, Ali)

GLCRSP-supported field research in the Ngorongoro Conservation Area and in neighboring Loliondo District was concluded. We conducted fieldwork on land use, health and nutrition of Maasai pastoralists and looked at processes of livelihood diversification in the NCA and in Loliondo. This research was supported, in large part, by a US National Science Foundation grant to K. Galvin and J. Ellis.

Preliminary analyses on livelihoods suggest that the prime motivating factor involved in the diversification of livelihood strategies, especially the adoption of cultivation, is to reduce the number of livestock sold to provide a pastoral family with non-livestock foods (mostly maize) and other necessities. In early 1999 cattle made up about 71% of total number of livestock held by a sample of Maasai living in the NCA whereas goats comprised 18% of the herd and sheep 11%. Cattle sales in 1999 was about 3.4% of the total cattle herd in 1998 relative to 5.6% in 1995. Small stock sold comprised about 0.4% of the herd in 1998 whereas in 1995 it was 2.2%. Reasons for selling animals were (1) to buy clothes, (2) to buy food, (3) to pay taxes, (4) to buy grain, (5) to buy veterinary drugs, and (6) to pay hospital bills. These data suggest that cultivation has had a positive affect on food security by reducing the proportion of livestock sent to markets. However, we compared the economic state of the Maasai in the NCA with their neighbors just north of the NCA and ascertained that Maasai in the NCA are not as well off in a number of measures of well being relative to Loliondo Maasai.

The livestock to human ratios for Loliondo and the NCA as measured by TLUs (Tropical Livestock Units) per person were assessed. (A TLU is a measure of total livestock biomass based on average weights of livestock of different species). In Loliondo people have more than three times as many TLUs per person (X= 10.3) than the Maasai who live in the NCA (X= 2.8) ($p< 0.0009$). Moreover, Loliondo Maasai have, on average, agricultural plots whose size is triple (X = 0.3 acres/person) that of the Maasai who live in the NCA (X = .1 acres/person)($p=0.002$). The majority of the NCA households (87%) are below the theoretical minimum of 6 TLUs per person needed for food security in pastoral populations (see Galvin 1992, Homewood 1992 for discussion on TLUs among pastoralists). The figure shows that a much lower percentage (42%) of Loliondo households is below this

minimum (Galvin et al.1999, Lynn in progress).

Comparison of nutritional data among the NCA Maasai with those living in Loliondo where conservation policies are much less restrictive should illuminate whether the problems experienced by the NCA Maasai are typical of pastoral populations in the region or whether differences between the two regions are due to conservation policy and the attendant reduction in human economic welfare as argued by the NCA Maasai.

Comparison of weight, triceps skinfold, and Body Mass Index (BMI) among NCA and Loliondo adults shows that, on average, adults in Loliondo are slightly heavier, and have slightly greater BMI scores than their NCA counterparts. Triceps skinfold (TSF) measures are significantly less among the Maasai in the NCA, however, suggesting that their fat reserves are compromised. Children follow the same pattern as do adults. Maasai children, like the adults, are chronically undernourished and their growth status is poor relative to Western reference standards. For height, weight, height for age, weight for age, skinfold thickness, arm-circumference, and BMI, the Maasai consistently show values around the 5th percentile. Comparison of children in the NCA with those from Loliondo show a pattern of differences in nutritional status that mirror those seen in the adults. In Loliondo boys and girls of all ages are, on average, taller, heavier, and fatter, and have greater arm circumference than their NCA counterparts. These differences, though not large, consistently show that overall, the Loliondo Maasai exhibit better nutritional status than their NCA counterparts. Nutritional status differences appear to be a direct reflection of differences in economic levels between the two areas as measured by livestock holdings and acreage under cultivation (Galvin et al. 1999, Magennis and Galvin 1999).

Implications of these results suggest:

- The Maasai children from Loliondo tend to have higher anthropometric measures than children from the NCA.

- Adults of Loliondo also tend to show higher measures of nutritional status as measured by BMI scores. TSF measurements were significantly higher among Loliondo women and men than among adults in Ngorongoro.

- The Maasai of Loliondo clearly have more resources available to them as measured by livestock holdings and agricultural plot size. The NCAA limits agricultural plot size (McCabe et al. 1997). In addition, conservation policy has placed restrictions on grazing zones in the NCA. This restriction, in addition to livestock disease impacts (Machange 1997) affect livestock productivity in the NCA.

- These results suggest that conservation policy affects resources available to the Maasai and this may influence nutritional status of the population, especially adults. Children in Ngorongoro tend to be better buffered from nutritional stress than are adults, a pattern common among pastoral populations (Galvin 1992, Galvin et al., 1994). Nevertheless, we do believe that overall the Maasai in Loliondo are in better nutritional state relative to their NCA counterparts.

- It appears from these initial comparisons that the Maasai of Loliondo possess a higher welfare status than do the NCA Maasai. At least some of this difference (crop acreage) is attributable to conservation policy. However other factors such as landscape variation,

distance to markets, and livestock disease incidence, etc. may also contribute to this human welfare variation. Analyses of these factors are underway.

Livestock Management and Land Use in NCA, Tanzania (McCabe)

During the early part of 1999 T. McCabe analyzed data relating to livestock ownership and sales for 40 herd-owners living in the NCA. This was data necessary to help construct the socio-economic model for pastoralists in the NCA. The total number of livestock in the sample was: cattle-3,399; sheep-523; goats-890. Total cattle sales were 116 which represented a 3.4% offtake. Total small stock sales were 6 which represented a 0.4% offtake. The 6 most common reasons for selling animals were (1) to buy clothes, (2) to buy food, (3) to pay taxes, (4) to buy grain, (5) to buy veterinary drugs, and (6) to pay hospital bills. McCabe also compared this with data collected in 1995 in order to get an idea about how representative this data was. The results were that cattle sales represented a 5.6% offtake and small stock sales a 2.2 % offtake. The same items showed up in the reasons for sales but in a slightly different order than the 1998 data. Based on these two samples McCabe feels quite confident that the 1998 data is representative of livestock sales and factors which influence a decision to sell livestock.

During late July and August McCabe continued his field research in the NCA. He concentrated on the process of livelihood diversification and historical land use patterns. Not all of this information has been analyzed yet, but preliminary analysis suggests that the prime motivating factor involved in the diversification of livelihood strategies, especially the adoption of cultivation is to reduce the number of livestock sold to provide a pastoral family with non-livestock foods (mostly maize) and other necessities. The historical information on land use suggested that although only a few families lived in the Ngorongoro Crater, it was an important source of grazing and water for many people and their livestock living in the Olairobi and Nainokanoka areas.

Livestock/Wildlife Disease Interactions in NCA, Tanzania (Rwambo, Grootenhuis, DeMartini)

Participatory rapid appraisals to determine the priority diseases of livestock, the animal health constraints to livestock productivity and the community perception to wildlife as a potential source of diseases of livestock were conducted in the Ngorongoro Conservation Area (NCA). The pastoralists identified East Coast fever (ECF), ormilo (turning sickness), malignant catarrhal fever, anaplasmosis, contagious bovine pleuropneumonia, blackquarter, lumpy skin disease and anthrax as the most important diseases affecting cattle, sheep and goats. Since 1984, the incidence of tick-borne diseases including ECF and ormolu has increased drastically and the average mortality rate associated with the two tick-borne diseases was 18% in adults and 52% in calves under 12 months of age. This high mortality rate in itself could be responsible for the serious decline of cattle populations that has been observed in the NCA for a number of years. Tick-borne diseases, principally East Coast fever, were listed as responsible for the high calf mortality. During the study, it became apparent that there is very little information, if any, on cause-specific morbidity and mortality data on nearly all the livestock and wildlife diseases in the NCA.

The risk of transmission of diseases from wildlife to livestock was associated by livestock owners only with wildebeest. We were surprised

to note that the community did not associate buffalo as a source of livestock disease, particularly as a source of ECF. Disease incidence varied with the ecological setting, but, because of animal movements, virtually all livestock are at risk from all diseases present in the NCA. The annual removal of livestock from the short grass plains during the wet season to the intermediate and highland areas in avoidance of exposure to MCF virus being secreted from 2-4 months old wildebeest calves exposes livestock to high risks of transmission of tick-borne and infectious diseases. Although the disease risks are not evenly distributed in the NCA, the frequent migration of livestock in search of good pasture, water, salts, markets and in avoidance of specific diseases invariably leads to livestock being at risk of exposure to all the wildlife and livestock diseases. The situation is worsened by the concurrent migration of various wildlife species in search of pastures, water, and salts. However, the risk of transmission of some diseases including MCF, trypanosomosis, anthrax and blackquarter is confined to geographically defined areas where risk can be mitigated by avoidance albeit at the expense of availability of good grazing. This information on disease interactions will be useful in the development of a disease model for the integrated monitoring and assessment system (IMAS).

