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GL-CRSP-IMAS PROJECT
COLORADO STATE UNIVERSITY

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2. **Project Title**: Integrated Modeling and Assessment for Balancing Food Security, Conservation and Ecosystem Integrity in East Africa.

3. **Summary**

We have completed the development of 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 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 describes cash-flow and dietary energy intake in pastoral households and has been 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 assesses the risks of transmission between livestock and wildlife.

The IMAS application to the Ngorongoro Conservation Area, Tanzania, was completed last year, and this year we followed up with increasing refinement of the model, contacts with stakeholders, including the adminstrative authority, pastoralists, a development agency (DANIDA), and an NGO (African Wildlife Foundation). Model analyses completed last year were transmitted to a number of agencies in Tanzania, and the NCA outputs were used as the primary example for training IMAS users in Tanzania. Also at the NCA, we continued studies of pastoral land use and comparative studies of land use policies and their impacts in the NCA and adjacent Loliondo District. Outreach activities in Tanzania included training, and feedback workshop, and contacts with pastoralists in the field.

In Kenya, a wide range of field studies are under way in the Greater Amboseli Ecosystem, Kajiado District, Kenya. Jeff Worden, a PhD. candidate (CSU) has been studying the spatial distribution of Maasai settlements, and their effects on vegetation and wildlife. The overall objective is to determine how changing patterns of Maasai settlement and land use effects vegetation and wildlife communities. He has been engaged in study area identification, stakeholder interactions, training, a settlement census, a high resolution total wildlife and livestock count, and cooperative research. Other ecology related research in Amboseli includes efforts to assess ecosystem dynamics over the long-term in collaboration with D. Western. Intensive ground counting techniques applied by R. Reid et al. in Maasai-Mara and Amboseli are providing unique and valuable information in pastoral-wildlife interactions.

An initial SAVANNA ecosystem model adaptation to the Greater Amboseli study area was completed. The SAVANNA application to Greater Amboseli includes seven plant functional groups (palatable grasses, palatable forbs, unpalatable herbs, swamps, palatable and unpalatable shrubs, and deciduous woods). Eleven animal groups are represented, including

three livestock groups (cattle, goats, and sheep) and eight groups of wildlife (wildebeest, zebra, buffalo, grazing antelope, browsing antelope, giraffes, warthog, and elephants).

Data are being collected by Burnsilver, Galvin, and Thornton in Greater Amboseli to develop a socioeconomics model of pastoral welfare responses to development and conservation policy. Shauna Burnsliver, a PhD. candidate (CSU) has been documenting grazing orbits, surveying households across the study areas, conducting a large scale settlement survey of households to identify economic strategies-spatial scale of resource use, and developing a Land Use Typology and Landscape Heterogeneity index. Prof. Galvin et al. have conducted an anthropometric survey and diet composition study.

R. Boone spent several weeks in Kenya and Tanzania conducting IMAS training. Computer files were created that allow each of the 16 model experiments from the NCA to be viewed in the SavView modeling software developed on the project, and the entire collection was written to a CD for distribution. About 350 pages of training material were prepared for use in workshops. Training model results were closely reviewed by two dozen resident experts and stakeholders, with positive feedback.

Notable linkages were made with government agencies and NGOs who are involved in policy making in Kenya and Tanzania, including Kenya National Environment Secretariat, Kenya Wildlife Service, Tanzania Wildlife Research Institute, Ngorongoro Conservation Area Authority, Tanzania National Parks, Tanzania Ministry of Agriculture, African Wildlife Foundation, World Bank, and DANIDA. There is substantial interest by these agencies in further adoption and application of the IMAS to improve pastoral-wildlife interactions in East Africa.

4. **Research**

Field Research - NCA, Tanzania

Forage Range Survey and Livestock Nutrition Monitoring in Ngorongoro Conservation Area (Angello J. Mwilawa, Victor A. Runyoro and Patricia Moehlman)

A field study was completed with the aim of examining the range forage condition in relation to livestock condition during the dry season (May – August, 1999) in Ngorongoro Conservation Area Authority (NCAA). To identify preferred forage range species under pastoralists assessment, determine chemical forage nutritive value among the preferred species, and establish field monitoring livestock condition in NCAA with pastoralists participation. Two grazing routes were selected for forage range survey and pastoral household communities for fecal sampling and livestock condition. The routes were first Oloirobi – Endulen and secondly Oloirobi – Malanja Depression – Olbalbal routes. Four households were identified in each route and fecal samples were collected during June – August. From this study, pastoralists identified over 20 forage species as preferred by livestock. On average the percentage chemical composition for the forage sampled were 93.38, 10.19, 72.07 and 71.60 for DM, CP, IN-VDMD and IN-IOMD respectively. While the mean percentage on mineral composition for K, Ca 2+, Mg 2+, P and Na were 3.02, 1.47, 0.26, 1.21 and 0.93 respectively. The livestock Body Condition Score (BCS) during May was M+ for cattle and F for small ruminants indicating that at this time the livestock was in good condition. Diet quality from NIRS scan showed that livestock grazed better pasture in June than the following months.

It was concluded that the indigenous knowledge from pastoralists gave a better indication as to which could be the most useful forage species for future research in the area. Pastoralist participation in fieldwork could be an opportunity for learning and for future local participation in monitoring activities such as livestock conditioning and fecal sampling procedures. The study needs to be conducted for a longer period and should be during the wet and dry seasons. Results obtained during fieldwork once discussed, with stakeholders could be an impetus towards planning for the future. It can be a means towards motivating local and external resources for more research and development. The authors suggest that pastoralists should be locally trained for range condition and livestock conditioning (BCS) whereas the NCAA should assist in the technical part such as bringing fecal samples for NIRS analysis interpretation of the results.

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

We are concluding our work using a long-term data set collected by Patricia Moehlman and her colleages as part of the Ngorongoro Ecological Monitoring Program. Multivariate statistical analyses have assisted us in understanding some of the dynamics of the system, but results have not been definitive. This year we compiled a suite of satellite vegetation greenness data (NDVI) at three resolutions (1 km, 4 km, and 7.6 km square cells). We divided NCA into a series of blocks based upon topography and plant cover, then generated greenness profiles through time for each block. We are comparing these profiles to trends in plant biomass and to changes in herbivore populations.

In a finer-scaled study, we are comparing the vegetation of Ngorongoro Crater as it was mapped in the late 1960s (Herlocker and Dirschl 1972) with a recently created map of vegetation of Ngorongoro (P. Moehlman, unpub. data). Both maps include detailed information on vegetation types and cover. We used GIS analyses to quantify the proportion of the crater covered by each of the vegetation types, and are calculating changes in cover types through time. We believe that changes in cover types may help explain changes in buffalo and wildebeest population, and may relate to the removal of livestock from Ngorongoro Crater in 1974.

Ecology, Conservation and Maasai Land Use in the Ngorongoro Conservation Area. (Lynn, Ellis, Galvin)

This portion of the study compared aspects of the pastoralist economy, land use, livestock management and settlement patterns between the NCA and the adjacent Loliondo Game Control Area (LGCA). Goals of the research involved determining if, and to what extent:
1) constraints on Maasai land use, resulting from NCA conservation-based policies and management practices, actually compromised the economic situation and welfare of NCA Maasai pastoralists;
2) ecological variation within NCA, and between NCA and the LGCA, influenced Maasai land use patterns and the local pastoral economy.

We compared livestock holdings and agricultural activities of Maasai pastoralists in NCA and LGCA. Results showed that many NCA Maasai are in a precarious economic position, with very small herds of livestock and small (cultivated areas?)farms. LGCA Maasai are somewhat better off in both respects, with considerably greater livestock holdings and significantly larger farms. Cultivation is limited by regulation within the NCA. Average acreage cultivated there is 0.120 acres/person, whereas it is 0.271 acres/person in the LGCA. Although there are no restrictions on livestock numbers within NCA, there are regulations prohibiting grazing within Ngorongoro and Empakaai craters, in Olduvai Gorge, and the Northern Highland Forest Reserve, together a significant portion of the NCA. In addition and more importantly, NCA livestock are prevented from using much of the shortgrass plains during the wet season, by occupancy of nearly 0.5million wildebeest and the associated disease Malignant Catarrhal Fever (MCF).

The result of these constraints on grazing is that disease-driven mortality rates are very high among NCA livestock and herd sizes are small and static. Annual mortality among cattle herds appears to be closely related to herd size. Small herds had much higher % mortality rates than large herds in both NCA and LGCA. This suggests that disease, the major mortality factor (of which East Coast Fever, a tick-borne disease, is dominant), is density-independent in occurrence, thus having a much greater effect proportionally on small herds than on large ones. Because cattle herds in the NCA are small (modal herd size 0-49) annual % mortality is high there: 23.6%. Whereas the larger cattle herds in LGCA (mean and mode around 150) have a significantly lower rate: % annual mortality = 12%. Thus the NCA Maasai appear to be caught in a poverty trap from which escape is difficult under current circumstances. Although the major cause of this problem is the prevalence and threat of livestock disease, we conclude that conservation policy contributes indirectly to the NCA Maasai's dilemma by exacerbating constraints on grazing patterns and land use. Conservation policy directly limits cultivation and thus food security, as related to crop production.

