

**HEALTH FOR ANIMALS AND LIVELIHOOD IMPROVEMENT (HALI)  
IN THE RUNGWA-RUAHA ECOSYSTEM, TANZANIA**

**NARRATIVE SUMMARY**

The HALI project is a stakeholder-driven research and capacity-building program aimed at assessing the effects of zoonotic disease and water management on health and livelihoods in the Rungwa-Ruaha ecosystem, Tanzania. This biologically diverse and economically important region is seriously threatened by the seasonal drying of the Great Ruaha River. The primary drivers reducing flow in the Great Ruaha are uncontrolled agricultural water diversions that do not feed back into the river and intensive livestock grazing of wetlands. These processes have additive and interactive effects which have combined to cause the normally perennial Great Ruaha River to stop flowing and dry up for longer periods of time each year. We hypothesize that restricted water flow, degraded water quality, and increased interactions between livestock and wildlife species facilitate disease transmission and illness in livestock, wildlife, and people; reduced livestock productivity; and inadequacy of water for wildlife and hence reduced wildlife tourism potential. We have employed a stakeholder-driven participatory process to design an effective research and capacity-building program that will assess and mitigate zoonotic disease prevalence and the effects of water management on health and livelihoods. This project will serve as a model for other rural regions where water availability is diminishing and zoonotic diseases are important considerations due to high HIV/AIDS prevalence. Specifically our research will:

1. Determine the prevalence and transmission ecology of zoonotic diseases (diseases which can be passed between animals and people), including bovine tuberculosis, brucellosis, and water-borne pathogens among wildlife, livestock, and pastoral and agropastoral communities.

2. Assess the effects of water management and quality on the presence, abundance, and severity of disease.

3. Assess how water management and disease affect the health and economic livelihoods of agropastoral and pastoral communities.

4. Identify and recommend measures that will mitigate the effects of zoonotic diseases and water limitations on rural communities.

5. Strengthen the zoonotic disease education and research capacity of the Faculty of Veterinary Medicine at Sokoine University of Agriculture in Morogoro, Tanzania.

Results from this collaborative and participant-driven research program will inform management and policy to improve human, livestock, and wildlife health; facilitate economic development through improved livestock productivity and wildlife-based tourism; and strengthen local capacity to diagnose zoonotic disease problems and to design disease prevention programs.

This report covers the first three months (July-Sept. 2006) of the project. At our inception, we have focused on building the needed infrastructure in Ruaha (bush camp, solar electricity, transportation, communications, field laboratory, local working relationships, etc.) to implement the project activities, enhancing the structure of the HALI team, initiating the formal (one postdoctoral researcher and two Master's students) and informal training activities, and formalizing institutional relationships. There have been no changes to the research plan for the project. Overall, we are making satisfactory progress toward the original objectives in our plan, especially good progress given the short time frame since funding has been allocated (August 30, 2006).

## RESEARCH

**Overall Problem Model and Approach.** The HALI project addresses complex disease and natural resources issues using the “One Health” paradigm, stressing that the health of domestic animals, wildlife and people are inextricably linked to the ecosystem and natural resources on which all depend (Osofsky et al. 2005). Diseases that can be passed between animals and people may be a significant barrier to improving human, domestic, and wildlife health in the Rungwa-Ruaha ecosystem. The presence of disease in this ecosystem (Wilson 2003) and the potentially far-reaching consequences of disease at the human-livestock-wildlife interface have been recognized (Bengis et al. 2004), but the scale of the problem has not been assessed and solutions have not been developed.