Forage Range Survey and Monitoring Livestock Nutrition in NCA (Mwilawa, Runyoro, Moehlman)

The objectives of this project are: 1) to identify forage range species and preferences by livestock for forage species, 2) to determine forage nutrient value, 3) to establish a protocol for pastoralists to monitor livestock nutrition. Analyses of these factors will support an effective system for early warning and crisis prevention by reporting of livestock nutrition and well-being in a timely manner. Through linkage to the GL-CRSP LEWS project, this information can be disseminated to managers and policy makers at both local and national levels. This information will also be used in the IMAS models of livestock and wildlife nutrition and condition, and pastoral welfare.

The methods are as follows. Two grazing areas in the NCA were selected and are being sampled along transects. Pastoralists are being interviewed about forage species and their values to livestock. Forage samples are collected for nutrient analysis. Four pastoral households were selected along each sample route for fecal sampling and livestock condition assessment. Fecal sampling and livestock body condition scoring occurs on a monthly basis.

Range Ecology Research in NCA, Tanzania (Kidunda, Maskini)

This study investigated and quantified variables that affect the distribution patterns and utilization made on pastures by herbivores.

The study was carried out at Ngorongoro area in three locations i.e. the Crater, Malanja depression and Esilwa. The zones are: Short grass plains, Endulen-Kakesio woodland, Northern woodland, Nainokanoka, Ngorongoro Crater and the Northern Highlands Forest Reserve. The study was divided into two parts but were both assessed concurrently. Study one dealt with spatial distribution of grazing pressure by domestic and wild herbivores and study two focused on the assessment of range condition.

Forty samples were collected from the four locations in the Crater namely Seneto, Munge, Ngoitoktok and Lerai using a $0.25m^2$ to get the actual production. Ten samples were collected from each location along a transect of one

kilometer distance (one sample per 100 meters). A transect of 3km was sampled at Malanja and Esilwa thus making a total of 30 samples from each area. Ten 0.25m^2 grazing cages were placed along side the sampled plots in each site and they were moved after eight weeks for determining utilization and potential production under reduced grazing pressure. All the sampled points were geo-referenced using a GPS unit for ease of further visits and comparisons. Soil samples were taken at an interval of 200m in each site.

This field study provided key information needed to assess livestock-wildlife interactions using the IMAS.

Plant Biodiversity and Biomass in the NCA (Moehlman, Weisberg, Boone)

A data set has been collected by Patricia Moehlman and her colleagues over many years, as part of the Ngorongoro Ecological Monitoring Program. The CRSP has offered support for analysis of this data using multivariate statistical analysis of species composition. Biomass data are to correlated to satellite vegetation greenness data (NDVI), to enable the use of satellite data for more spatially extensive biomass monitoring.

Socioeconomic Field Research in Amboseli/ Kajiado, Kenya (Mbogoh and Munei)

In preparation for the Kenyan case study application of Savanna and the socio-economic module, fieldwork was undertaken in June-August 1999. A small survey was undertaken of the group ranches surrounding Amboseli National Park (the wildlife dispersal areas), with two primary objectives:

- To update existing knowledge about the economics of ranching compared with alternative income-generating activities, including ranchers' perceptions of the economic impacts of wildlife on ranching in these areas.

- To initiate collection of input data with which to parameterize the socio-economic module linked to the Savanna model.

The results of this survey work have been written up as a report entitled "*Study on wildlife, livestock and human interaction in Kajiado District in Kenya: results of the economic study*". The study focused on the Amboseli National Park wildlife dispersal areas encompassing the Kimana Group Ranch and the Mbirikani Group Ranch. The study sought to examine the economics of livestock keeping within the game reserves' wildlife dispersal areas, including a documentation of other economic activities that compete with livestock keeping in these areas, and magnitude of income and/or losses due to wildlife, ecotourism and other non-livestock keeping activities in these wildlife dispersal areas.

Pastoral livestock and other human economic activities have coexisted with wildlife in the East African rangelands for hundreds of years. This interaction has come under stress in the last few decades, and is turning into conflicts over the use of resources. These conflicts especially intensified after implementation of a land reform program that transferred pastoral trustlands into group ranches, individual ranches and private agricultural holding in the mid-1960s in Kajiado District. The change of property rights to pastoral rangelands from communal ownership to group ownership and recently to private ownership has brought the conflicts to a new level whereby the prospects for sustained coexistence is diminishing. The activities undertaken in this project attempt to evaluate the prospects for continued coexistence of pastoral livestock and other human economic

activities by analyzing the nature of conflicts as well as identifying possibilities for resolving some of these conflicts, at least by searching for avenues of mitigating the costs imposed by wildlife on pastoralists and their economic activities.

The study involved the following:

- A literature search and review of secondary data sources on the economics of ranching in Kajiado District;
- Design, testing, finalization and use of a simple survey instrument to elicit information from the ranchers/pastoralists on the economics of group and commercial ranches in Kajiado District;
- Data collection in the field using the survey instrument and through informal interviews.

Apart from informal discussions with relevant government officials and other stakeholders in the wildlife dispersal areas of the Amboseli National Park, a sample of 34 members of Kimana Group Ranch and 27 members of Mbirikani Group Ranch was randomly selected and interviewed to establish the status of individual livestock ownership within the group ranches and the associated costs and returns from the various economic activities undertaken by these members. The two group ranches are reasonably representative in terms of the mix of human economic activities carried on as well as ecological conditions. However, Kimana Group Ranch, the smallest of the six group ranches in Kajiado, was chosen as it reflects and represents the growing importance of agro-pastoralism. Kimana has the highest proportion of high-potential land and consequently a high proportion of cultivated area. Mbirikani Group Ranch, on the other hand, represents another extreme: although containing some pockets of high-potential land along the rivers, Mbirikani basically consists of arid grassland. These two group ranches give a sufficient representation of the nature of the interactions between wildlife and livestock in the dispersal area of the Amboseli National Park, at least for an initial study.

The study elicited information on a wide variety of topics:

- Size, composition and infrastructure of the two group ranches;
- Household composition and food consumption aspects;
- Livestock holdings and typical herd compositions;
- Costs of livestock production with details on water use, acaricide costs, labor, grazing costs and veterinary care;
- Income to the group ranches from wildlife and ecotourism;
- Estimated costs of wildlife to the group ranches, including impacts of disease transmission from wildlife to livestock, death or maiming of livestock from attacks by wildlife, and human life losses or maiming following attacks by wildlife.
- Off-farm income;
- Farm-gate prices of inputs and outputs;
- Extent, inputs and outputs, and gross margins of crop enterprised engaged in.

These data are still being analyzed, but will provide some of the input data needed to adapt the socio-economic module to conditions in Kajiado District.

Tentative conclusions from the data indicate that there is little evidence of severe competition for available resources between livestock and crop production at both Mbirikani and Kimana Group Ranches. If anything, there

appears to be some degree of complementarity. Manure from cattle/livestock keeping finds use in crop production. Both crop and livestock enterprises appear to give relatively high rates of return to capital, and most pastoralists and agro-pastoralists are able to derive their livelihood from the two enterprises. There is a need for more detailed case studies in the survey areas in order to be able to verify and estimate the economics of ranching and crop production within the livestock dispersal areas of the Amboseli National Park.

Livestock/Wildlife Disease Interactions in Amboseli/Kajiado, Kenya (DeMartini, Grootenhuis, Rwambo)

We visited Amboseli NP and surrounding areas to study aspects of wildebeest biology related to MCF occurrence and we also have carried out some pilot surveys of livestock diseases in Maasai cattle. In discussions with David Western, we learned that the longevity of wildebeest is around 26 years with a mean lifespan of approximately 15 years. Mean lifespan is dependent on predator density. For instance in the NCA the predator density is higher and the mean lifespan is around 12 years as a result. The total wildebeest population is biased towards females. To what extent is not known. The populations dynamics are that 50% of the calves die in the first 10% of their lifespan, ie. in Amboseli within 1.5 years and in the NCA in 1.2 years. Of the adults, 50% die in the last 10% of their lifespan, ie. in Amboseli between 13.5 and 15 years and in the NCA between 10.8 and 12 years. Our observations indicated that less than 10 % of the population were newborn calves. At the end of May; the calves were not older than one month, indicating they were born in April. This is much later than generally reported. This can prolong the risk of exposure of cattle to MCF virus. wildebeest calve in the month of March. We interviewed some livestock owners: one had 35 cattle of which 5 died of MCF, another had 28 cattle and lost two to MCF. The wildebeest population in Amboseli starts to calve in March according to these spokesmen. They believe that the placenta is washed into gulleys and poorly drained depressions; the water in these sites are considered the source of MCF infecition in cattle. Other diseases mentioned as problems were: CBPP (Orkipei), Ormilo, foot and mouth disease, and tick borne diseases, particularly East Coast fever.