We explored how major variations in landscape and vegetation influenced human activities and the pastoral economy. We found no significant relationships between ecological zones and livestock holdings, either in terms of herd sizes or human:livestock ratios. However, there were significant differences among eco-zones in extent of cultivation.

Three settlement patterns were found among Maasai households. Households that have one permanent boma and use one grazing area all year were designated Type A; Type B households also had a single permanent boma, but livestock grazing and watering locations were changed on a seasonal basis. Those households with one or more permanent bomas and one or more temporary bomas, where livestock were taken on a seasonal basis, were designated Type C.

Comparisons among household types demonstrated that variations in landscape and ecological pattern promote different settlement and land use patterns among Maasai pastoralists. It is likely that the transhumant (type C) settlement/movement patterns with long- distance seasonal migrations are most vulnerable to constraints which disrupt these migrations. This is precisely the problem befalling NCA pastoralists due to policy-based restrictions on grazing and wildlife usurpation of lowland plains habitats. By contrast, the less extensive movement patterns of type A or B households may be less vulnerable to these and other restrictions on long distance movements; these are likely to be undertaken only during times of stress such as intensive droughts. These results show how landscape and land use interact in pastoral resource exploitation strategies, and how settlement or movement restrictions may have quite different consequences in different physical and ecological settings.

Pastoral Land Use in NCA, Tanzania (J. Terrence McCabe)

Terry McCabe's CRSP activities for the year 2000 were, in many respects, a continuation of the work done in the year 1999. He conducted research in Tanzania during the months of January, February, June, and July. He refined his understanding of land use in the Ngorongoro Conservation Area with an emphasis on collecting data for the highlands area around Nainookanooka and in the highlands to the south of Kakesio. Very briefly, it was learned that nearly all the cattle from the villages of Nainookanooka, Alaililai, and Irkepusi move down to the lowlands following the short rain and remain there until the wildebeest begin to calve. He also learned that the small stock from Alaililai also migrate down to the plains and remain there for the wet season. The small stock from the villages of Nainookanooka and Irkepusi do not migrate down to the plains. Nearly all of the cattle from the villages of Ossinoni and Kakesio migrate to the highlands bordering Lake Eyasi and south of Kakesio. There is very good grazing in these highlands but very few water sources. Cattle remain in the Kakesio highlands until the water sources dry up.

McCabe was also able to observe the migrations of people and livestock in another very dry year. The was a major influx of people and animals from the area north of the NCA by March of this year. These people were migrating to the Ndutu area. People and animals were also moving into the NCA from the south, especially from Kisongo area (west of Arusha). These people located in the area around Endulen. The people from Olbalbal were moving in three directions: some were migrating out to Ndutu, some were moving up onto Olmoti mountain, and some were moving towards Endulen. I also learned that there is a major initiative to vaccinate cattle in the NCA against East Coast Fever. The program appears to be highly successful and should have important implications concerning long term herd growth in the NCA. He also learned that there were major outbreaks of MCF in the NCA during late March and April.

Other activities included consultation with members of the project involved in constructing the disease sub-model, and consultation with Bob Davies who was working on a policy document for the Kajiado district in Kenya.

Field Research - Greater Amboseli and Mara Ecosystems, Kenya

ILRI Ecological Field Studies (R.Reid, Team Leader).

Impacts of land tenure, land-use change and old settlements on wildlife and landscapes in Amboseli:

R. Reid worked closely with J. Worden as a field advisor for his Ph. D. study, including logistical support, scientific discussions and field visits (30%). The ILRI ecology team also held several meetings with the principal researchers in the Amboseli ecosystem to understand and discuss a broader collaborative approach to system-wide research (100%). A. Muchiru, working with D. Western and R. Reid, completed final drafts of two papers analyzing the impact of abandoned pastoral settlements on wildlife use and vegetation. This work concludes that wildlife differentially prefer to forage on old settlement sites compared with the surrounding landscape and that old settlements affect vegetation patterns for up to a century after the settlement is abandoned (15%). F. Atieno, advised by Prof. J. Njoka and R. Reid, completed his MSc. thesis on the impacts of land-use change on vegetation and rangeland fragmentation in the Amboseli ecosystem (80%).

Impacts of human population growth on wildlife in Maasai Mara:

In November, 1999, the Kenya-CRSP team and a wide group of collaborators conducted a fine-resolution total count of 1550 km^2 of the Mara ecosystem. This dataset was collected in the Mara to be used as a comparison to similar data collected by J. Worden in Amboseli. Also, in the GIS analyses conducted in 1997/98 by the ILRI GIS team, Maasai Mara appeared as one of the protected areas under the greatest human population pressure in East Africa. The count data were analyzed and a draft for publication written. The analysis showed that, contrary to expectation, wildlife form a 'biodiversity ring' around Maasai settlements, probably because of the abundance of old settlement sites nearby, predator protection provided by pastoralists to wildlife, and facilitation of energy and nutrient flows from livestock to wildlife. Initial land-use modeling shows that current changes in land tenure, that encourages pastoralists to settle evenly on the landscape, will strongly hasten the recent 60% decline in wildlife in this system.

Maasai Settlement, Landscape Mosaics, and the Spatial Patterning of Vegetation and Wildlife in the Greater Amboseli Ecosystem (Jeff Worden)

The past year has seen the initiation and completion of a variety of field work in Kajiado District. Jeff Worden, a PhD. candidate (CSU) has been studying the spatial distribution of Maasai settlements, and their effects on vegetation and wildlife. The overall objective is to determine how changing patterns of Maasai settlement and land use effects vegetation and wildlife communities. By documenting changes in settlement patterns and the effects of settlements on vegetation and wildlife at the local scale Worden is hoping to paint a picture of how sedentarization and changes in settlement and land use influence the ecosystem at landscape scales.

Working with Dr. David Western and others he has been able to identify a highly indicative transect running north from Amboseli. He has established four study sites along this transect (might reduce this to three as things evolve)- a) Meshanani, b) Lengesim, c) Selengei, d) Osilalei-Olontuluguum (running from South to North). The intention is to try and cover a gradient of land use/tenure types ranging from large scale unadjudicated in Meshanani, to relatively large scale (increasingly constrained) unadjudicated at Lengesim and Selengei, to smaller scale adjudicated in Osilale-Olontuluguum within an ecosystem. There is also a rainfall gradient (lowest in the south and highest in the north) that results in a parallel gradient of habitat types running from bushed grassland in Meshanani to Commiphora woodland in Leng/Selengei to Acacia Commiphora woodland in Osil/Olontuluguum. Within each study site/habitat type Worden will try to identify an intensity gradient as well. This design will allow him to look at the effects of tenure and possibly habitat complexity on scales of livestock resource use and settlement patterns as well as the differential effects of human disturbance (settlements both current and abandoned) on vegetation and wildlife parameters at multiple scales both within and between habitat types.

Study sites and stakeholder interests were identified early this year. Sites were selected in order to capture a gradient of increasing precipitation and sedentarization moving north from Amboseli National Park. Numerous site visits were conducted in order to identify specific study areas and to lay the foundation for cooperation with local stakeholders. In an effort to maximize the positive effects of field work and IMAS implementation we are currently working with a variety of local institutions and organizations including: Osilalei, Selengei, and Olguliluli Group Ranches and their individual members, Amboseli Tsavo Group Ranch Conservation Association, Kenya Wildlife Service, African Wildlife Foundation and the African Conservation Centre. Another important aspect of the field work to date is the training of 2 local field assistants.

One of our first priorities was to establish the current distribution of Maasai settlements. The distribution of settlements and a few of their important characteristics were recorded in each of the study sites in a settlement census. Both permanent (Emparnat) and seasonal (Enkaron) settlements were recorded along with the age of the settlement, number of houses, number of elders, presence or absence of agriculture and other spatial attributes. A total of 258 settlements were surveyed, of which 233 fell within the final study area boundaries. Overall settlement density varied with Osilalei having .77 settlements per km2, and Selengei and Meshanani each with .14 and .11 respectively. As predicted, however, the mean number of families (elders) and people per settlement in the subdivided area (Osilalei) was lower than in the more traditional areas.

There was also a significant variation in the spatial distribution of settlements on the landscape. As predicted, settlements on Osilalei group ranch, are spread more evenly across the landscape than the patchier distribution observed on both Selengei and Meshanani (Olguliluli). Similarly, settlements on Osilalei were significantly younger with a marked peak in settlement age corresponding with the El Nino rains of 1997 and a massive movement onto individually demarcated plots. We currently analyzing the details of this spatial and temporal distribution, and intend to compare this with an historical perspective following the completion of a census of old settlement sites in the study area.

Worden has also recently completed a high resolution total count of both Meshanani and Selengei areas. This aerial census of all livestock and wildlife was designed to illuminate the interactions of human disturbance and the spatial patterns of wildlife use. Conducted at a resolution of 11 hectares, the technique enables us to discern the discrete distributions of livestock and wildlife in the context of human settlement, water, and vegetation characteristics. The count analysis for the year 2000 dry season is currently underway. We will be conducting a wet season count in 2001 following the return of the rains. Part of the proposed analysis will be a comparison of this technique with other counting protocol currently in use in the area. Worden has also had the opportunity to cooperate closely with Dr. David Western on his long term Ilkisongo Count conducted in early October of this year. Techniques from both of these counting protocol are being incorporated into a method Worden is helping to design for Mbirikani Group Ranch so that they can better manage their wildlife, livestock and tourism resources.