For example, recent surveillance indicated that approximately 80% of cattle sampled in Usangu Game Reserve (UGR), adjacent to Ruaha National Park (RNP), were exposed to bovine tuberculosis (Iringa District Livestock Office, unpublished data). Interestingly, RNP sightings of buffalo (*Syncerus caffer*), a species sensitive to bovine tuberculosis (BTB), have declined by approximately 70% over the past 16 years, and they have shown a dramatic collapse in their local range (WCS unpublished data). Prevalence of BTB has not been assessed for wildlife in RNP, but BTB was recently discovered in multiple wildlife species in protected areas of northern Tanzania (Cleaveland et al. 2005). Thus its role in the observed buffalo decline needs further study. The combination of high BTB prevalence in livestock, lack of information in wildlife, and a large HIV/AIDS-infected local human population represents a potential human health disaster. Specifically in Tanzania, about 60% of the increase in the notification rates of human pulmonary tuberculosis during 1991-1993 and 1996-1998 were associated with HIV infection (Range et al. 2001).

In addition to direct health impacts, disease undermines the marketability of livestock through frequent quarantines and lowers productivity through morbidity and mortality, especially in drought years. Tanzania’s livestock production is exceptionally low, with meat production only 4%

of Sub-Saharan Africa, despite harboring Africa’s 3rd largest national herd. Per-capita calories from animal products are 18% lower than the rest of Sub-Saharan Africa and 73% lower than the rest of the world (Trends 2003). These numbers not only affect the local availability of protein (Demment et al. 2003; Neumann et al. 2003), but they also affect Tanzania’s development trajectory by undermining its ability to market its livestock products internationally. Poor livestock productivity due to disease also fuels the wild bushmeat trade, thereby impacting biodiversity and degrading wildlife tourism potential (Brashares et al. 2004).

**Water Management.** The costs of water disruption are significant and far-reaching. First, pastoralists that have traditionally used the Great Ruaha River to water livestock have been forced to find other sources. Water restriction has decreased the area available for grazing and increased the concentration of livestock using dwindling water sources. Pastoralists report that this process has increased disease transmission at water holes and has led to decreased forage quantity and quality. However, the effect of these factors on herd productivity has not been quantitatively assessed. Another major cost of river drying has been the loss of wildlife tourism potential, both for RNP and for the village-managed Lunda-Mkwambi Pilot Wildlife Management Area (LMPWMA). Tourism in this part of Tanzania is concentrated in the dry season, when wildlife is visible near perennial water. The spatial distribution of surface water has declined over 60%, leading to a comparable decline in high-potential area for tourism. This reduction in wildlife viewing area is particularly significant for village economies struggling to diversify their economic base beyond livestock and rice production (Walsh 2000).

**Interaction of Water and Disease.** Transmission of BTB and other diseases may increase with reduced water availability, as people, wildlife, and livestock are increasingly forced to share dwindling and lower quality water sources. In South Africa, buffalo herds with higher rates of bovine tuberculosis had increased sensitivity to drought and endoparasites and more rapid loss of body condition during the dry season (Caron et al. 2003). With the drying of the Great

Ruaha River, the spatial distribution of buffalo has declined nearly 33% in the GRR portion of the Park (WCS, Aerial buffalo count, 19-20 October 2004, unpublished data), compressing herds into a smaller area where potential for disease transmission is higher and forage competition is more severe. The risk of disease is likely to increase as water quality is diminished through increased fecal contamination and stagnation of the remaining dry season watering holes.

***Participatory Process to Define the Problems.***

United States Agency for International Development Sustainable Agriculture & Natural Resource Management Collaborative Research Support Programs (USAID-SANREM CRSP) planning funds were used to explore the problems and research needs surrounding large-scale linkages between agriculture and biodiversity in the Rungwa-Ruaha ecosystem. First, participatory pastoralist focus groups were organized to clarify the problems and check assumptions. Semi-structured interviews and male and female focus groups allowed community respondents to discuss the important issues and ensured that culturally-appropriate research and disease/development intervention methods would be proposed. The goals of the participatory process were to: 1) highlight the socio-economic circumstances of pastoralist and agropastoralist households; 2) identify the rough division of labor among men and women, and age classes, with respect to animal husbandry, water, and disease management; 3) explore pastoralists' perception of disease issues, their drivers, and what can be done to mitigate the effects of disease on livestock, livestock productivity, and human health; and 4) establish the extent to which risk-factors identified elsewhere in Tanzania are realized in the Rungwa-Ruaha ecosystem.