Research on Maasai Livelihoods in Kaputiei/ Kajiado, Kenya (Njoka)

The thrust of the CRSP in Kajiado is to identify and support sustainable livelihoods which depend on the natural resource base in the ecosystem. Food security of the pastoralists is largely determined by the trends of the natural resources, the vulnerability context of their way of life and by the policies and institutional framework in which development interventions are carried out.

The current study was done in 1999 with the following main objectives:

- Assess the state of the natural resources in Kaputiei and determine the sustainability of the existing livelihoods based on the trend of the resource base;

- To evaluate the changes which has taken place since the livestock development initiatives in 1970's and 1980's.

This report is based on the Sustainable Livelihood Framework approach that focuses on the vulnerability context of people's environment, the livelihood assets that enable the people to adopt various livelihood strategies in order to survive in their environment. The Livelihood Assets include human capital, natural

capital, social capital, physical capital, and financial capital. The transforming structures and processes determine the influence and access to these capitals. Government and private sector define policies, laws, culture, and institutions both at local, national and international levels that establish an enabling environment for the evolution for sustainable livelihood outcomes. These livelihood outcomes are the end product of livelihood strategies that can be pursued in a facilitative good governance environment.

Trends influence the viability of livelihood strategies. The most important trends in Kajiado are the population trends and resource trends. The human population in Kajiado has been growing at 5.5% per annum between 1969 and 1979 and by 5.64% per annum between 1979 and 1989.The population in Kajiado has grown from 29,000 in 1948 to 68,000 in 1962, to 86,000 in 1969 and from 149,000 in 1979 to 259,000 in 1989.The population is projected to continue growing at over 5%.

The sustainability of livelihoods in the pastoral areas depend to a large degree on the natural resource base. In Kaputiei, the sustainable utilisation of the natural pasture is a crucial factor for livestock production. Ecological monitoring of the condition of grazing resources over the last three decades show that there has been a decline of quality of grazing resources especially in southern rangelands. The northern rangelands are more resilient to grazing pressure. The red soils in the south are more prone to water erosion than the black cotton soils.

Land use Trends.

1) Sedentarization of pastoralists: government policies which favor a sedentary lifestyle.

2) Conversion of dry season grazing area to cultivation- sedentary population are involved in shifting agriculture around their settlements which are usually located in the high potential area in ASAL.

3) Privatization of land is a growing tend as more people settle down and immigration continues. This has become more significant as the governments in the region opt more individual land tenure system.

4) Displacement of pastoralists due to civil strife, drought impoverishment and cattle rustling menace.

5) Influx of farming communities in pastoral areas due to high population increase in high potential areas together with the effects of Land use changes in the highlands.

6) Deforestation of water catchment area increase water scarcity, soil erosion and pollution of rivers due as a result of agrochemicals.

The mobility of livestock and whole families during 1990's drought years is still practiced by 36% of the population. The grazing resources have been privatised and 27% of the population has fenced their land in 1999.This in contrast to the 1977 situation where no household had fenced the grazing resource. The families are now living in smaller settlements of closely related family members. Almost all the households are cultivating their land. In 1977, the evel of livestock borrowing within the community was estimated at 28.6% (N=789 households), and 30.3% for cattle and small stock respectively.

Range Ecology. The Athi Kapiti range site in the north is in good range condition according to rapid reconnaissance survey conducted in 1999. This in line with the assessment done in 1977 where 66% of the range was in good to excellent condition, 27% in fair condition and only 7% in poor range condition(N=77points at one km interval.) The range condition for livestock in central kaputiei has improved significantly under individual land tenure

system. In 1977,44% of the range was in good condition, 38% in Fair condition and 185 in poor condition.(N=100 points at one km interval). The range condition in South Kaputiei has not improved since the last assessment carried out in 1977 when 46% of points sampled were in very poor to poor condition and 33% in fair and 21% in good condition.

Wildlife /Human/Livestock Conflicts. Predation losses on domestic animals in 1999 survey are estimated at a 731 goats, 566 sheep, 364 heads of cattle, and 198 calves for a sample size of 90 households. The mean losses per household are calculated as 8.12(Confidence Interval, CI at 95%=1.98) goats, 6.34(CI=1.69)sheep, 4.03(CI=3.79)heads of cattle, and 2.20(CI=0.77) calves. The losses are inflicted by hyenas, leopards, and lions.

The value of predation losses at current prices are calculated as US$15,595 for goats $13,832 for sheep, $62,089 for cattle losses and $11,505 for calves. The total value sustained by 90 household is therefore estimated at US$103,021 or an average of $ 1,145 per household. These figures are solicited from the heads of the households and the prices used are their own prices. The pastoralists are not compensated for predation losses and there is general discontent among the people interviewed regarding the co-existence with wildlife. Many of them are now complaining about the crop damage, competition for grazing damage to fences and competition for water as well as disease transmission from wildlife to livestock. So far there are not shared benefits or losses by those who are benefiting from wildlife resource.

Sources of Income among the Kaputiei Maasai. Livestock related sources of income are the most important as would be expected. The sale of cattle is the most important source of revenue to meet household needs.Milk sale is an important activity and it is unfortunate that lack of organised marketing of milk is considered a serious problem by the Maasai. Land market has also emerged as source income to meet large hospital bills and school fees.

Rapid Field Assessment Protocols for Pastoral-Wildlife Ecosystems (Rainey, Reid, others)

A rapid field assessment protocol is being developed to assess interactions between pastoralists and wildlife. This will provide data that are useful both for independent analyses, and for providing input into the IMAS models. This protocol will be cost-effective to implement, using systematic ground sampling on a spatial grid, and monitoring along transects. Fine-scale spatial interactions between livestock and wildlife, and in vegetation structure can be discerned. These fine-scale interactions are not detectable from aerial surveys, but are nevertheless very important. The method has been applied in Maasai-Mara, with financial support from other sources. The origins of the grid based approach are wildlife surveys M. Rainey conducted in the Maasai Mara to train American college students in field ecology. The walking transect method has been developed by Rainey at Melepo Hills, Kajiado District. It was successfully used to monitor wild dogs and other carnivore presence and predation on livestock, and shift a security situation in pastoral areas.

IMAS Modeling and Model Development

IMAS Software Development (Boone)

An graphical user interface (SavView) is being constructed for the SAVANNA modeling system. The interface will allow those not accustomed with ecological modeling to use the system, and to address common management questions (e.g., numbers of livestock, improved animal health) without input from modelers. The interface is being built without being specific to a particular adaptation of SAVANNA, to the degree possible. Therefore only small modifications will be required to apply the interface to a novel area. There are three primary portions of the interface, a parameters section allowing user input, a graphing section, and a mapping section. The graphing and mapping sections are perhaps 80% complete, leaving the section for user input requiring the most effort.

Risk-Based Disease Model for Livestock/Wildlife Disease Interactions (DeMartini, Howe, Boone, Pelissier, Mariner)

A risk based biased mixing model was developed, and used to evaluate the effects of spatial proximity on the probability of transmission of malignant catarrhal fever (MCF) virus, from wildebeest to cattle in the NCA. A methodology was developed for integrating disease models into geographic information systems (GIS) and remote sensing ecology models. Patterns of MCF occurrence in cattle were estimated for months between January and July, the period of shedding by wildebeest calves, over a 15 year period. The risk based biased mixing model allowed input of exposure values based on hourly estimates of virus survival in the environment, essentially creating an epidemiologic curve of exposure over weekly time steps. The SAVANNA ecology model provides input maps of wildebeest and cattle population density during the first week of each month for each 5 square kilometer cell of the NCA. Calculations for the probability of first infection in cattle were dependent upon infectiousness of MCF virus, proximity of cattle to wildebeest, and the weekly values for exposure of cattle to the virus in the grazing areas. Simple probability calculations based on prevalence of MCF in cattle determined the length of time until complete saturation of MCF appeared in pastoral cattle as a result of exposure to virus excreted by wildebeest calves. Cattle exposed to MCF virus experience a high mortality rate but are a dead end host since there is no virus shedding from infected cattle. In this respect, the MCF model fits a simple growth curve with a Gaussian distribution of inverse half life decay, which simulates rapid spread of the virus as the probability of exposure increases, depending on virus survival in the environment. Risk mitigation in the MCF model is sensitive to spatial proximity of pastoral cattle with migrating wildebeest during the calving season. Currently, this model is being refined for MCF and modified to include other diseases, particularly rinderpest and East Coast fever. Application of the model in areas other than the NCA, such as the Kajiiado area of Southern Kenya and the Serengeti/Mara ecosystem are being investigated.