Greater Amboseli (Ikisongo) Wildlife and Ecology (Dr. David Western)

The entire Ilkisongo aerial data set has been compiled, checked and upgraded to windows-compatible format over the last six months. The data include density distributions for all large mammals (as well as for livestock, human habitation and farms) in the 8,500 square kilometer ecosystem. The environmental data include herb and canopy conditions, water and fire. The data have been sent to CSU on diskette, ready for test runs and modeling using SAVANNA.

Data have also been fully compiled in windows format for the fixed permanent vegetation plots measured monthly from 1975 until 2000. The data include herb layer cover, height, dry mass, green mass and grazing index. These data have been compiled on diskette and sent to Randy Boone ready for comparative analysis with NDVI measurements for the same area. The ground-truthing exercise for the NDVI data can now be done from the long term data set from Amboseli.

A large scale sample count was completed over eastern Kajiado in October, coinciding with the end of the extended drought. The data have been coded and the final tally of animal counts and distributions. including livestock and human settlement, is complete. Jeff Warden was trained as one of the two counting crew prior to the count.

Normal monthly measures of fixed vegetation plots and total counts of livestock, settlements, elephants and buffalo were maintained over the last six months.

Socioeconomic Field Research In Kajiado District, Kenya (S. Burnsilver, K. Galvin, P. Thornton, S. Mbogoh,)

Activities for the Kajiado case study to date have largely concentrated on surveys to collect the socio-economic data with which to modify PHEWS for the greater levels of market integration found there and with which to calibrate the model. A set of scenarios have been defined.

Collaboration with the Agricultural Economics Department at the University of Nairobi continued, and involved a study of the economics of commercial ranching in Kajiado and the impacts of subdivision on household food security in the wildlife dispersal areas round Amboseli National Park. This work was designed to complement other socio-economic and ecological work being carried out in the same area, and was aimed at providing more detailed information for parameterizing the socio-economic model. Some details on the surveys are presented below.

The field research here has focused on the issue of how pastoral welfare, livestock production and human-wildlife interactions are impacted by larger-scale political economic changes in pastoral land use patterns. The research efforts revolve around the following three core questions:

1. What are current Maasai land use patterns across a gradient of ecological and human induced infrastructural heterogeneity?
2. How is the traditional strategy of pastoral mobility modified within the constraints imposed by current land tenure arrangements and household level choices of economic strategies?
3. What is the relationship between levels of pastoral welfare and the quantity/quality of human-wildlife interactions and Maasai land use patterns as reflected in economic strategies/spatial land use?
   a) What are the economic strategies of Maasai households across different regions of the study area? To what extent are economic intensification and diversification occurring, and is there a spatial component to these economic strategies within the Amboseli basin ?
   b) What are the implications for Maasai productive strategies at the household level?
   c) Do these processes have implications for human-wildlife interactions within the Amboseli region?

Data Gathering and Data Synthesis Activities:

- Intensive multiple-entry interviews with a core group of sampled households
- Documentation of grazing Orbits for intensively interviewed core households
- Large Scale survey of households across the study areas
- Large Scale Settlement Survey of households- identification of economic strategies-spatial scale of resource use
- Development of a Land Use Typology and Landscape Heterogeneity index
- Anthropometric survey and diet composition questionnaire

Six study areas have been chosen as focus areas for the study. As well as falling along a climatic/vegetation gradient, these study areas represent a range of land tenure types, levels of market access and available combinations of resource/economic infrastructure- all variables that interact to affect the land use strategies pursued by pastoralists within the wider Amboseli study area.

Intensive Interviews with Households:

Survey data on Maasai economic and production strategies is being gathered at two scales. A core group of 38 Maasai households was randomly selected across the six study areas. These households are being interviewed at three separate time periods. The goal of the first interview is to establish the range of economic and productive activities with which each household member is involved, to identify the range of interactions households have with wildlife (both economically and productively), as well as to begin a process of documenting the timing of household interactions with the market and grazing movements of a household's livestock. This information is linked directly to the larger research questions, i.e.; to both identify spatially what processes of diversification and/or intensification of pastoral strategies are taking place, as well as to highlight the combinations of resources (infrastructural, natural, or household specific (i.e. labor/wealth)) which push households down one economic path vs. another.

Grazing Orbits:

An additional core research question asks if there are gains and losses in scale of resource use associated with choices of economic strategies (agropastoralism) and/or land tenure arrangements (i.e. subdivision). In order to address this question, the daily grazing movements of the core 38 households are being documented at three different time periods (long dry, short rainy and short-dry seasons). Initially we documented the 1999-2000 grazing movements of household animals verbally in interviews. As well, we have followed the herds of these households from sun-up to sun-down during the previous long dry season using a handheld GPS unit. Additional data being gathered concurrently includes vegetation type and herd behavior observations. Grazing Orbit Data include: grazing day type, herd owner, herd composition, vegetation cover, herd behavior.

For analysis purposes the data will be placed into a GIS format. Combined with oral accounts of grazing movements, analysis of grazing orbits will allow us to quantify both seasonal livestock movements and "scale" of resource use for a variety of household types across different land use areas within the larger Amboseli study zone.

Survey Development- Generalized Land Use/Economic Survey:

A large-scale land use/economic survey is scheduled to be carried out across the six Amboseli study sites. Approximately 120 households across the six study areas will be interviewed by six enumerators employed and trained in the field. The function of this survey is twofold: 1) to contextualize the data gained through the intensive interviews with households across multiple seasons, and 2) to contribute additional data to the formation of a "land use typology" across the study area.

The basic methodology is based on the use of cluster analysis for identifying categories of pastoral land use. The importance of the cluster analysis is to come up with homogenous households that are engaged in similar economic activities. In the Amboseli study area, we will use data from the large scale surveys of households (n=120) in order to identify clusters of homogeneous pastoral households across the study areas (i.e. households that are similar to each other based on a cluster of specific land use and economic variables).

Large Scale Settlement Survey of households:

Detailed information on settlement locations, spatial patterning of land use types (agriculture and livestock settlement locations) and economic strategies of individuals within households (i.e. type of diversification activities) has been gathered for each settlement within the six study areas. This data will provide contextual information on overall economic patterns and land use types at the large scale- i.e. that of each study zone. Combined with data from the Generalized economic/land use survey, the settlement data will provide the basis for development of both "a land use typology" for the study area, as well as contribute to the formulation of the landscape heterogeneity index (described below).

Development of a Land Use Typology and Landscape Heterogeneity Index:

One of the central questions motivating this study is to identify what are "current Maasai land use patterns across a gradient of ecological and human induced infrastructural heterogeneity". Four types of data gathered so far are contributing to the resolution of this question.

1. Basic GPS data documenting human infrastructure types
2. Large- Scale Settlement Survey of Households
3. Generalized Land Use/Economic Survey
4. NDVI imagery

There are two goals for the development of a "typology of land use strategies" for the Amboseli study area; 1) to describe the resource landscape available for pastoralists, and 2) to categorize the land use choices (economic and spatial, i.e. diversification and intensification) being made by pastoralists within the various constellations of available resources across the system. Number two will be accomplished using survey data and cluster analysis from the general land use/economic survey to define land use categories. The first component- "description of the resource landscape" will be based on the development of a heterogeneity/complexity index. This index will be a combined function of both ecological and human-induced infrastructural heterogeneity of particular areas. NDVI values will be as a basis for quantifying the ecological heterogeneity of the system, while a distance function developed in an ARCVIEW GIS database will represent human-induced complexity in the system. The index will be used to answer the following questions:

1) What ecological and human infrastructural heterogeneity currently exists for pastoralists within and across the study areas?
2) Given the above described "existing complexity in the system", and using spatial data from grazing orbits and cluster analysis, are pastoralists organizing their production strategies and/or economic strategies in order to increase their access to ecological and human infrastructural heterogeneity within the Amboseli system?

Anthropometry and Diet Intake (Galvin):

Anthropometric measures of nutritional status were taken on almost 1000 Maasai during May and June 2000 and within each of the six study areas. In addition a number of diet intake surveys were conducted in June and July 2000 for Maasai women and their children.

The nutritional status information and the household diet data provide information on human economic status and human welfare under current circumstances. This information will be used in the PHEWS modeling system to project the effect of changes in policy, management, economic or ecological conditions. For example, if policy or management decisions are contemplated that suggest an increase or decrease in the flow of income or food energy, we can, based on the current notional status indicators, suggest the impact of these decisions on human welfare and food security.

In addition, data on current notional status provides a baseline measure for monitoring of human welfare changes. Monitoring provides a means of measuring the impact of policy or man agent changes, resulting either from IMAS recommendations or other considerations.