Our visits revealed that most pastoralists draw water directly from rivers or shallow wells, as they often live too far from developed water sources. Respondents also indicated they are sometimes forced to draw water from the same sources as livestock when usual water sources become dry. Perceptions about disease and actual disease risk may differ by gender; men make most livestock management decisions (including healthcare) and women attend to daily husbandry needs (milking,

calf management, tick removal). Accordingly, women may be important sentinels for recognizing livestock disease. Women may be exposed more frequently and be at higher risk for disease transmission because of their more regular and close contact with livestock (particularly cattle), and livestock products (mostly milk, meat, fat and occasionally blood). Additional information is detailed in our SANREM planning grant report (webpage link: <http://www.vetmed.ucdavis.edu/whc/sanrem.cfm>).

In order to strengthen institutional and local-level linkages, a two-day workshop on July 25-26, 2005, linked experts from University of California, Davis and Wildlife Conservation Society, Tanzania National Parks, the Iringa District Veterinary Office, and Sokoine University of Agriculture to local stakeholders, which included wildlife managers (specifically the natural resource management Association for the 19 villages in Lunda-Mkwambi pilot Wildlife Management Area; MBOMIPA), and local livestock extension officers. Small group and plenary sessions examined the potential for disease interactions to affect livestock population dynamics, livestock productivity, human livelihoods, human health, wildlife populations, and tourism possibilities.

Participants agreed that the highest priority diseases for study were pathogens that: 1) are impacted by water use issues, 2) may severely affect human health (especially individuals with HIV/AIDS), 3) adversely affect livestock health and productivity, and 4) threaten the persistence of endangered species. Specific disease agents adhering to these criteria included tuberculosis (human, bovine, and atypical strains), brucellosis, rabies, and water-borne bacteria and parasites.

An overwhelming consensus emerged from diverse stakeholders including pastoralists, multiple levels of government, non-profit organizations and academia: a significant proportion of the rural population in the Rungwa-Ruaha landscape is affected by water-related diseases, and these diseases are affecting health, agricultural productivity, food security, and biodiversity in the Rungwa-Ruaha ecosystem.

Considering the problems described above and the needs for research as defined through the local

community meetings and the stakeholder planning workshop, the HALI project seeks to:

- Assess the prevalence and transmission ecology of zoonotic diseases among wildlife, livestock, and pastoral and agropastoral communities. These research results will inform the design of disease prevention programs and management decisions.
- Assess the affects of water (river and other water bodies) management on the presence, abundance, and severity of disease impacts. These research results will be used to inform the development of water management strategies to improve the health of livestock and pastoral and agropastoral communities and the health of wildlife and the ecosystem.
- Assess how water management and disease affect the health and livelihoods of agropastoral and pastoral communities. The results of this research will provide estimates of the economic costs of disease-related water management decisions in order to support water management decisions that minimize disease and improve livelihoods.
- Identify and recommend measures that will mitigate the effects of zoonotic diseases and water limitations on rural communities.
- Strengthen the zoonotic disease education and research capacity of the Faculty of Veterinary Medicine at Sokoine University of Agriculture (SUA), Morogoro, Tanzania. This project will increase local capacity to investigate zoonotic diseases, respond to disease events, and develop disease prevention programs.

Implementation involves sampling and testing domestic animals and wildlife, sampling and testing water, data analysis, epidemiological modeling and analyses, and impact assessments. During research activities efforts will be made to engage community stakeholders, local people, and policy-makers so that appropriate recommendations, interventions and training activities can be developed as results become available.