Socio-economic Modeling (Thornton, Galvin)

The objectives of this work are to; (1) develop a simple rule-based model that describes cash-flow and dietary energy intake in typical households in pastoral areas such as the Ngorongoro Conservation Area, Tanzania and Kajiado District, Kenya, (2) link the model to the SAVANNA ecosystem model to investigate scenarios and the impacts of economic and environmental changes, (3) use the linked model

to assess both ecological and socioeconomic impacts of interventions, particularly as these relate to household food security.

Work continued on the socio-economics module for the Savanna model with scientists at CSU and the University of Colorado. Thornton travelled to Colorado State University Natural Resource Ecology Laboratory (CSU NREL) in May 1999. A simple rule- based model was constructed and tested using data from previous studies and from the field work carried out in NCA during 1997 and 1998 under this project. The current model deals with three household wealth strata in NCA. The model is currently run in a stand-alone mode. Work is in progress to link it to Savanna output files, and ultimately the model will be fully integrated with Savanna. The model deals with simple household cash accounting and with dietary energy flows. Decision rules are predicated on the basis that the household has a target quantity of Tropical Livestock Units (TLUs) per person and a target cash income rate per month per person in the household.

The approach being taken is to use a small set of rules that govern the operation of the model, and then use the revealed characteristics of the model through simulations to adjust some of the key model parameters, so that the model behaves in a plausible fashion. For example, to model energy/food flow in the household, energy requirements of the household are calculated based on household size, age/sex ratios, and a proportion of the recommended daily allowances. This requirement is met from various sources: net milk energy (after any infrequent sales), diseased or dying animal meat, the household's own stock of maize, the household's own stock of crops other than maize, purchased maize and non-maize food, and handouts, if there is still an energy deficit. Similarly, cash flow levels in the household are monitored each time step and updated according to cash income from livestock sales, crop sales, wages, milk sales and gifts, craft income etc. Cash outgoings include food, household goods, very infrequent livestock purchases, and other payments out of the household.

Model refinement and linkage to the Savanna model will be undertaken early in 2000. Once this is accomplished, scenario analysis can be undertaken to answer questions such as the following:

- What will be the effects (socio-economic and ecological) if household maize cropping area increases?

- What are the likely impacts of a single drought, or of recurrent droughts in successive years?

- What are the likely impacts of changes in household targets for livestock numbers and cash?

Such information can be used to assess the impacts of possible future changes in the system in NCA, in terms of the effects on people, livestock and wildlife, and to help suggest ways in which negative impacts can be ameliorated and conflicts resolved.

Land Use Modeling (McCabe)

Throughout the year McCabe has been collaborating with Randy Boone on the aspects of the model that relate to the migratory patterns of people and livestock in the NCA. We have divided the NCA into blocks and are determining the percentage of livestock that move from one block to another during each month. He has also been working with Mike Cougenhour and Randy Boone on the rules based model for pastoral migration.

In addition McCabe has been working with the livestock disease modeling team on the development of the model for malignant catarrhal fever, which is transmitted from wildebeest calves to cattle during the months of January through March in the NCA. McCabe's role in this aspect the model development has been to provide information on the location of the wildebeest migration and how this articulates with the movement of cattle throughout the year.

Ecosystem Modeling (Boone)

An adaptation of the SAVANNA modeling system was completed for Ngorongoro Conservation Area, the results were assessed to the degree possible, and then a suite of 14 experiments, of six general types, were conducted. These experiments represented natural events or scenarios land managers might contemplate for NCA, and were selected in-part to demonstrate the flexibility of IMAS methods. The six types of questions addressed included the effects of: 1) drought, 2) elevated livestock numbers, 3) improved veterinary care, 4) increased access to grazing lands, 5) changes in water supplies, and 6) growth in human populations and agriculture. The results of these analyses were demonstrated to project scientists, and modifications made where necessary.

Compilation of GIS data for modeling in Tanzania is complete, with all layers in place. Minor modifications, such as updating climate data used in modeling, are all that remain. A series of maps from our GIS library were prepared for use by cooperators in the field, and are proving to be very useful. Analyses of long term remote-sensed NDVI data continue, tracing the dynamics of vegetation in the NCA, over a decadenal time period. We have completed compiling NDVI used for visual analyses. Now we are conducting finer-scale analyses for use in comparisons to field data collected throughout NCA. We are using NDVI data to make comparisons to range quality and herbivore populations in NCA and Ngorongoro Crater. Patterns of vegetation biomass are reflected in the images, available since their first acquisition in 1982, and should correlate with standing biomass. More detailed imagery from the mid-1990s is also being used.

GIS Data, Analysis, and Modeling

Kenya (ILRI - Reid, Okello)

The following databases were collected or developed for the district: towns (major centres), roads (by categories), locational boundaries, human population data up to sub-location level (1979 and 1989), group ranch boundaries, wildlife management zones, soils, parks, rivers (and streams), and land use/land cover. Data on the distribution of water points was acquired from the Ministry of Water Resources.

Initial analysis of the Kajiado dataset was completed in 1998/99. This analysis focused on the effects of human activities on the abundance and distribution of wildlife and livestock from 1978 to 1998.

Kenya (Boone)

The Kajiado GIS data collected by the ILRI team and forwarded to CSU has been incorporated into our system. The ILRI team will also provide a vegetation map for the Amboseli Region, for use in SAVANNA modeling. In return, the CSU team has provided satellite imagery to the ILRI team. The SAVANNA modeling system was installed onto one computer at ILRI.

Maps were made and delivered, to support field research in Kenya.

Kenya (Atieno)

A study was undertaken to map out and document the land cover, the changes, their possible causes, and effects on vegetation species diversity and abundance within the Greater Amboseli Ecosystem serving as a source of multiple resources but faced with conflicting demands, policies and management systems. Both Remote sensing, Geographic Information System and ancillary data together with ground-based techniques were applied. Cover change analysis was carried out between the years 1988 and 1998 using maps produced from Landsat TM scenes.

Land use-land cover maps for 1998 and 1988 were produced with an accuracy of 85.7% from which it was revealed that there have occurred tremendous land use/land cover changes coupled with significant differences in vegetation species composition, diversity and structure across the study site. Bushed grassland, cultivated land and water bodies increased from 45%(140,409ha) to 54%(167,572ha), 3.7%(11,469ha) to 11.5%(35,766ha) and 0.01%(31.2ha) to 0.24%(756ha) out of the total land area respectively. Vegetation cover however decreased generally from 96.3% to 88.247% during the ten year period. Bushed grassland and cultivated fields have significantly increased while the bushlands, grasslands and wooded grasslands reduced compared to 1988; in addition overgrazing, abandonment and erosion most likely have resulted in a change of wooded grassland and grasslands.

Four land use types were identified ranging from intensified rainfed agriculture on the mountain slopes; down slope expansion of sparse agriculture under more extensive land use system and extension of swamp-edge/riparian cultivation to increase in outside park tourism including campsites and wildlife sanctuaries. There occur overall landscape fragmentation and changing number, diversity and density of land cover patches due to changes in land use.

In conclusion, the study area has faced land use changes over the past decades. A large portion has been converted to small-scale agriculture and some degraded in terms of vegetation resources as a result of overgrazing failing to take into consideration the vulnerability of the range ecosystem. In sum, declining vegetation cover, formation of erosional sites, abandonment of cropping fields, declining water availability, and wildlife reduction in number and species diversity can be seen to be the outcomes of recent land use changes, settlement, expanding cultivation and changing climatic conditions within the study area.

The Maasai pastoralists can now be seen to be expanding their small-scale agriculture into the swamps for their livelihood. However it would be ironical to believe that this is a sustainable way of food production since the swamps will continue to diminish and dry off as cultivation continues. This land use change consequently will have negative impacts on the existing biodiversity which will in turn negatively affect pastoral strategies involving mobility, and resource base especially as more dry grazing zones disappear. This presents a questionable scenario for the survival of pastoral production system considering the increasing human population pressure which will definitely seek more ways to increase food production.

Progress Relative to Criteria for Evaluation

Our criteria for evaluation was stated in our 1999 Workplan as follows.

"This project can be evaluated in terms of our field, data, and modeling activities. Field

activities should produce data sets which are useful for conducting an integrated assessment of pastoral wildlife interactions, GIS work at site and regional scales will produce data sets and analyses which are useful at both scales. The modeling efforts should progress to the point of being able to demonstrate that the model based IMAS is a useful approach. The project can also be evaluated based upon the feedback we elicit from the region from policy makers in government agencies, representative of NGOs and decision makers."