Animal Disease Assessment in Kajiado (DeMartini, Grootenhuis, Rwambo)

A disease risk assessment was conducted using a participatory rapid appraisal (PRA) approach. The team first visited Dr. Kamaru, District Veterinary Officer in Kajiado who cited enhanced livestock disease control problems because of the drought, including FMD, CBPP, and ECF due to lack of adequate tick control. Transboundry issues (Kenya-Tanzania) relating to animal movement and disease introduction were also mentioned. The team then visited the directors and several households in three group ranches that surround Amboseli National Park, including Eselenkei, Mbirikani, and Lolarash Group Ranches. We developed a set of questions relating to livestock mortality and causes of ill-health by age class in cattle, sheep and goats. They also inquired about traditional knowledge of sources of diseases from wildlife interactions, particularly malignant catarrhal fever transmission from calving wildebeest. Several diseases consistently were cited as among the 5 most important problems including East Coast fever and other tick- borne diseases, malignant catarrhal fever, contagious bovine pleuropneumonia, foot and mouth disease, and anthrax. Mortality among calves was surprisingly high, often over 50%. The team also visited the Veterinary Officer in Loitokitok, Dr. Luge Mwamodo, who was very helpful in translating Maasai names for these diseases into English. Future development and application of the disease model was considered, and a timeframe was planned for completion of the rinderpest and ECF components and the input and output parameters for the general disease model.

<u>IMAS Modeling and Model Development</u>

IMAS Software Development (Boone)

An initial version of a graphical user interface called SavView was completed, constructed for use with SAVANNA. The SAVANNA modeling system is powerful, but its use requires understanding some 50 parameter files and how the system references them. SavView eliminates the need for that expert knowledge to conduct experiments (but applying SAVANNA to a new area still requires expert knowledge). The interface includes three main sections. The first is a parameters section that allows users to change parameters to address a given management question. Users can change: livestock and wildlife population parameters; rainfall to represent droughts or changes in the distribution of rainfall throughout the year; population rates-of-change, such as juvenile livestock survival; human populations and growth rates; cultivation parameters; restrictions on grazing; and changes in water supplies. The second section of SavView is used to plot trends over time for plant biomass, nitrogen balances, livestock and wildlife populations, rainfall, etc. The third section allows users to map ecosystem changes through time, such as changes in: plant biomass, offtake by herbivores, animal populations, cultivation, etc. Up to a year of maps may be displayed for any one variable, or four independent variables may be mapped for the same time period, allowing for detailed comparisons of results.

SavView was written to be flexible, so that the interface can be adapted to new areas with little of the interface requiring changes. A comprehensive on-line manual describing some details of the SAVANNA model and the use of SMS (an older user interface for SAVANNA) and SavView is available (Boone 2000). In addition, a streamlined version of the manual containing the information about SAVANNA, SMS, and SavView that would be of interest to an end-user of the ecosystem modeling component of IMAS was compiled (Boone and Coughenour 2000). While conducting workshops in Tanzania and Kenya, 35 paper copies of each of these volumes were distributed to participants. The participants in the workshops found SavView to be an intuitive interface, with attendees able to view SAVANNA output with little training.

The SAVANNA modeling system was adapted for use in Kajiado District, Kenya. Weather stations are too sparse in Kajiado to be certain that the algorithms in SAVANNA could smooth rainfall fairly without further input. SAVANNA was adapted slightly to use a series of 12 NDVI images representing vegetation greenness from space, in smoothing rainfall. Another modification was made because in Kajiado herbivore populations make use of specific types of water sources, with some being used only by livestock, some only by humans, and many used by livestock and humans. Allowing wildlife to use these water sources would be inappropriate. SAVANNA was therefore modified to allow the use of multiple distance-to-water maps for a given season, with each herbivore assigned an appropriate map.

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

A risk based biased mixing model reflecting the probability of transmission of malignant catarrhal fever (MCF) virus from wildebeest calves to adult cattle was completed and demonstrated to stakeholders. At the heart of the model are the SEIR equations, which track quantitatively proportions of animals that are Susceptible, Exposed, Infected, and Removed. The SAVANNA model provides cell-based maps of the distributions of wildebeest and cattle populations for each week during a 15 year simulation. The densities of wildebeest and cattle were combined in the SEIR equations with parameters representing the proximity of cattle to wildebeest within each cell, the infectiousness of the MCF virus, and the rate of spread of the virus for each month. The model generated estimates of the numbers of cattle infected by the MCF virus each week.

Several attributes made modeling MCF relatively straightforward. The spread of MCF virus is from wildebeest to cattle, and cattle do not infect other wildlife. Therefore other wildlife populations were not considered in the MCF model. Further, essentially all cattle with MCF die, and the cattle do not shed the virus, making the movement of cattle after infection unimportant in disease spread. The rinderpest disease model we have created is, in contrast, more complex.

Rinderpest can occur in East Africa in two general forms, a severe form causing outbreaks such as that of the 1890s, causing high mortality among herbivores, and a mild form that appears endemic in parts of Kenya and perhaps in Tanzania as well (S. Tempia, Terra Nouva, pers. comm.). An outbreak of the severe form of rinderpest has not occurred in northern Tanzania for many years, but rinderpest continues to be listed as an disease of major concern (Rwambo et al. 1999), because of its devastating affect.

Rinderpest modeling is more complex than that for MCF because the rinderpest virus may spread from cattle to other herbivore species, some cattle infected with rinderpest will survive, and infected cattle may spread the disease to other cattle. To include the influence of movements of cattle in our model, we adopted a division of NCA that had been used previously in aerial surveys, which delineated 16 blocks within the area. Five matrices, representing transitions between five seasons of the year (e.g., early wet to wet, wet to transition, transition to dry), were created that show the proportion of cattle moving from each block to other blocks in that time period. Thus these transition matrices tracked proportional movements of cattle across the NCA. We used somewhat modified SEIR equations in each block, estimating the number of cattle infected by rinderpest and the growth of the disease within the block. Also at each time-step we calculated how many infected animals moved into each block, with higher rates of immigration of infected animals increasing the likelihood of a rinderpest outbreak. Thus if there is a rinderpest outbreak in a block with a resident population of cattle, the disease is unlikely to spread to other blocks (disregarding for a moment movements of migratory animals that might be infected). In contrast, if an outbreak occurs in a block frequently visited by pastoralists and their animals, the outbreak could easily spread across NCA. The IMAS rinderpest model describes the waxing and waning of infection in each block realistically, and also the spread of the disease across NCA.

Ecosystem Modeling (Boone)

Modifications to the SAVANNA modeling system application to Ngorongoro Conservation Area were completed early in the year, such as increasing biomass and including more herbivore functional groups. These modifications yielded a finalized model, pending the input from experts in East African ecology and local stakeholders. The final model for NCA, the SAVANNA modeling system, and the SavView graphical user interface were written to a CD for distribution. A suite of 16 experiments related to those in Rainy et al. (1999) were repeated with the finalized model, addressing effects of: 1) drought and the redistribution of rainfall through the year, 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. Computer files were created that allow each of the 16 experiments to be viewed in SavView, described above, and the entire collection was written to a CD for distribution. Lastly, about 350 pages of training material were prepared (Boone 2000; Boone and Coughenour 2000) for use in workshops. Our training efforts are described elsewhere, but during that training model results were closely reviewed by two dozen resident experts and stakeholders, with positive feedback. Thus the SAVANNA application for Ngorongoro has not been modified further, excluding modifications made to join SAVANNA with the PHEWS model created by Thornton and Galvin, described elsewhere in this report.

A draft application of the SAVANNA modeling system to southern and central Kajiado District, Kenya, is complete. The GIS layers required to apply SAVANNA were created primarily based upon information available from ILRI. Digitized contours were used by ILRI to create a detailed digital elevation model, yielding elevation, slope, and aspect. Vegetation mapping by F. Atieno (Atieno 2000) was combined with multivariate statistical methods to extrapolate vegetation cover across the Kajiado study area. Available soils GIS layers were merged to yield a final map. A list of water points provided to ILRI were used to generate draft distance-to-water maps. Lastly, herbivore force maps were based upon input provided from J. Worden and others.

The SAVANNA application to Kajiado includes seven plant functional groups (palatable grasses, palatable forbs, unpalatable herbs, swamps, palatable and unpalatable shrubs, and deciduous woods). Eleven animal groups are represented, including three livestock groups (cattle, goats, and sheep) and eight groups of wildlife (wildebeest, zebra, buffalo, grazing antelope, browsing antelope, giraffes, warthog, and elephants). Plant modeling was guided by information provided by Atieno from his fieldwork (Atieno 2000), by Bekure et al. (1991), and other sources. Herbivore modeling was guided by aerial survey data provided by the Department of Resource Surveys and Remote Sensing, Kenya and processed by M. Waweru, by de Leeuw et al. (1998), and other sources. DRSRS information provided to CSU by M. Waweru also included shrub and tree cover estimates, which we used in modeling. We are conducting experiments with the Kajiado application of SAVANNA exploring the effects of: fragmenting ownership patterns (e.g., placing group ranches) and its effects upon livestock populations and vigor; the effects of encroachment or fencing of Amboseli National Park on wildlife populations; and the removal of swamps as a source of dry-season forage for livestock and wildlife.

Socioeconomic Modeling: Pastoral Household and Economic Welfare Simulator Model - PHEWS (P. Thornton, K. Galvin)

PHEWS, the socio-economic household model for Ngorongoro Conservation Area, has been completed and tested, and is fully integrated within the Savanna Modeling System. A set of scenarios was drawn up, that PHEWS and Savanna together would be used to investigate, and these were run and analyzed. PHEWS was also to be adapted for Kajiado in Kenya (the second project site), a much more market-orientated production system. Work has progressed on this, primarily the fieldwork needed to parameterize the model (see section below on Field Research).