### **Activity One: Commencement of the HALI Project**

**Progress.** The objectives for this activity were to: 1) obtain proper research permits in Tanzania, 2) obtain an institutional Animal Care and Use Protocol at the University of California, Davis, 3) identify new Tanzanian students and project staff, and 4) relocate expatriate team members D. Clifford (postdoctoral researcher) and M. Clifford to Tanzania. A research proposal and permit application were submitted to both the Tanzanian Wildlife Research Institute (TAWIRI) and the Tanzania Commission for Science and Technology (COSTECH) by D. Clifford on 4 July 2006. Professors Kazwala and Kambarage from Sokoine University of Agriculture (SUA) sponsored Dr. Clifford's proposal. The Conservation Resource Centre (CRC) in Tanzania facilitated the permit application process through both government departments. The Tanzanian Wildlife Research Institute (TAWIRI) approved the HALI project research proposal on 28 September 2006. COSTECH approved the permit on 16 October 2006. The animal care and use protocol #12394 submitted by J. Mazet and D. Clifford to the University of California Davis, Animal Care and Use Committee on 12 July 2006 was approved on 24 August 2006. Two Tanzanian veterinarians, Julius John and Annette Kitambi have been selected by Dr. Kazwala to participate in the project and use the research as the bases for Masters degrees at Sokoine University of Agriculture. Hildegard Aloyce has also been hired as the primary research assistant. It is our hope to transition the management of the HALI project to complete Tanzanian management in the long-term. Unfortunately, because of the remoteness of the study site, severe living conditions, extremely tight timeline (only 2.25 year project), and lack of trained Tanzanians in zoonoses of wildlife and livestock, we were not able to recruit Tanzanian leadership for the field portion of the project. This deficit in available scientists was recognized before support from the GL CRSP was solicited, and an expatriate field lead, Deana Clifford was identified. Our goal is for Dr. Clifford to collaborate with the faculty of Sokoine University of Agriculture and other team members to build the capacity necessary

for the project to transition to Tanzanian leadership both at the University (existing) and in the field (goal). Dr. Clifford and her husband M. Clifford arrived in Tanzania on 9 August 2006 to immediately begin this process, as well as rapid data collection.

**Activity Two: Preparation for implementation of zoonotic disease testing of livestock, water sources and wildlife**

**Activity Three: Preparation for implementation of the assessment of the impact of water management and disease on the health and livelihoods of agropastoral and pastoral communities**

**Progress.** The objectives for the first three months of this activity were to 1) finalize the selection of sampling sites and identify participating households for livestock disease sampling and socioeconomic work, 2) create the capability to run appropriate diagnostic tests for disease both in the field and at SUA, 3) to initiate sample collection for those samples for which the team already holds permits or for which none will be required, and 4) begin compiling a spatial model of livestock and wildlife distribution.

Drs. Peter Coppolillo and Deana Clifford began the selection of sampling sites on 18 August 2005. The HALI project will partner with a new “Community liaison” project of the Wildlife Conservation Society’s Rungwa-Ruaha Living Landscapes program (leveraged funds) to work with study villages for disease sampling and socioeconomic work (Activity 3). As part of this effort specific people in each of the villages will be linked with a HALI project team member (Mr. Ayubo Omari Msago) so that disease cases or outbreaks will be reported immediately.

During the first week of September 2006, Mr. Bakari Mbano met with officials from the village association responsible for managing the Lunda-Mkwambi wildlife management area (MBOMIPA) in order to obtain permission for the HALI project to collect samples from wildlife species legally-hunted in the region. The MBOMIPA association has approved our request and given HALI team members permission to train community game scouts in safe