We believe we have been very successful on both counts. A list of the studies is provided below.

I. CRSP Field Studies

1) NCA socioeconomics and nutrition - Galvin, Magennis, et al.
2) NCA land use and herding - McCabe
3) NCA livestock and wildlife disease - Rwambo, Grootenhuis, DeMartini
4) NCA range ecology - Kidunda and Maskini
5) NCA livestock nutrition and pastoral welfare - Mwilawa
6) Amboseli socioeconomics - Mbogoh and Munei
7) Amboseli livestock and wildllife diseases - Demartini, Grootenhuis
8) Kaputiei Maasai livelihoods - Njoka
9) Kaputiei range assessment - Njoka
10) Kiboko range assessment - Kinyamario and Mworia
11) Rapid field resource assessment protocol - Rainey, Reid
12) Policy - Kenya and Tanzania - Davis
13) Amboseli pastoral-wildife - Worden, Western (in progress)
14) Amboseli pastoral land use and socioeconomics - Burnsilver, Galvin (in progress)
15) Mburo Uganda pastoral-wildllife - Acen, Ellis (in progress)

II. Collaborative field studies (not supported by CRSP, but a 2-way exchange)

1) NCA land use and human welfare - Lynn, Galvin
2) NCA socioeconomics and nutrition - Galvin, Magennis
3) NCA pastoralism - McCabe
4) NCA plant diversity and biomass - Moehlman, Weisberg, Boone
5) Greater Serengeti vegetation, land use, elephant impacts - Metzger, Sommerville, Coughenour, Ellis

III. CRSP Modeling and GIS Studies

1) IMAS software development - Boone
2) NCA ecosystem model - Boone
3) Amboseli ecosystem model - Boone
4) Disease model - DeMartini, Howe, Boone, Mariner, Pelissier
5) Socio-economics model - Thornton, Galvin
6) NCA GIS and vegetation map - Moehlman, Boone, Kalkhan
7) NCA vegetation greenness dynamics using NDVI data - Boone, Moehlman
8) Greater Serengeti GIS - Boone, Lynne, Metzger, Kalkhan
9) Kajiado GIS - Okello, Reid, Boone
10) Amboseli GIS - Western, Boone, Atieno
11) Amboseli vegetation and land use mapping using Landsat data - Atieno

IV. Collaborative GIS and Modeling Studies (not supported by CRSP, but 2-way exchange)

1) Kenya GIS - DRSRS and ILRI (Kruska, Reid)
2) East Africa GIS - Kruska and Reid (ILRI)
3) Greater Serengeti Ecosystem Modeling - Coughenour, Sommerville

GENDER

The beneficiaries of the IMAS include pastoralist families, as well as other stakeholders in East African pastoral/wildlife systems. A measurable impact of the IMAS is increased food security for humans, including women and children. Although pastoral women usually do not own livestock they do have control over food acquisition and distribution. Thus, they are an integral component of our project. As baseline data for the socio-economic submodel we interviewed Maasai women about household food security. Information on agricultural food production and livestock production, women's diet intake and health status was collected. All household members were assessed for nutritional status. This information will be used in the IMAS system to project the effect of changes in policy, management, economic or ecological conditions. If policy or management decisions are contemplated that suggest an increase or decrease the flow of income or food energy, we can, based on the current nutritional status indicators, suggest the impact of these decisions on human welfare and food security by sex and age.

There are several women involved in the project. The co-PI is female (Galvin) and there are two other US-based female researchers involved in the project (Magennis, Burnsilver). In addition, we have a female team member who is working in Kenya and is our regional coordinator (Reid) and another who is our site-coordinator for Tanzania (Moehlman). A PhD graduate student from Uganda (Acen), and MS student in Tanzania (Ali) are female. Our graduate students funded on other projects, but working in Tanzania and contributing directly or indirectly to the CRSP work are all female (Metzger, Lynn, Sommerville). A female was principal organizer of our REDSO-funded workshop in July (C. Wilson). It is likely we will employ a female post-doc part-time in the coming year (Christensen).

POLICY

There is a distinction between policy makers and policy analysts/researchers. The latter are appropriately involved in IMAS development but the former are involved at the stage where there are results from the IMAS and there are opportunities to ask questions of the model. In the early stages of the development of the IMAS, our efforts have been focused on the latter. Policy analysts/researchers are being involved in the stages of model building and testing. Policy makers have been kept informed of our progress.

The recent change in leadership at Kenya Wildlife Service has undermined, again, our efforts to establish a viable working relationship with KWS. Director D. Western was replaced by R. Leaky, who has since been replaced by Mr.Nehemia Rotich. We have not yet met with Mr. Rotich, however, he is a long-time acquaintance of one of our primary Kenyan collaborators, and we are optimistic that our ties with KWS can be renewed. We plan meetings this year.

Randy Boones gave a talk at KWS in July, which was well attended by KWS personnel.

Policy connections at the REDSO workshop (Nairobi, July 1999) included the attendance of Humphrey Kaburu from the Kenya Ministry of Environmental Conservation. He indicated there would be interest in the IMAS from within the Ministry. Alan Bornbush, Technical Advisor from USAID to KWS, participated, and offered to take the message to KWS. The new head of the Uganda Wildlife Authority (Robbie Robertson) was invited and intended to come but could not. He has since

expressed considerable interest in the IMAS and is encouraging a visit to Uganda (planned for 2000). From Tanzania, E. Gereta, the senior ecologist from TANAPA was present.

Invited to the REDSO workshop were the Chairmen and Wardens of the Narok and Trans-Mara County Councils. They were unable to attend, but expressed an interest in doing so. Our workshop facilitator and collaborator is in contact with these officials, and we aim to continue our efforts at communication (Ole Kamuaro).

We made outreach effort to policy makers in the Ngorongoro Conservation Area, Tanzania, by demonstrating the IMAS to NCA and others (eg. V. Runyoro Chief Ecologist NCA, Amiyo Tlaa Ecologist NCA, J.N. Mutalemwa, Engineer, Chief Manager, Works and Transport Dept. NCA.). There was political change at the NCA in1999, including the sacking of the NCA Board of Directors, and Board Chairman by the Principal Secretary of the Ministry of Natural Resources. To date, the board has not been replaced, but we are poised to reestablish communications when that occurs.

A number of officials were invited to our Arusha mini-workshop in July, but did not attend. These included the The District Executive Director, Monduli District Council, The District Executive Director, Simanjiro District Council; Head, Department of Community Conservation, TANAPA; Head, Depart. Of Tourism, TANAPA; Director General, TANAPA; Acting Director General, TANAPA; Director of Planning and Research, TANAPA. The senior ecologist from TANAPA did attend, however.

Dr. J.K.K. Msechu, an official from the Ministry of Agriculture in Dar es Salaam attended our Sokoine University IMAS mini-workshop, and was very interested in further communication.

Our efforts to influence policy in Tanzania will develop further in 2000, when we meet with ministry personnel. We are encouraged that the new Director of Wildlife (Ministry of Environment) is Mr. Emmanuel Severe who attended the GL-CRSP year-end conference at Tarangire N.P., Tanzania in December, 1998. In order for policy makers, specifically Ministries, to enter into an MOU with our project, they must see that we have established an institutional linkage in Tanzania. To this end, we are working with Profs. Nikundiwe and Feetham Banyikwa of the Univ. of Dar es Salaam to establish this linkage. Once in place, we aim to approach the Ministries.

Historical Land Use and Policy Changes in Kajiado, Kenya (R.K. Davis)

Bob Davis conducted a review of the historical changes in policy and land use in Kajiado, since the inception of group ranches in 1968. Davis was in a unique position to provide key information to the IMAS project regarding these policy changes, since he was involved in conducting assessments which led to the land use shift to group ranches in the 1960's. Davis' report refers to a number of obscure, but influential papers and reports which would otherwise be difficult to obtain. He covers the following topics:

- Notes from Studies of Group Ranches in Kajiado District, Kenya (Reasons for the policy shift, and responses of pastoralist to the land use/policy shift in the early days of group ranching)

- Land use studies (Refers to early economic assessments of alternative land uses including ranching and tourism)

- Game cropping (survey of early ideas and why support for the idea has subsided)

- Sport hunting (the early economic returns, and concerns for its future, made moot by the sport hunting ban, but an option still worth considering)

Trends in Governance (J. Njoka)

In addition to the ongoing economic reforms, Kenya has also been going through the process of decentralising decision making to local level.In this context the policy of group ranch development which was started in the 1970's has been overtaken by the wave of change where production decision should be driven by private initiative .The relevant objectives in this trend as far as the pastoralists are concerned are:

- Decentralisation and participatory approaches of development creates good policy environment supporting for pastoral institutional building agenda;

- Democratisation trend is also creating and enabling environment to tackle issues of accountability and transparency.