Early in the project perhaps the major design criterion to be elucidated for the development of this model was that a rule-based approach should be used. Two factors in particular influenced this decision: the low level of market integration in NCA, meaning that standard economic models were unlikely to be appropriate, and the recent building and testing of simple, top-down models that seemed to offer substantial benefits with respect to the simplicity of the model processes and relatively short development time, while still providing useful information to the modeler and other users.
The general modeling approach taken is thus 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 reasonable behavior of the model is obtained.

We hypothesized that there is a quantity T of Total Livestock Units per person that characterizes pastoral systems. While it is not immediately clear what this value of T is, the idea is that T increases to levels at which the operator becomes a commercial beef rancher, and it decreases to the point where agro-pastoralism commences (and at 0 it defines agriculture). The rules in the household model reflect the management decisions that are taken to aim at this target TLU per person, which may vary with wealth levels. If there are excess animals, these can be sold for cash. If there is a deficit, then animals can be bought, if there are resources to do so.

We also hypothesized a hierarchy of goals at the household level. First, the household has to meet its food requirement. If there is a shortfall, then this is made up by recourse to various options, including the selling of an animal, if necessary. Second, the household is assumed to manage for T in terms of investment and disinvestment decisions -- these types of livestock purchases and sales can be considered different to the meeting of household food requirements. Third, there is discretionary consumption; after the first two goals have been dealt with, with consequent impacts on the cash reserves (purchase of food, for example), there may be a certain amount of cash left over for spending on various items.

Considerable field work had been undertaken in NCA, planned in part to generate information with which to test these hypotheses within a simple model framework. Once tested and applied in NCA, the plan was to use the same basic structure for the Kenyan case study area, Kajiado, using data collected from surveys and existing secondary sources.

One of the very attractive features of the Savanna Modeling System (SMS) is the ability to map outputs spatially, and to be able to assess how spatial outputs change over time as well. A set of socio-economic outputs from PHEWS has been defined, and these are output to the mapping file that can then be accessed by SMS for mapping. These spatial output variables are shown in Table 1. Modeled households are located in the landscape of NCA in a random fashion, depending on an underlying probability map for household location (Boone and Coughenour, 2000). Spatial variation arises because of two factors: differences in household density per pixel, and differences in the relative preponderance of rich, medium and poor households in NCA. Given data shortages, we hypothesized, following Smith (1999) and Lynn (2000), that NCA could be divided up into three distinct areas, based essentially on elevation: lowlands, midlands and highlands. It has been observed (Lynn, 2000) that the relative occurrence of poor, medium and rich households in each of these areas is different, although detailed data on these changes are not yet available. We thus hypothesized a set of relative household occurrences based on the following:

- We classified 73% of the pixels in NCA as lowlands, 9% as midlands, and 18% as highlands;
- The weighted average of household type needed to match the typical household;
- Estimates were based on observations in the field.

As a result, we estimated that:
In the lowlands, 39% of households are poor, 40% medium, and 21% rich.
In the midlands, 29% of households are poor, 44% are medium, and 27% are rich.
In the highlands, 22% of households are poor, 38% are medium, and 40% are rich.

In mapping output from PHEWS, output variables are weighted per pixel using these relative household occurrences, depending on where the pixel lies (lowlands, midlands or highlands).

Overview of Results:

The activities of this modeling effort concentrated on two of the case study regions: Ngorongoro Conservation Area (NCA), northern Tanzania, and Kajiado District, southern Kenya, areas with very different specific problems but that share common problems relating to pastoralism, wildlife conservation, and agriculture. A socio-economic household-level model was constructed and calibrated for NCA, and a range of scenarios were simulated. The model, named PHEWS (Pastoral Household and Economic Welfare Simulator Model) produced results to show that all households depend on outside sources of calories. Pastoralist welfare in NCA, even with small amounts of agriculture allowed, is not internally sustainable at current human population levels. If realistic population growth rates are imposed for the next 15 years, then the household food security situation deteriorates markedly. The model suggests that the introduction of agriculture in 1991 in NCA occurred at a time to make a substantial improvement in householders' welfare, by reducing the dependence on "outside" grain at a time of rapid population growth. By the late 1990s, these welfare gains would have been overtaken by human population growth rates in excess of 6% per year. From a household welfare perspective, banning agriculture is not an option: poor households would be dependent for nearly one quarter of their calories from gifts and relief. Doubling the area of agriculture per household was shown to have a highly beneficial impact on the food security of poor and medium households. This doubling would still amount to only 0.6% of the land area of NCA. If pastoralists are to continue as part of the landscape of NCA, then allocating increased amounts of agricultural land seems an effective mechanism for improving household food security for the less well-off. The model shows that the NCA pastoralists are susceptible to drought; in the immediate term, household food security is severely compromised, but there is also the longer-term impact on livestock numbers, where livestock numbers have to be built up in the aftermath of drought. The model also indicates that various productivity-increasing interventions can have beneficial impacts on household welfare.

Results from a Scenario analysis - The NCA Control Model:

Boone and Coughenour (2000) describe the control model, the idea of which is to model Ngorongoro as it is now. The control model was used to calibrate the PHEWS module. Ecologically, the outputs of the control model are quite stable: animal populations rise and fall annually and in response to longer-term weather patterns of below-average and above-average rainfall, but basically the system is relatively stable. For calibrating PHEWS, the object was to end up with similar stability in terms of household welfare and household herd numbers. The control run was thus undertaken with no population increase imposed, and with the values of a number of other inputs.

Summary results for the NCA control run are tabulated in Table 2. The first six rows of the table show the total percentage makeup of diet for the three household types.

The data of Smith (1999) and others show clearly that the diets of the Maasai in NCA do not vary much depending on household wealth. Assuming that gifts/relief (the portion of the diet that cannot be produced by the household from animals or crops, and that cannot be bought with cash) are in milk, then the dietary figures from the control run indicate that NCA diets are made up of about 12% meat, 29% milk, and 56% grain, which accords well with the approximate 10:30:60 proportions for meat, milk and grain that other researchers have found (Homewood and Rogers 1991; Bekure et al 1991). A major indicator of household welfare lies in the percentage of gifts or relief. As might be expected, this changes sharply, depending on household wealth, from 13% of all dietary energy in poor households to zero for rich households. The problems that poor and medium households have are not surprising, given that these households have 1.07 and 1.65 TLUs per Adult Equivalent, on average. Even the rich households have only 4.40 TLUs per AE, which is well below the threshold of 6-8 that is often cited as a necessary requirement for sustainable pastoralism (Dahl and Hjort, 1976; Galvin et al., 2001).

The need for poor households to receive gifts or relief is highly seasonal, as might be expected. Results for the average monthly relief figures for poor and medium households indicated that such households are clearly at serious risk of food insecurity during certain months, when the household’s own resources can provide 60% or less of the energy requirements of the household members. Interestingly, there was an interaction between the time when households are most affected and household type. Poor households were, on average, particularly badly affected in December, January and February, while medium households were more affected in August, November and December. Medium households had larger herds and more area in crops compared with poor households, but they had more people than poor households (about 12 Adult Equivalents compared with 7) and thus greatly increased monthly caloric requirements.

The results also highlighted differences in income and cash used to buy food by household type (these are totals over the 15 years of the simulation run). The average size of the cash box per month is shown in row 9. The standard deviation of these figures by household type showsedhuge variability; for poor and medium households alike, the CV is close to 100%, again underlining the vulnerability of such households to cash shortages and thus to food shortages as well. Again, as might be expected, the results show edthat the richer the household, the greater the percentage of food available from the household’s own resources, although even rich households were dependent for 40% of their calories on outside sources.

It must be remembered that these results apply in a reasonably steady-state situation. Assuming that the calorie transfers via gifts and relief are actually occurring, then the control run describes a reasonably stable situation. The results for evolution of household herd sizes for rich households demonstrated substantial seasonal variation, but the overall trends in livestock numbers per household are fairly flat. This is not surprising, given that total numbers are cyclical but stable (Boone and Coughenour, 2000) and that the number of households is constant. Similarly, if the two ratios, actual TLUs per Adult Equivalent and cash income per month per Adult Equivalent, or the two welfare ratios (these as a proportion of the household's desired numbers of TLUs and cash income), are plotted over time (data not shown), no trends were apparent for any of the household types. In a typical simulation year, poor households in the control run were selling two or three goats for cash; medium households are selling three goats and a steer for cash, while rich households were selling three or four steers during the year for cash.

As an example of the spatial output that can be produced using SMS, maps of model output were produced which showed that household density in NCA for the first four months of the control run. The maps were identical, as there is no population growth in the control run. In sum, the results from the control run for the household model showed reasonable stability over a 15-year period, but sustainability of households and household welfare for the less well-off are still dependent on gifts and/or food relief. All households depend on "outside" food calories, which have to be purchased.

Adult Equivalent for all household types was very low, and poorer households were very food- and cash-insecure. The control run shows clearly that pastoralist welfare in NCA, even with small amounts of agriculture allowed, is not even remotely internally sustainable at current human population levels. Even the basis for looking at a range of alternative scenarios, therefore, is of real concern. A range of other scenarios were run using Savanna and PHEWS. Details of the model can be found in a report by Galvin, Thornton and Mbogoh.