collection of tissue samples from hunted wildlife. On 28 September 2006, Dr. Deana Clifford, Mike Clifford, and several Rungwa-Ruaha program staff members trained 18 MBOMIPA game scouts in safe tissue collection and storage. As part of their job, game scouts routinely handle blood and tissues from hunted animals. Our training served to educate the scouts about diseases they might contract from their job, and also gave scouts practical advice and supplies (latex gloves) so that they can lower their risk of contracting a zoonotic disease from the animals with which they work. As a result of this process, samples have been collected from impala, buffalo, and eland. Given the political sensitivities surrounding hunting of wildlife species in Tanzania, Mr. Mbano’s successful efforts on behalf of the HALI project are to be commended. Not only will these samples provide valuable data, but the training opportunity is an important step for helping to ensure the health of those working with hunted wildlife. It will also serve as the community’s first introduction to the HALI Project, which will serve to promote collaboration and transparency among hunters and the village-association (MBOMIPA) responsible for regulating hunting in the study area.

Drs. Clifford, Coppolillo, and Kazwala met with Dr. Vitarus Lyaruu from Tanzanian National Parks to discuss the possibility of collaborating on an upcoming planned capture of at least six buffalo inside Ruaha National Park. Given TANAPA’s expertise in wildlife capture, this collaborative disease surveillance effort on the wild species most likely to be infected with bovine tuberculosis is an exciting opportunity to sample live wild animals inside the park to try to determine if bovine tuberculosis is present within the park. HALI project assistance will likely enable more animals to be captured and more pathogens to be tested on samples collected. This capture will also serve as an opportunity to train veterinary students from SUA. It is anticipated the capture will occur in October or November of 2006.

Spatial data that is currently being compiled by HALI team members in the Community Liaison Program (A. Msago) are being used to help finalize sampling sites and identify participating villages and households. The output will be a finalized list of

sites for disease sampling in livestock, wildlife and water, and a list of participating households for the disease and socioeconomic work. This data will also contribute to the spatially explicit model of livestock density that will assess overlap with observed wildlife distributions. This aspect of the project will be supervised by P. Coppolillo with consultations from our team members from SUA, TANAPA and TAWIRI in regards to the wildlife distributions. The outputs from this model will preliminarily identify points of maximum disease transmission potential, based on pastoral household locations, water points and observed wildlife distributions. To ensure stakeholder involvement during project activities, D. Clifford will also be introduced to District, Division and Village Authorities. Completion of these activities is anticipated for early next year.

**Activity Four: Identify and recommend measures that will mitigate the effects of zoonotic diseases and water limitations on rural communities**

**Progress.** This activity will proceed after the data collection phase. All of the data collected will be used to assess the health and socio-economic impacts of disease in light of the larger watershed management and environmental concerns. The approach to research these relations will involve a spatial data analysis of the economic and environmental drivers of disease infection rates. Geo-referenced data from this study and from economic, environmental, and public health sources will be collected and used to develop an appropriate model framework for examining the socio-economic determinants of watershed health and disease in the Rungwa- Ruaha ecosystem. This analysis will provide data-based recommendations for mitigation measures to be implemented at all levels from animal husbandry to water policy.

We are currently seeking funding to support innovative outreach to effectively distribute our recommendations at the community level. We have the commitment from a world-renowned collaborator, Theatre for Africa, to develop community theater using local pastoralists and stakeholders as actors to boost the implementation of recommendations. Unfortunately, funding for this process has yet to

be identified. Similarly, given adequate funding, we plan to deliver strong natural resource policy recommendations using a quantitatively based model for disease assessment and for exploring different disease and water management scenarios using empirical data. Should we identify funding for additional years of the project, this modeling work will be completed to allow natural resource managers and policy makers to explore mitigation measures in a relative cost-benefit framework.