- The objectives refer to a process which is not easy to measure. The status and environmental impacts of emerging pastoral institutions after the demise of group ranches need further study to determine the future of natural resource management.

OUTREACH

Target - Potential End Users of the IMAS

IMAS, the SAVANNA modeling system, and our experiments were demonstrated to East African scientists and managers at a workshop entitled "Integrated modeling, assessment, and management of regional wildlife-livestock ecosystems in East Africa," held at the International Livestock Research Institute in Nairobi, in early July. A more technical demonstration of the work was given to ILRI technicians. Soon after, four demonstrations of IMAS were made throughout northern and central Tanzania (i.e., Arusha, Ngorongoro, Dar es Salaam, and Morogoro). Finally, IMAS and SAVANNA experimental results were demonstrated to personnel of the Kenyan Wildlife Service. All told, the IMAS project was introduced to over 100 East African land managers, scientists, and stakeholders. During demonstrations of our work, we received very positive feedback and encouragement. Some of the most ardent support came from those responsible for managing areas for which IMAS has yet to be applied (e.g., Tarangire National Park, Tanzania) but who struggle with issues the system can address.

A public web site was created for the IMAS project: (http://nrel.colostate.edu/PROGRAMS/MIKEC/imas/), and includes background information, personnel contacts, news, project descriptions, and products. Project descriptions and minor modifications to the site are still pending.

A private users web site was created for a 'Savanna Forum,' allowing current users of the model post questions and answers, and have discussions about it's use.

Target - Stakeholders

We have contacted and informed key stakeholder groups such as pastoralist and wildlife organizations in Kenya and Tanzania

We have involved Prof. Bob Woodmansee in the project, to find ways to apply his Structured Analysis Methodology (SAM) to the problem of livestock-wildlife interactions. The SAM is a structured approach to addressing stakeholder concerns in natural resource management.

Target - NGOs

In Kenya, we were pleased that AWF has shown a high degree of interest, facilitated by their representation at the REDSO workshops, and other discussions. We have encouraged this collaboration from the outset of the project. The new Director of AWF (P. Bergin) is fully informed. While in Tanzania we had discussions with Alan Kijazi at the African Wildlife Foundation and with Carol Sorenson, who is directing a large livestock development project for DANIDA in the NCA. T. McCabe had the chance to discuss the utility of the model to their projects in a bit more depth than we were able to do in the mini-workshops and model demonstrations.

Developmental Impact

Environmental impact and agricultural sustainability

Ecosystem Modeling and GIS Analyses

Livestock based agriculture cannot be developed in East Africa without careful consideration of environmental impacts. The potential for negative livestock-wildlife interactions is high if livestock development is insensitive to ecological responses. In addition to the potential negative effects on ecosystem processes which are vital to agricultural and ecological viabilities, there is a risk of financial losses through negative impacts on ecotourism - a primary source of revenue for the region.

The IMAS ecosystem and GIS models are to be used to anticipate, and avert, the potential negative effects of livestock development on wildlife and ecosystems. The IMAS studies of land use change and the socioeconomic forces driving these changes will provide the basis for more informed management and policy decisions affecting the environment.

Socioeconomics Modeling

The socio-economic module is a contribution to the IMAS, whose major purpose is to assess the trade-offs of various management scenarios on wildlife and people in pastoral systems. The socio-economic module will provide a new dimension to IMAS scenario analyses.

Issues of human welfare vs. wildlife conservation remain political issues in Tanzania and elsewhere in East Africa.. In Kenya we have the potential to update our understanding of group ranching and their economics, and land privatization, as these have been, and continue to be quite large political issues. It is important to monitor and interpret what is happening and this project can contribute to this. In Tanzania, Uganda and Kenya, land use surrounding world heritage wildlife reserves has intensified, and grazing lands have been increasingly converted to cropping. The IMAS includes assessments of the socioeconomic responses to these changes.

Contributions to U.S. Agriculture

The issues of livestock-wildlife and livestock-environment interactions are not unique to East Africa. Indeed many of the same issues occur in the U.S., particularly in the grazing lands of the Western U.S. We expect that the IMAS approach we are developing for E. Africa will be directly useful for livestock based agricultural systems in the U.S. The other SAVANNA modeling projects funded by US Geological Service, National Park Service, Environmental Protection Agency, and Colorado Div. Wildlife have many of the same objectives as the work proposed here, particularly development and use of the same model for the purpose of managing ecosystems dominated by large herbivores. SAVANNA is being used to assess wildlife-livestock conflicts with respect to brucellosis in Yellowstone N.P. The model is being used to assess carrying capcity for wild horses, and interactions between wild horses and bighorn sheep in the Pryor Mountains, Montana. It is being used to assess land/resource-use interactions between wildlife and ranchers in Colorado.

Animal Disease Modeling

Epidemiologic modeling of tropical livestock/wildlife disease interactions benefits U.S. agriculture in at least two ways: 1) There is a persistent and increasing threat of introduction of infectious or parasitic diseases into the US from Africa. Increased knowledge of the manifestations, diagnosis, and transmission of these diseases will assist in their detection and control if introduced into the US. 2) One disease being modeled, malignant catarrhal fever (MCF), is an important disease of bison, cattle, and deer in North America. Outbreaks associated with African wildebeest in zoos have been reported, but the sheep-associated form of MCF is more common. Information about frequency and mechanisms of transmission as well as viral persistence in the environment in Africa will be of value as baseline information for the disease in North America. Comparison of the viral agents in each continent and their pathogenicity may lead to new strategies for diagnosis and control.

Contributions to Host Country

Information for Improving the Balance Between Wildlife and Livestock

The project provides information to the host countries that will be useful for developing livestock agricultural systems that minimize impacts on wildlife. This information takes several forms, including numerous field studies on rangeland ecology, socioeconomics, landuse, livestock ecology, and wildlife-livestock interactions described elsewhere in this report. We have also assembled useful GIS and remote sensing data sets that were previously unavailable. We are developing parameterized ecological simulation models that will provide information for policy and land use decisions. We are educating host country personnel to use these differerent forms of information.

Disease diagnosis and control in East Africa

The investigations on wildlife / livestock disease interactions in the NCA revealed that some wildlife diseases and several livestock diseases constrain pastoralism and cause conflict between livestock production and conservation of natural resources. To balance pastoralism and conservation of natural resources in the NCA there is a need to develop a sustainable livestock management program for the control of tick-borne and infectious diseases. A prerequisite of the development of such a program is the presence of a capacity to diagnose disease both in wildlife and livestock. Although some capacity to recognize clinical disease and provide

treatment exists, there is a clear lack of diagnostic ability to deal with mortality epidemics in both livestock and wildlife. Through interaction in the field and communication, GL-CRSP project veterinarians provide assistance and encouragement to government veterinarians dealing with these important disease problems.

Linkages and networking. This project is linked to other external projects as described in Section 10 below. We are networking with a wide array of institutions, projects, and initiatives as evidenced elsewhere in this report.

We have a linkage to the TAMU LEWS project by way of an arrangement for Angelo Mwilawa to conduct the fecal sampling protocol in NCA. Mr. Mwilawa is associated with both projects. The fecal samples are to be collected once a month beginning in August 1999. The fecal profiling is collected in two different routes. The scanning will be done either in Ethiopia where the machine has been installed already, or in Mpwapwa, when a machine is installed there.

An agreement was developed with the Kenya Department of Resource Surveys and Remote Sensing (DRSRS) to conduct a joint analysis of their rich aerial survey data.

Collaboration with International Research Centers. We are collaborating with the International Livestock Research Institute (ILRI) in a major way, as our budget allows. Our partership with ILRI is highly valued, and has proven to be extremely productive. It has facilitated much of our work.

Livestock and the environment are becoming big issues for ILRI in particular so obvious benefits for ILRI to be heavily involved in such work as the CRSP. ILRI can provide benefits for the CRSP too in terms of infrastructure and access and expertise in specific areas.

In planning for future development of the disease model, discussions were held with Dr. John McDermott, an epidemiologist working at ILRI. He will examine and critique MCF map and will work with us on this and other models. Economic analysis of the cost of disease and its control will be an important component of the IMAS, and Dr. Phillip Thorton of ILRI indicated his willingness to work with Dr. Grootenhius on this aspect later this year. We also met with Drs. Paul Rossiter, Chip Stem and Richard Kock, all veterinarians working with the FAO/OAU/EU PARC rinderpest project; they are willing to share data and insights on MCF and rinderpest in wildlife and livestock as our models are developed.