GIS Data, Analysis, and Modeling

ILRI GIS Team (R. Reid, Team Leader)

In 1999/2000, the ILRI-CRSP GIS and ecology research was subsumed into ILRI's new People, Livestock and Environment Programme. This team completed the following activities on the project. The contribution of the CRSP grant resources to this activity was 70%.

A GIS analysis of the impact of people on wildlife in Kajiado District was completed. The intention was to analyze the impacts of changes in land tenure on wildlife, but no land tenure data layer was available for this analysis. Instead, the team focused on the impacts of water development on the distribution and diversity of wildlife, comparing the semi-arid savanna in Kajiado to arid savannas in northern Kenya. In the arid savannas, human presence and livestock grazing and browsing excludes wildlife from within 5-10 km of waterpoints, effectively reducing the abundance and diversity of wildlife in the region. In Kajiado, where forage is more abundant, wildlife and livestock strongly intermix, with no exclusion of wildlife by livestock and people. We concluded that the impacts of water development is lower in wetter savannas, but that the strong intermixing of livestock and wildlife in these same savannas will lead to more frequent transmission of disease between livestock and wildlife, more people-wildlife conflicts and more side-by-side competition of livestock and wildlife for forage.

M. Waweru assisted F. Atieno to collect, manipulate and provide the spatial GIS coverages and rainfall data needed by R. Boone to develop the Kajiado application of the IMAS.

CSU GIS Team (Boone)

AVHRR satellite images of Normalized Difference Vegetation Indices that represent vegetation biomass were acquired from USGS sources for southwestern Kenya and northeastern Tanzania. These images cover the entire span of data collection for the satellite (ca. 1982 to the present) at a resolution of 7.6 km squares. More detailed images at 1 km resolution were acquired for the period 1992 to 1996. The suite of NDVI images are being compared to changes in detailed vegetation samples and herbivore populations within a database created and maintained by D. Western.

Satellite imagery was provided to ILRI for their use in mapping vegetation change. In turn, ILRI has provided to CSU a completed vegetation map for the Amboseli region, a digital elevation model for Kajiado, water points, soils, weather stations and associated data.

5. **Gender**

There are several females involved in the project, at all levels. This includes the co-PI (Galvin), a senior scientist (Magennis), a U.S. grad student (Burnsilver), our regional coordinator based in Naoribi (Reid), our site-coordinator for Tanzania (Moehlman), a PhD graduate student from Uganda (Acen), our graduate students funded on other projects, but working in Tanzania and contributing directly or indirectly to the CRSP work (Metzger, Lynn, Sommerville), and our technical trainee at ILRI/Nairobi is female (Margaret Waweru).

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 have 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.

6. **Policy**

Activities and Linkages

Mr. ole Kamurao, assistant to the Director, National Environment Secretariat in Kenya, assisted us greatly with policy linkages in 2000. His activities led to considerably heightened awareness within the Ministry of the IMAS project. This is demonstrated in the letter the Director, Mr. K'Omudho addressed to the PI in which he said:

"This is to inform you that we welcome the idea of working together in partnership during the implementation of the project. This is important for us because, National Environment Secretariat (NES) is charged with the responsibility of coordinating all environment issues in the country. Indeed NES coordinates several groups of stakeholders on various environmental issues in the country. The IMAS would clearly fall under our National Action Programme to Combat Desertification as well as National Biodiversity Strategy and Action Plan where issues on Savanna Ecosystem are addressed. We therefore, see IMAS as a tool that will facilitate realization of our national priorities as spelt out under the above two programmes among others. There is need therefore to establish a strong linkage between IMAS and these two programmes."

In Tanzania, we made our results available to a primary development agency working in Ngorongoro Conservation Area (DANIDA), who were quite interested in adopting the model and using to assess the impacts of development (C. Sorenson, pers. comm.). We also have worked with the Ngorongoro Conservation Area Authority personnel to adopt the information and the technology we have developed (V. Runyoro, pers. comm.). Most recently, the NCAA Conservator has expressed an interest in applying the IMAS to conduct further assessments of pastoral-wildlife interactions in NCAA (J. Ellis pers. comm. w. Mr. I. Chausi). We have also made the Tanzania National Parks Authority (TANAPA), and Tanzania Wildife Research Institute (TAWIRI) aware of our products, and both have expressed interest. A paper on the IMAS will be delivered to the !st TAWIRI Scientific Colloquium in Arusha in December. The Tanzania Ministry of Agriculture is also quite interested in the IMAS, is involved through Mpwapwa Research Station, and through training we have provided. All three of these organizations are influential in effecting policy in Tanzania.

The Kajiado Group Ranches: A Perspective (R.K. Davis)

A policy analysis paper was commissioned to R.K. Daviswhich presents a 30-year perspective on developments in group ranching in Kajiado District, Kenya (Davis 2000). Group ranching was initiated in Kaiiado District as early as 1962. The Land-Group Representatives Act of 1968 made it possible for the ranches to become organized entities able to accept loans and conduct a corporate business enterprise. The Land Adjudication Act of 1968 launched the process of conveying common and undivided land titles in the ranches to the members of the group, paving the way for a development program to convert the subsistence pastoralism on these ranches to commercial ranching. By 1980 group ranches covered some 75 per cent of the district. The project was hampered by failures of governmental assistance and execution, misused funds and investments, drought and high interest loans. As early as 1972 ranches began subdividing into individually owned plots. By 1990 nine ranches had been subdivided and title deeds issued. Another 31 ranches were somewhere in the process of subdivision and 11 ranches were either undecided or had decided against subdivision. Some flagrant attempts by elites with the collusion of officials to take group lands hastened the movement to subdivide. The group ranches were predicated on the premise that Kajiado land and cattle could be used more efficiently. One of the key considerations in economic efficiency concerns the control of resources by the more productive operators. If individual ranches are to be the dominant form of tenure in Kajiado and if there can be a free exchange of grazing resources as well as labor and livestock among the ranches, there may be a better prospect for improved efficiency of Kajiado cattle operations than existed with the group ranches. In this way the vision held for the group ranches will be realized by abandoning the group ranch concept. This would surely by the ultimate irony of the program. There are many variables in the equation determining the future of land, livestock and wildlife resources and human welfare in Kajiado. If the tourist economy were to recover its robustness and if ranchers had a full range of opportunities with wildlife, including cropping and tourist hunting, wildlife could become a dominant economic opportunity for a great many Kajiado landowners. Given the record of the past 30 years it is difficult not to be pessimistic about the changes taking place in the Kajiado livestock and wildlife economies. There are great uncertainties about the spread of fencing from shambas and small stock pasturage to wholesale areas, about subdivision and the spread of cultivation to submarginal areas, about wildlife becoming a commercial reality for the ranchers, about the government's ability to stem corruption, guarantee property rights and recover the Kenyan economy. With all this, the Maasai have proven their ability to survive hard times and to prosper in good times.

Policy Implications of Research in Ngorongoro, Tanzania (Lynn and Ellis)

Our research has demonstrated that conservation and development policy must be carefully crafted for application in multiple use areas like NCA, the Greater Amboseli Ecosystem and other places where wildlife conservation, livestock development and enhancement of human food security and welfare are all goals. Although there has been a lot of optimism for the future of community-based conservation, our results show that this optimism may be premature. We expect that optimization of multiple goals is not possible in most instances and either conservation values or human development will suffer if this multiple-optimizing viewpoint prevails. Rather policies and management of multiple use areas should seek compromises which can be accepted by the relevant stakeholders. At the NCA for example, it is becoming more and more obvious that current policies are not sustainable. Something must change, and it is likely that if NCA is to remain a multiple use area, then compromises in both conservation and in human expectations will be required. The conservator of the NCA has asked us to assist in planning for the future, by using GL-CRSP Savanna-IMAS assessments to help understand the possible effects of alternative policy and management directions. We see this as an excellent opportunity to pursue the ultimate goals of GL-CRSP, NREL and ILRI and will do our best to provide this requested assistance to the NCA.

7. **Outreach**

IMAS Training - Target: Potential End Users of the IMAS

IMAS, the SAVANNA modeling system, SavView, and our experiments were demonstrated to participants of two workshops, and others, during a six-week outreach effort. At a five-day workshop, coordinated by P. Moehlman, was held at the University College of Lands and Architectural Sciences within the University of Dar es Salaam, Tanzania. R. Boone trained 11 participants (Table 3) in IMAS goals, the SAVANNA modeling system, and how to conduct experiments. Each participant was provided with a copy of a manual that was used in training, plus a copy of a manual for use by those not needing to know the details of SAVANNA, a CD storing IMAS software, and a CD storing a suite of experiments addressing management questions. Following the week-long workshop, a presentation on IMAS and ecosystem modeling was presented at Mpwapwa, Tanzania, at the Livestock Production Research Institute. At Mpwapwa interest in IMAS was high, and Boone departed with Institute personnel running new experiments using IMAS software installed on their machines. Upon returning to Dar es Salaam, the IMAS software was installed on a computer of Dr. J.K.K. Msechu of the Ministry of Agriculture, and he was provided supporting materials. IMAS software was then installed on a computer GL-CRSP purchased which was placed in the Community Conservation Center, African Wildlife Foundation, Arusha, Tanzania. That installation is available to anyone interested in using IMAS to address potential management questions, and Allan Kajazi and Naima Abdallah of the African Wildlife Foundation attended the Dar es Salaam workshop, so people knowledgeable in IMAS are available for assistance. Boone then traveled to Ngorongoro Conservation Area, installed IMAS software on a computer made available through the DANIDA program, and presented IMAS to a group of seven scientists and managers.