**Activity Five: Strengthen the zoonotic disease diagnostic capacity and educational capacity at Sokoine University of Agriculture, Tanzania**

**Progress.** As part of this long-term activity to strengthen the zoonotic disease diagnostic and educational capacity at SUA, our first short-term objective was to draft a memorandum of understanding between the University of California - Davis, Tanzanian Wildlife Conservation Society, and Sokoine University of Agriculture in order to facilitate the working relationship between the participant organizations for this project, another GL CRSP-funded project in progress (Avian Flu School, PI-Carol Cardona), as well as future expansion of research and capacity building activities. Principal HALI team members P. Coppolillo, D. Clifford and D. Bunn, R. Kazwala, and D. Kambarage met on 24 August 2006 at SUA in Morogoro, Tanzania, to discuss the framework for an agreement. A consensus from the meeting emerged to craft a broad MOU that would build on the strengths of all three organizations in zoonotic disease and animal health. Prof. Kambarage from SUA has prepared the first draft of the MOU. D. Bunn has drafted language for the UC Davis portion.

Additionally, D. Clifford, R. Kazwala, and M. Clifford have been meeting regularly to discuss project logistics, budgetary processes, and to identify potential students for the Masters in Preventive Veterinary Medicine Program (MPVM) at SUA. Two Tanzanian veterinarians, Dr. Julius John and Dr. Annette Kitambi, have been selected as MPVM students supported by the project. We are making satisfactory progress on both our capacity and educational objectives. All institutions are eagerly

moving towards a more formal collaborative structure for research and capacity building that has grown from our initial collaboration on the project.

### **GENDER**

Our commitment to gender diversity is evidenced by the composition of our team members. Female team members, Jonna Mazet (Lead-PI), Deana Clifford (TZ project coordinator/postdoctoral researcher), and Woutrina Miller (water-borne pathogens) from the University of California, Davis; Hellen Ngowi from Sokoine University of Agriculture; and Dee McAloose from the Wildlife Conservation Society, will bring senior expertise and mentorship to the project. To help address the paucity of female academicians in Tanzania, we have identified a promising female veterinarian, Annette Kitambi, to conduct MPVM research on this project. Additionally, we have employed a female field research assistant, Hildegard Aloyce, for the socioeconomic research in order to ensure our methods are gender appropriate and that accurate data reflecting gender differences are collected.

One of the most significant areas to be explored in the HALI project is the gender-related division of labor and their potential relationships to disease exposure, transmission and prevalence. Maasai, Barabaig, Sukuma and Gogo pastoralists are all present in the area, and gender roles vary significantly among these groups. Familiarization visits and informal interviews will complement survey work and allow more time to assess gender-segregated activities. Through these methods we will obtain a more detailed account of the gender differences in disease exposure within each ethnic group.

### **POLICY**

Results from the HALI project are anticipated to have direct relevance to policies in Tanzania regarding public and animal health, poverty alleviation, and natural resources. Tanzania's current Veterinary, Water and Wildlife Policies are being reviewed as part of initiating research activities, but no direct policy interventions occurred during the first three months of the HALI project. As part of establishing

the project and implementing our work, we will look for the opportunity to engage policy-makers and discuss the upcoming work. Additionally, we have been and will continue to regularly update the USAID Tanzania Mission as part of our efforts. Policy outreach is planned for the third year of the study once data have been evaluated.

### **OUTREACH**

Informal outreach activities will be facilitated through the local village-association (MBOMIPA) responsible for community-based land management, and other local NGOs such as the Southern Highlands Livestock Development Association (SHILDA) and the Rungwa-Ruaha Living Landscapes program of the Wildlife Conservation Society. We held a one-day informal training course for 18 MBOMIPA game scouts on how to safely process the carcasses of hunted wild animals. Training materials were developed by Prof. Kazwala from SUA and Deana Clifford. Game scouts were informed in Swahili by Rungwa-Ruaha program staff members about precautions they can take to reduce their occupational risk of disease exposure from hunted wildlife. The scouts were also taught how to record the location of a hunter-kill using hand-held Global Positioning System (GPS) units and how to take pictures of carcasses using digital cameras. Acquiring knowledge about health precautions and a basic skill set to monitor hunter-killed animals, has allowed the game scouts (most of which have only primary school education) to be active participants in health surveillance for hunter-killed wildlife. Data collected by the scouts regarding how many animals are hunted and where they are hunted will also be used by MBOMIPA to monitor its resident hunting program and plan future land management activities. Outreach to game scouts was conducted first, as these scouts may be at risk of contracting disease from wildlife during their normal working activities, and because the hunting season was already underway when HALI project team members arrived in the field.