Other Contributions

Support for Free Markets and Broad-based Economic Growth. Free markets and economic growth can be enhanced by improving the balance between livestock-based agriculture and ecotourism. Neither livestock based agriculture nor ecotourism, can prosper without considering the sustainability of this balance. These two forms of market enterprise are intertwined, and codependent, in that pastoral economies do, or at least could derive necessary income from both sources. Ecotourism must be protected as a free-market enterprise in East Africa, because it generates a large amount of foreign income. Touristic expenditures are undoubtably recycled many times in the regional and local economies.

Contributions to and Compliance with Mission Objectives. This project is concordant with Strategic Objective 2, of Country Missions of Tanzania, Uganda, and Kenya, which aims

to promote agricultural productivity while conserving natural resources.

There was good communication with Dennis Weller, and Alan Bornbush at the Kenya mission in the last year. James Ndirangu was present at our REDSO workshop. We have recently briefed Meg Brown, Weller's replacement, and aim to work out ways to complement the Community-based Conservation projects. From the Tanzania Mission, R. Ruybal attended our IMAS demonstration in Dar es Salaam. He has now been re-posted, and we are planning to meet with Dr. Pat Foster-Turley, who has just arrived. Our Tanzania Site Coordinator met with Dr. Ken Baum who is in charge of the EPIQ program and hence the USAID Tarangire Program.

Concern for Individuals. We are working with land users and land holders, mostly pastoralists, whose livelihood depends upon their continued ability to utilize the grazing ecosystem. We are eliciting input from these stakeholders about their concerns. We are also concerned with the wants and needs of people who place a high value on having wildlife populations and a healthy environment.

Support for Democracy. Our work supports democracy by increasing food security, by striving for compatability in different forms of land use, and perhaps most importantly, by providing an objective source of information to any stakeholders, and to the public. Democracy cannot thrive, corruption and graft are more prevalent, and tyrants are more likely to wield power, in environments where people are in strife, where there is mistrust, and where there is an advantage for those able to spread propaganda.

Humanitarian Assistance. We provide humanitarian assistance when we can and when there is a great need, on an incidental basis while working in the field. However, we are not funded to provide humanitarian assistance on this project.

Leverage Funds and Linked Projects

Integrated Assessment of African Savannas through Spatial-Dynamic Vegetation and Land Use Modeling. U.S. National Science Foundation. M.B. Coughenour and J. Ellis, Principal Investigators. 1997-2000. $450,000 for three years.

Land Use Change in East African Savannas: A case study in northern Tanzania. U.S. National Science Foundation, Anthropology Program. K.A. Galvin and J. Ellis, Principal Investigators. 1997-1999. $200,000 for two years.

Responses to Climate Variability and the Utility of Climate Forecast Information for the Livestock Sector in the Arid and Semi-arid Zone, South Africa. NOAA Climate and Global Change Program. K. Galvin, J. Ellis and C. Vogel, Principal Investigators. 1998-2001 $336,000 for 3 years.

Sequence Analysis of Ovine Herpesvirus 1-Associated with Bovine Malignant Catarrhal Fever. Objectives: Determine the sequence of the rhadinovirus associated with MCF. PI, DeMartini USDA Grant. No. 99-35204-7723. 8/1/99 - 7/31/01, 8% effort. $187,000 total costs.

Peter Pelissier. Was supported for 3 months by CSU College of Veterinary Medicine and Biomedical Science to work with the GL-CRSP in developing the MCF model. He assisted in parameterization and baseline literature review for the model, and he made a field trip to Kenya in July, 1999.

Dr. DeMartini. obtained a USDA grant to analyze and compare the genome of the two viruses that cause sheep-associated and wildebeest-derived malignant catarrhal fever. Epidemiology surveys and studies of the disease are also being supported by smaller grants from the College Research Council of the CVMBS and the National Bison Association.

Three Landsat TM scenes (1995 and 1998) were donated by AFRICOVER, Nairobi for use by F. Atieno, an MSc. student on the project.

An agreement was developed with the Dept. of Resource Surveys and Remote Sensing to conduct a joint analysis of their rich aerial survey data for the years, 1977, 1978, 1980, 1981, 1982, 1986, 1990, 1991, 1992, 1993, 1994, and 1998. This type of agreement is granted to very few projects, and reflects a substantial commitment by both parties. The data set includes information on over 60 variables, including the abundance and distribution of livestock and wildlife, vegetation, settlement, boreholes, crop cultivation, erosion, burning, and infrastructure.

Applications of the IMAS-CRSP Methodology (Indirect Contributions)

Large Mammalian Herbivores, Plant Interactions and Ecosystem Processes in Five National Parks. USGS. Biological Resources Division (BRD). Francis Singer, P.I. , M. Coughenour co-PI. $683,000. 4/95-8/99.

Spatial Modeling of Yellowstone Bison and their Environments. USGS BRD. $113,000. M.B. Coughenour, P.I. 5/98-5/02.

Dynamics of Tree-grass Interactions. National Center for Ecological Synthesis and Analysis. W. Parton, PI., M. Coughenour co-PI. Support for 3 workshops. 5/98-11/99.

The role of Habitat in the Decline of Mule Deer in Colorado: Research and Adaptive Management at Landscape Scales. Tom Hobbs, PI., M. Coughenour co-PI. Colorado Division of Wildlife. $840,000. 9/99-9/03.

An Integrated Assessment of the Consequences of Climate Change for Rocky Mountain National Park and its Gateway. EPA-STAR. Tom Hobbs, PI. M. Coughenour co-PI. $898,900. 7/99-6/02.

TRAINING

Long Term

In Progress:

Randy Boone, Postdoctoral Research Associate, Colorado State University - full support.

Jeff Worden, PhD. candidate , Colorado State University - full support.

Shauna Burnsilver, PhD. candidate, Colorado State University - partial support.

Joyce Acen, PhD. candidate, Ugandan, at Colorado State University, Ecology - full support.

Kris Metzger, PhD. candidate, Colorado State University, partial support for field work only.

Asha Salim Ali, MSc. candidate , University of Dar es Salaam, Architecture and Lands - support for field studies(under Prof. Nikundiwe).

Fred Atieno, MSc. candidate, University of Nairobi, Range Science - partial support (under Prof. Njoka).

Okello Onyango, GIS/modeling trainee, ILRI - salary.

Completed

John Mworia, MSc. candidate, University of Nairobi, Botany - support for field studies (under Prof. Kinyamario).

Mohamed Maskini, MSc. candidate, Sokoine University, Animal Sciences - support for field studies (under Prof. Kindunda).

Short-Term

Workshops

Integrated modeling, assessment, and management of regional wildlife-livestock ecosystems in East Africa. Workshop, Nairobi. July 6-9, 1999.

Mini-Workshops

Demonstration of IMAS and Discussions of Potential Uses in Tanzania, July 1999:

African Wildlife Foundation, Arusha
Univ. Dar es Salaam
Sokoini University, Morogoro

Visiting scientists training

Trained in the SAVANNA modeling system during their visits to Colorado State University:

Angello Milawa
Prof. Feetham Banyikwa

GIS training course

A two-week GIS training course was developed and conducted at ILRI in April 1999. Nine participants attended: 6 from Kenya, 1 from Tanzania (3 were invited) and 2 from Uganda (3 were invited). The course was conducted by 6 GIS technicians from ILRI and DRSRS and was rated excellent by course participants.

Technical training in SAVANNA - (training trainers)

In July, the ILRI GIS analyst, Okello Onyango, travelled with the CSU CRSP team to Tanzania to learn how to demonstrate the SAVANNA model. Okello is the first of a team of African trainers who will be trained to lead demonstration of the model in East Africa.

The second is Prof. Mtalo from U. Dar es Salaam (in progress).

COLLABORATING PERSONNEL

United States:

Child, Dennis. Department Chair, Professor, Colorado State Univ., Rangeland Ecosystem Science Dept.

Coughenour, Michael. Senior Research Scientist, Associate Professor (Affiliate), Advising Faculty Colorado State Univ., Natural Resource Ecology Lab., Rangeland Ecosystem Science Dept., Graduate Degree in Ecology

Davis, Robert, Senior Associate Univ. of Colorado; Institute of Behavioral Science

DeMartini, James. Professor Colorado State Univ., Pathology Dept.

Ellis, James. Senior Research Scientist, Associate Professor (Affiliate), Advising FacultyColorado State Univ., Natural Resource Ecology Lab., Rangeland Ecosystem Science Dept., Graduate Degree in Ecology

Galvin, Kathleen. Senior Research Scientist, Assistant Professor, Advising Faculty Colorado State Univ., Natural Resource Ecology Lab., Anthropology Dept., Graduate Degree Program in Ecology

Howe, Rodney. Research Scientist. USDA-APHIS, Fort Collins. CO.