In April, 2000, the ILRI GIS team hosted and helped organize the SAVANNA model training held at ILRI in Nairobi. Three to four ILRI technical and scientific staff participated in the training. Before this training session, M. Waweru, the ILRI-CRSP GIS analyst replacing O. Okello, traveled with the Randy Boone to Tanzania to learn how to demonstrate the SAVANNA model. M. Waweru replaced Okello as a lead trainer and demonstrator of the IMAS in East Africa.

The training workshop at ILRI, and was coordinated by M. Waweru and O. Onyango. The three- day workshop was attended by 15 scientists and managers (Table 4), with one traveling from Ethiopia to attend. Each was provided with the same IMAS materials as workshop participants in Dar es Salaam. In the workshop, Boone reviewed details of SAVANNA necessary to know to understand the general system, introduced the interface tools SMS and SavView, then reviewed the results of the 16 experiments from Ngorongoro Conservation Area. Discussions with workshop participants helped improve the Kajiado application as well.

Following the workshop, Boone, J. DeMartini, and J. Grootenhuis met with members of Terra Nouva to discuss use of disease modeling in their work with rinderpest, and J. Worden and Boone met with Dr. Jackson Wandera of the Semi Arid Rural Developement Programme to discuss their use of IMAS.

IMAS Demonstrations - Target: Interested Resource Management Agencies, Donors, and NGOs

After the Savanna training course, M. Waweru demonstrated the model's capabilities with M. Said at the Dept. of Resource Surveys and Remote Sensing in May, 2000. The demonstration was very well received and DRSRS expressed strong interest to continue working as part of the CRSP team to develop, apply and demonstrate the IMAS. R. Reid and P. Thornton also demonstrated the IMAS to collaborators and donors from the World Bank, USAID-REDSO, USAID-Global Bureau, USDA and KWS.

IMAS Installations - Target: End Users

The IMAS modeling system, including SAVANNA, is now installed in several computers at: 1) the University of Dar es Salaam, at computers at 2) the Mpwapwa Livestock Research Institute, 3) the Ministry of Agriculture, our central site at 4) the Community Conservation Centre, African Wildlife Foundation, Arusha, two computers in 5) Ngorongoro Conservation Area, and on several machines at the 6) International Livestock Research Institute. Additional installations are on personnel notebook computers of people working in East Africa, such as that of J. Grootenhuis.

Feedback Workshop in NCA - Target: Pastoralists and the NCAA

A Feedback Workshop was held by Angelo Mwilawa, Mohammed Maskini, and Victor Runyoro at the Ngorongoro Conservation Area. The workshop went on very well. Indeed the pastoralists were pleased as we informed them the outcome of the Mwilawa and Maskini field work, which involved assessments of range and livestock condition in various parts of the NCA. There was a good representation from pastorlists while the NCAA was represented by Victor Runyoro and otheres. Among other things the primary issues which come up from pastoralists and NCAA staff were as follows:

(1) The studies should be conducted for a longer period and should cover a larger area.

(2) There is a need for intensive range forage evaluation and possibly estimation of forage available for livestock and how livestock should be distributed overtime. We informed the group as to how the IMAS Model could be useful if they updated it with projected livestock numbers and boma locations. This would consider which species of wildlife are grazing in similar areas, and then with proper adjustments to the grazing and boma locations in the model, they will be able to determine what can be done.

(3) Participation of local pastoralists during field work was highly appreciated. Hence there was a need for proper training where possible of pastoralists in areas of range condition and livestock condition.

(4) Where possible NCAA should assist to provide water sources for livestock so that to reduce movement and concentration of livestock during dry season in search of water.

(5) Pastoralists would like to visit some other places to see what other others are doing in relation to conservation.

(6) What can be done to improve the livestock grazing areas?

(7) Participants in workshop showed a great appreciation for what IMAS has contributed and the efforts of the IMAS team in coming back to present results to the stakeholders.

Field Contacts in NCA - Target: Pastoral End Users and Stakeholders

Terry McCabe discussed the assessment and the model with potential users in the area north of the NCA. There are a number of NGO's working on land use issues and the managers of LOSADEI are particularly interested, if we are to continue and expand the project to the Loliondo area.

General Outreach - Target: Any Interested Parties.

The web site for the IMAS project: (http://nrel.colostate.edu/PROGRAMS/MIKEC/imas/) was updated, with a series of reports and abstracts now online.

8. **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.

<u>Contributions to U.S. Agriculture</u>

Wildlife-livestock Interactions

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 Division of 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 National Park. The model is being used to assess carrying capacity for wild horses, and interactions between wild horses and bighorn sheep in the Pryor Mountains, Montana. It is being used to assess interactions between the interests of a tourist based economy outside Rocky Mountain National park (town of Estes Park), and potential climate change effects on the park ecosystem.

Animal Disease Modeling

Epidemiologic modeling of tropical livestock/wildlife disease interactions benefits U.S. agriculture in at least two ways: 1) There is an 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.

<u>Contributions to Host Country</u>

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 per month beginning 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 partnership 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. Our 2 PhD students working in Kenya have been operating under the ILRI research umbrella, and have also been supported by ILRI in terms of the provision of office space and other research facilities. The two students are ILRI research scholars, in this respect.

9. **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 and Kenya, which aims to promote agricultural productivity while conserving natural resources. In Kenya, the mission has been previously involved in community-based conservation programs in the vicinity of our study area, in Kajiado District near Amboseli Park, exemplifying support for natural resource conservation. In Tanzania, the mission is supporting a “Heartlands” project with aims that are very compatible with the aims of our IMAS project. The Heartlands project is in largely pastoral areas, and it aims to ensure that natural resources are conserved while human welfare is increased through development. Both the Kenya and Tanzania missions are aware of our project, and to our knowledge, are supportive.

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 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.

10. **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, with fourth year no-cost extension.

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..

Climate Ecosystem Interaction on East Asian Steppes: Implications of Climate Change & Land Use Intensity. J. Ellis. PI. 200-2003. $469,000 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.

<u>Applications of the IMAS-CRSP Methodology (Indirect Contributions)</u>

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

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.

11. **Training**

<u>Competed:</u>
1. MSC. Fred Atieno. University of Nairobi, Range Science.
2. MSC. Mohammed Maskini. University of dar es Salaam. Range Science
3. MSC. John Mworia. University of Nairobi, Botany.
4. MSC. Stacy Lynn. Colorado State University, Range Science.
5. MSC. Nicole. Smith. Colorado State University, Anthropology.

<u>In progress:</u>
1. Postdoctoral Research Associate, Colorado State University - full support (Randy Boone)
2. PhD. candidate , Colorado State University - full support (Jeff Worden)
3. PhD. candidate , Colorado State University - partial support (Shauna Burnsilver)
4. PhD. candidate, Ugandan, at Colorado State University, Ecology - full support (Joyce Acen)
5. PhD. candidate, Colorado State University, partial support for field work only (Kris Metzger)
6. MSc. candidate. University of Nairobi, Range Science - partial support (Fred Atieno, under Prof. Njoka)
7. GIS/modeling trainee, ILRI - salary (Margaret Waweru)

<u>Short term</u>

IMAS Training-Courses

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

Visiting Scientists

Mohammed Maskini (Tanzania), Fred Atieno (Kenya), and P. ole Kamuaro (Kenya) visited CSU in March following the annual meeting in Mexico.

Technical training in SAVANNA - (training trainers)

Margaret Waweru (Kenya). Trained during visits by R. Boone to ILRI.

12. **Collaborating Personnel**

<u>USA</u>

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 Faculty Colorado 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

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

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

<u>Kenya</u>

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.

Rainy, Michael. Explore Mara Ltd., International Livestock Research Institute. Consultant.

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

Waweru, Margaret. Department of Resources, Surveys and Remote Sensing and International Livestock Research Institute.

Western, David. African Conservation Centre.

Tanzania

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

Maskini, Mohammed. Sokoine Univ.

Kidunda, Rashidi. 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

Runyoro, Victor. Ngorongoro Conservation Area Authority.

Uganda

Acen, Joyce. Graduate Student, Colorado State University.

13. **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

14. **Publications in 2000**

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, University of Nairobi).

Boone, R.B., K.A. Galvin, N.M. Smith and S.J. Lynn. 2000. Generalizing El Nino effects upon Maasai livestock using hierarchical clusters of vegetation patterns. Photogrammetric Engineering and Remote Sensing 66(6):737-744.

Boone, R.B., M.B. Coughenour, K.A.Galvin, and J.E. Ellis. Addressing management questions for Ngorongoro Conservation Area, Tanzania, Using the Savanna Modeling System. Submitted to Afric. J. Ecol.

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

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. (forthcoming in Climate Research 2001)

Galvin, K.A., J. Ellis, R.B. Boone, A.L. Magennis, N.M. Smith, S.J. Lynn and P.Thornton. Compatibility of pastoralism and conservation? A test case using integrated assessment in the Ngorongoro Conservation Area, Tanzania. In: Displacement, Forced Settlement and Conservation. D. Chatty, ed., Berghahn, Oxford. (forthcoming 2001).