The results of our disease testing and socioeconomic work will dictate the goals of future outreach activities at the local level. Optimally we will target activities at the most at-risk groups

identified by our research activities and use a combination of formal workshops, produced materials and informal visits to achieve outreach goals. We anticipate our outreach materials will be applicable to other regions facing similar health problems. As mentioned above, we are also currently seeking funding to support innovative outreach to effectively distribute our recommendations at the community level with our collaborator, Theatre for Africa. In the U.S., the project has been featured in outreach materials (newsletters) aimed at raising the awareness about the role of zoonotic diseases in health and economics.

### DEVELOPMENTAL IMPACT

**Environmental impact and relevance.** Diseases that can be shared by people, domestic animals, and wildlife are a challenge to biodiversity conservation and environmental sustainability. Diseases spread from domestic animals to wildlife can threaten the persistence of species through direct mortality or by making animals more vulnerable to predation or other environmental perturbation. Furthermore, disease contributes to livestock losses and poor productivity, which in turn contributes to the continuance of poaching wildlife for a source of protein. These conflicts are heightened in communities that border protected areas, as these rural communities are often poor, rely heavily on livestock keeping, have little access to health care, and often have little stake in the protected area itself. As community conservation initiatives increase in scope, complex disease issues that emerge at the interface of wildlife, domestic animals and people must be taken into account when planning land management strategies and ensuring access to natural resources for people and animals.

The HALI project is extremely relevant as it is one of the first projects to assess complex disease and natural resource issues at the wildlife-livestock-human interface. Information about the presence or absence of zoonotic diseases in wildlife, livestock, and their shared water sources will assist both Tanzanian National Parks and the neighboring community wildlife management area under the jurisdiction of MBOMIPA in managing their natural resources. These findings are not only applicable at

a local level but can be used to advise approaches for health in other community-based management systems in Africa. This need for health research at the wildlife-livestock interface has been identified as an important part of the South African Development Community's Biodiversity Conservation Strategy (SADC Biodiversity Support Program 2006). Additionally, findings from HALI will be used to improve the health of livestock and thereby reduce the need to poach wildlife for food security.

**Agricultural sustainability.** High stocking densities of livestock not only lead to environmental degradation through overgrazing of marginal habitats, but also enhance disease transmission thereby contributing to poor animal health. The HALI project hopes to promote sustainable agricultural practices by improving the health of livestock and promoting sustainable herd sizes. In addition, water policy recommendations emanating from the HALI project and collaborating efforts will provide data-rich models for evaluating livestock sustainability in areas where natural resource preservation practices may fuel conflicts at the livestock-wildlife interface.

**Biotechnology.** The HALI project uses advanced diagnostic methods in combination with locally-based field research to assess the ecosystem level effects of disease and water management on animals and people. As much of the disease diagnostic work as possible will be conducted in Tanzania using recent advances in field diagnostic kits, and by using modern disease diagnostic methods such as polymerase chain reaction (PCR) techniques at Sokoine University of Agriculture. Although logistically difficult at times, developing in-country capacity to conduct zoonotic disease testing will result in a more sustainable development program and enable Tanzanian universities, such as SUA, to address ongoing health problems more effectively.