Magennis, Ann. Associate Professor, Colorado State Univ., Anthropology Dept.

Mariner, Jeff. Veterinarian. Consultant. Fort Collins.

McCabe, Terrence. Assistant Professor, Associate Director, Univ., of Colorado, Anthropology Dept., Institute of Behavioral Science

Pelissier, Peter. Veterinarian. Consultant. Fort Collins.

Rittenhouse, Larry. Professor, Colorado State Univ., Rangeland Ecosystem Science Dept.

Woodmansee, Bob. Professor, Colorado State Univ., Rangeland Ecosystem Science Dept.

Kenya:

Else, James. Veterinarian, Wildlife Consultant.

Grootenhuis, Jan. Veterinarian, Consultant

Kinyamario, Jenesio. University of Nairobi, Dept. of Botany

Kruska, Russell. International Livestock Research Institute

Mbogoh, Stephen. Univ. of Nairobi, Agricultural Economics Dept.

Munei, Kimpe. Univ. of Nairobi, Agric. Econ. Dept.

Njoka, Jesse. Professor, University of Nairobi, Range Science Dept.

Okello Onyango. International Livestock Research Institute.

Rainy, Michael. Explore Mara Ltd., Consultant. Representative, Ololepo Hills Grazing Assoc.

Reid, Robin. Senior Ecologist. International Livestock Research Institute

Rwambo, Paul. Veterinarian.

Said, Mohammed. Department of Resources, Surveys and Remote Sensing.

Thornton, Philip. Agricultural Systems, International Livestock Research Institute

Western, David. African Conservation Centre.

Tanzania:

Banyikwa, Feetham. Adjunct Faculty, Research Associate . Univ. of Dar es Salaam, Syracuse University

Kidunda, Rashidi. Assistant Professor. Sokoine Univ.

Kijazi, Allan.African Wildlife Foundation.

Mwilawa, Angello. Livestock Research Scientist, Ministry of Agriculture and Cooperatives, Zonal Research and Training Center

Moehlman, Patricia. Biologist, Consultant. The World Conservation Union - IUCN, Equid Specialist Group

Nikundiwe, Alfeo. Professor, Principle and Professor, College of Architecture and Lands, University of Dar es Salaam

Runyoro, Victor. Ngorongoro Conservation Area Authority.

Uganda:

Acen, Joyce. Graduate Student, Colorado State University.

COLLABORATING INSTITUTIONS

African Wildlife Foundation
Colorado State University
Colorado University
International Livestock Research Institute
Kenya Agricultural Research Institute
Kenya Department of Resources, Surveys and Remote Sensing
Kenya Wildlife Service
Ngorongoro Conservation Area Authority
Ololepo Hills Grazing Association
Serengeti Wildlife Research Institute
Sokoine University
Tanzania Ministry of Agriculture
University of Dar es Salaam
University of Nairobi

Publications

Atieno, F. Effects of changing land use on land cover, vegetation species abundance and structure in pastoral areas: A case study of the greater Amboseli ecosystem, Kajiado District. Report (MSc Thesis in progress, Univ. of Nairobi).

Davis, R.K. 1998. Policies on land use on NCA and constraints on policy change.

Davis, R.K. 1999. Review of historical land use policy changes in Kajiado District, Kenya.

Howe, R. 1998. Spatially integrated disease risk assessment model (SIDRAM) (Phase I). White paper for the GL-CRSP/IMAS Project.

Howe, R., R. Boone, J. DeMartini, T. McCabe, M. Coughenour. 1999. A spatially integrated disease risk assessment model for wildlive/livestock interactions in the Ngorongoro Conservation Area of Tanzania

Rainey, J., E. Harris, M. Rainey, M. Coughenour (eds.). 1999. Integrated modeling, assessment, and management of regional wildlife-livestock ecosystems in east Africa: Report of a workshop held at the International Livestock Research Institute. July, 1999.

Maskini, M.S. 1999. Spatial and temporal grazing patterns of livestock ad herbivores in Ngorongoro Conservation Area. MSc Thesis, Sokoine University, Tanzania.

Mbogoh, S. and K. Munei. 1999. Study on wildlife, livestock and human interaction in Kajiado District in Kenya: results of the economic study.

Mwilawa, A., V. Runyoro, and P. Moehlman. 1999. Forage range survey and monitoring livestock nutrition in NCA.

Mworia, John. 1999. The impact of land use changes on the vegetation, soil and water balance in Kajiado, Kenya. Progress Report (PhD Research, Nairobi University, Kenya)

Njoka, J. 1999. Sustainable Livelihoods of Maasai Kaputiei of Kajiado District of Kenya.

Pelissier,. P.G. 1999 Preliminary assessment on the progress and feasibility of developing disease submodels for MCF, Rinderpest, and ECF in the Ngorongoro Conservation Area of Tanzania.

Rainey, M.E., and J.S. Worden. 1998 Ecotourism and wildlife conservation: some new insights from practical experience in the Melepo Hills, Kajiado District, Kenya.

Rwambo, P., J. Grootenhuis, J. DeMartini, and S. Mkumbo. 1999. Animal disease risk in the wildlife/livestock interface in the Ngorongoro Conservation Area of Tanzania.

Abstracts and Presentations

Ellis, J., R. Reid, P. Thornton, and R. Kruska. 1999. Population growth and land use change among pastoral people: local processes and continental patterns. Paper presented at International Rangeland Congress, Townsville, Australia.

Galvin, K.A., R.B. Boone, N.M. Smith and S.J. Lynn. Impacts of climate variability on East African pastoralists: Linking social science and remote sensing. Paper presented at a special session on social science contributions to climate change, at the annual meeting of the Society for Applied Anthropology, Tucson, April.

Galvin, K.A., A. Magennis, J.E. Ellis, S. Lynn and N.Smith 1999. Effects of conservation

policy on human well-being: A comparative study of pastoral Maasai nutrition and economy in northern Tanzania. Poster presented at the annual meeting of the Human Biology Association meetings, Columbus, Ohio, April.

Galvin, K.A., J.Ellis, R.B. Boone, A. Magennis, N.M. Smith and S.J. Lynn. 1999. Compatibility of pastoralism and conservation? A test case using integrated assessment in the Ngorongoro Conservation Area, Tanzania. Paper submitted to the Conference on Displacement, Forced Settlement and Conservation, St. Anne's College, University of Oxford, September.

Magennis, A. L. and K.A. Galvin 1999. Maternal-child nutrition among Maasai pastoralists, Loliondo District, Tanzania. Paper presented at the annual meeting of the American Anthropological Association, Chicago, November.

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McCabe, J.T. 1999. Conservation with a human face? Lessons from forty years of conservation and development in the Ngorongoro Conservation Area, Tanzania. Paper presented at the Conference on Displacement, Forced Settlement and Conservation, St. Anne's College, University of Oxford, September.

Comments

Comment from an anonymous member of our team in Kenya (and a concern of all of us). There is no memo of understanding with anyone in Kenya as far as we know. KARI and ILRI have not signed an MOU. This means that CRSP could be accused of operating illegally. Therefore we cannot report anything on host country contributions.

Although we have made efforts to influence policy, it has proven difficult with our expertise and resources. Professional lobbyist and public relations experts working on behalf of the whole African GL-CRSP might be necessary to achieve the desired impacts.

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Lynn, S. A comparative study of land use among two Maasai communities in northern Tanzania. M.S. thesis, Colorado State University, in progress.

Machange, J. 1997. Livestock and wildlife interactions. Pp. 127-142. In. D.M. Thompson, ed. Multiple Land-Use: The Experience of the Ngorongoro Conservation Area, Tanzania. IUCN, Cambridge, UK

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McCabe, J.T., N. Mollel and A. Tumaini. 1997. Food security and the role of cultivation. Pp. 397-416. In. D.M. Thompson, ed. Multiple Land-Use: The Experience of the Ngorongoro Conservation Area, Tanzania. IUCN, Cambridge, UK

Appendix

We have trained or are training 1 post doc, 4 Phd students, 4 MSc students, and 1 technician. We have conducted or are conducting 20 collaborative field studies and 14 collaborative modeling or GIS studies. We have developed an information base and modeling capability that heretofore did not exist about the natural resource management of the Ngorongoro wildlife-pastoralist ecosystem, and are in the process of doing the same for the Kajiado Kenya. We have developed a decision support system, inclusive of a computer model, a GIS data base structure, and a field sampling protocol, to assess interactions between livestock and wildlife. We have priovided opportunities for at least seven senior African scientists to collaborate with American scientists, including trips to the USA. We have increased host country capacities for making informed decisions by providing new scientific information about livestock-wildlife ecosystems. Policy analysts and policy makers are either involved or have been informed of our results.

Principal Investigators

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