Lynn S. 2000. Conservation policy and local ecology: effects on Maasai land-use patterns and human welfare in northern Tanzania. MS thesis, Department of Range and Ecosystem Science, Colorado State University, Fort Collins, Colorado, USA.

Maskini, M.S. 1999. Spatial and temporal grazing patterns of livestock ad herbivores and their impact on range condition in Ngorongoro Conservation Area.

Mworia, John, and J. Kinyamario. The impacts of land use changes on the soils and water balance in Kajiado.

Mworia, John, J. Kinyamario, K.Kiringe and M.Coughenour. Tree layer dynamics under different land uses and soils in a semiarid area of Kenya.

Smith N.M. 1999. Maasai household economy: a comparison between the Loliondo Game Controlled Area and the Ngorongoro Conservation Area, northern Tanzania. MA thesis, Department of Anthropology, Colorado State University, Fort Collins, Colorado, USA.

Thornton, P.K. and K.A. Galvin. Development of a socio-economics module for the SAVANNA model and its application to the Ngorongoro Conservation Area, Tanzania. (in prep; to be submitted to Agricultural Systems).

15. **Abstracts and Presentations in 2000**

Coughenour, M.B. and R. Boone. 2000. Integrated assessments and spatial-dynamic ecosystem modeling to assess development-biodiversity interactions in east Africa. Symposium: Human Development and Biodiversity Conservation in the Developing World: Finding a Balance in Concept and Practice.Ecological Society of America Annual Meetings, Snowbird, Utah.

Galvin, K.A. 1999 Integrated multidisciplinary human ecological research in anthropology. Invited paper presented at the public policy session on Anthropology and Multi-disciplinary Research at the annual meeting of the American Anthropological Association, November.

Galvin, K.A. 2000. Community based conservation: does it work? Invited paper presented at the Symposium, Human Development and Biodiversity Conservation in the Developing World: Finding a Balance in Concept and Practice at the Ecological Society of America annual meeting, Snowbird, Utah.

Galvin, K.A. 2000. Human/cultural dimensions of development and conservation issues. Invited paper presented at the Workshop, Sustainable Biodiversity in the International Arena, at the Ecological Society of America annual meeting, Snowbird, Utah.

Magennis, A.L. and K.A. Galvin. 2000 Growth patterns among Maasai pastoralists in northern Tanzania. Poster presented at the Human Biology Association meetings, April.

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, November.

16. **Comments**

The participants of the IMAS project sincerely wish to thank the GL-CRSP for its support during the last 3.5 years, and wish it good luck irrespective of our continued involvement.

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de Leeuw, J., H.H.T. Prins, E.C. Njuguna, M.Y. Said, and R.A. de By. 1998. Interpretation of DRSRS animal counts [1977-1997] in the rangeland districts of Kenya. Report from the International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands, and the Department of Resource Surveys and Remote Sensing, Nairobi, Kenya.

Galvin, K.A., P. Thornton, and S. Mbogoh. Integrated Modeling and Assessment for Balancing Food Security, Conservation and Ecosystem Integrity in East Africa (report prepared for GL-CRSP)

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

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Mworia, J., and J. Kinyamario. The impacts of land use changes on the soils and water balance in Kajiado. Report prepared for GL-CRSP.

Mworia, J., J. Kinyamario, K. Kiringe and M. Coughenour. Tree layer dynamics under different land uses and soils in a semiarid area of Kenya. Report prepared for GL-CRSP.

Rainy, J., E. Harris, M. Rainy, 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.

Smith N.M. (1999). Maasai household economy: a comparison between the Loliondo Game Controlled Area and the Ngorongoro Conservation Area, northern Tanzania. MA thesis, Department of Anthropology, Colorado State University, Fort Collins, Colorado, USA.

Thornton, P.K. and K.A. Galvin. Development of a socio-economics module for the SAVANNA model and its application to the Ngorongoro Conservation Area, Tanzania. (to be submitted to Agricultural Systems).

Table 1 List of output variables generated by PHEWS that can be graphed and mapped in the SMS

File	Variable	Temporal or Spatial Output
DIETP/M/R	· Household energy requirements, kcal · Milk consumed, proportion in diet · Maize consumed, proportion in diet · Meat consumed, proportion in diet · Sugar consumed, proportion in diet · Maize bought, proportion in diet · Relief consumed, proportion in diet	Temporal
HOUSP/M/R	· Cash reserves, Tz Sh · Own maize available, kg · Other crops available, kg · TLU welfare ratio · Cash welfare ratio · Actual TLUs · Adult Equivalents	Temporal
CASHP/M/R	· Cash reserves, Tz Sh · Net income, Tz Sh · Livestock purchase flag · Livestock sales flag · Crop sales, Tz Sh · Milk sales, Tz Sh · Other income, Tz Sh · Livestock sales, Tz Sh · Surplus milk sales, Tz Sh · Tea expenditure, Tz Sh · Livestock purchases, Tz Sh · General household item expenditure, Tz Sh · Maize purchases, Tz Sh	Temporal
ANIMP/M/R	· Cattle number in household herd · Percent female cattle in household herd · Percent adult cattle in household herd · Goat number in herd in household herd · Percent female goats in household herd · Percent adult goats in household herd · Sheep number in herd in household herd · Percent female sheep in household herd · Percent adult sheep in household herd	Temporal
IMAGE4	· Household density, number/km2*100 · Agriculture, ha/km2*10 · Net income, Tz Sh/1000 · Diet relief, % · Household maize availability, kg/km2 · TLU per Adult Equivalent, number*10 · Household's own food availability, % · Cash box, Tz Sh/1000 · Human population density, number/km2	Spatial & Temporal

Table 2. Summary output for the control run over 15 years for the three household types

	Poor	Medium	Rich
Total milk consumed (% in diet)	13.1	20.1	29.0
Total own grain consumed (% in diet)	16.2	12.5	17.1
Total meat consumed (% in diet)	11.8	11.9	11.5
Total other (incl sugar)(% in diet)	2.9	3.0	2.9
Total bought grain consumed (% in diet)	42.5	44.1	39.6
Total gifts/relief (% in diet)	13.4	8.4	0.0
Total income from selling (Tz Sh, 000)	498	686	2,826
Cash used to buy food (Tz Sh, 000)	1,098	1,951	2,108
Average cashbox per month (Tz Sh)	9,504	11,131	132,453
Cashbox sd per month (Tz Sh)	7,389	10,602	44,862
Own food available %	41.1	44.5	57.6
Average TLUs per Adult Equivalent	1.07	1.65	4.40

Table 3. Participants in an GL-CRSP IMAS workshop held April 3 - 7, 2000 at the University College of Lands and Architectural Studies, University of Dar es Salaam, Tanzania. The participants were trained in ecological modeling methods, and the use of IMAS modeling tools.

1.	Naima Abdallah	African Wildlife Foundation, Arusha, Tanzania
2.	Emmanuel Gereta	Tanzania National Parks, Arusha
3.	Allan Kijazi	African Wildlife Foundation, Arusha, Tanzania
4.	Nicephor Lesio	Njiro Wildlife Research Centre, Tanzania Wildlife Research Institute, Arusha
5.	Martin Loibooki	Tanzania National Parks, Arusha
6.	Anna Maembe	Tanzania National Environmental Management Council, Dar es Salaam
7.	Godwell Ole Meing'ataki	Tarangire National Park, Tanzania
8.	Angello Mwilawa	Livestock Production Research Institute, Mpwapwa, Tanzania
9.	Victor Runyoro	Ngorongoro Conservation Area Authority, Ngorongoro, Tanzania
10.	Pauli Sadiki	GeoInformation Centre, University College of Lands and Architectural Studies, Dar es Salaam, Tanzania
11.	Margaret Waweru	International Livestock Research Institute, Nairobi, and the Kenya Department of Resource Surveys and Remote Sensing, Nairobi, Kenya

Table 4. Participants in an GL-CRSP IMAS workshop held April 26 - 28, 2000 at the International Livestock Research Institute (ILRI), Nairobi, Kenya. The participants were trained in ecological modeling methods, and the use of IMAS modeling tools. M. Waweru participated in both workshops, in anticipation of her in-depth involvement in IMAS, but is not listed below to avoid duplication.

1.	Fred Atieno	ILRI
2.	Shauna BurnSilver	CSU and ILRI
3.	Giulia Conchedda	Ethiopia ILRI, Addis Ababa
4.	Lucy Gitau	Kenya Department of Resource Surveys and Remote Sensing, Nairobi, Kenya
5.	Russ Kruska	ILRI
6.	Andrew Muchiru	ILRI
7.	Wycliffe Mutero	Kenya Wildlife Service, Nairobi, Kenya
8.	Meshack Nyabenge	ILRI
9.	Wilber Ottichilo	International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands
10.	Judy Rainy	Bush Homes, Nairobi, Kenya
11.	Mike Rainy	Bush Homes, Nairobi, Kenya
12.	Robin Reid	ILRI
13.	Mohammed Said	Kenya Department of Resource Surveys and Remote Sensing, Nairobi, Kenya
14.	Cathy Wilson	ILRI
15.	Jeff Worden	CSU and ILRI