**Contributions to U.S. agriculture.** Emerging zoonotic diseases are important in all regional contexts and in the global economic market. Understanding the issues of disease transmission among wildlife, livestock, and people is key to limiting agricultural and natural resource conflicts in the United States. One excellent example of how information from this project will benefit the U.S.

is the application to the current controversy in the Greater Yellowstone Area concerning potential brucellosis transmission from bison and elk to privately owned cattle surrounding the Park. Our data will be directly applicable to this issue, and the natural resource management recommendations will likely translate very easily. In addition, our data will contribute to the understanding of zoonotic disease morbidity and mortality in people with HIV/AIDS. Finally, our results will likely provide data on the implications of water resource management on disease and livelihoods in any rural community. This information can be used domestically, as well as in future international aid investments. In addition, U.S. researchers will benefit from the expertise of Tanzanian collaborators and the infusion of novel ideas and progressive zoonotic disease investigative approaches currently underway at SUA.

**Contributions to host country.** Tanzania will benefit most immediately through increased capacity for laboratory diagnosis of zoonotic diseases at SUA. Diagnostic equipment and supplies will be purchased and available for use because of the HALI project, and SUA's diagnostic laboratory capacity will be expanded by the per sample analytical funding. The collaborative relationships and technology transfer will expand the diagnostic services available and the ability for Tanzania to develop novel diagnostic and research methodologies. This collaboration has already made significant impacts in Tanzania. For example, prior to our implementation the Tanzanian government was unaware that PCR capabilities existed in Tanzania. Now SUA's diagnostic laboratory has been elevated in esteem from a university service to a regional resource for advanced diagnostics for diseases like avian influenza. Similarly, the Faculty of Veterinary Medicine will benefit from collaborative studies and the introduction to new research partners and methods. The funding of two students and their projects will, at the minimum, provide important research results from Tanzanians on issues that have local implications and international impact potential, and at the maximum, may also produce two new faculty members for the University.

On the broader scale, our findings should have direct relevance to poverty reduction strategies in Tanzania. Improving health and livestock

productivity, as well as optimally managing water resources, has country-wide benefits. If zoonotic disease transmission can be reduced, Tanzanian health and welfare will improve and associated costs decreased. Similarly, improved livestock health will result in increased productivity and income. Water management improvements could have significant impacts on the country for agricultural growth, as well as reduction of electricity losses currently prevalent in the dry season.

**Linkages and networking.** The HALI project is developing strong linkages with the USAID Tanzania Mission, as well as the Animal Health for the Environment and Development (AHEAD) initiative led by the Wildlife Conservation Society. By linking with other programs working with AHEAD, results from the HALI project can be disseminated to a global network of professionals involved in health and development work. HALI is also solidifying its linkages with Tanzanian National Parks, the Tanzanian Wildlife Research Institute and the Division of Wildlife so that project activities benefit the needs of these government agencies within Tanzania.

**Collaboration with international research centers (IARCS) and other CRSPs.** The pilot phase of the HALI Project was funded by the Sustainable Agriculture & Natural Resource Management (SANREM) CRSP and explored the problems and research needs surrounding large-scale linkages between agriculture and biodiversity in the Rungwa-Ruaha ecosystem.

We have been unsuccessful at engaging an IARC partner despite multiple attempts to do so. We are hopeful that our success on the ground will stimulate involvement from the International Livestock Research Institute (ILRI) in Nairobi, Kenya. Indications to date are that involvement has not been possible because of limited resources at ILRI rather than a lack of interest in the project. We also have begun exploring linkages with human health researchers in the public health sector; we are hopeful that these collaborations may also result in IARC partnerships. The community level disease assessments of the HALI project are also linked with another GL CRSP funded initiative focused on training people for Avian Flu Preparedness.

## OTHER CONTRIBUTIONS

**Support for free markets and broad-based economic growth.** As mentioned above, animal disease undermines the marketability of livestock locally and globally. Disease also limits agricultural development by lowering overall productivity (morbidity and mortality), especially in drought years. Similarly, the costs of water disruption are significant and far reaching. Water restriction has decreased the area available for grazing and increased the concentration of livestock using dwindling water sources. This process has also led to increased disease transmission and decreased forage quantity and quality. Tanzania's livestock production is exceptionally low, despite harboring Africa's 3rd largest national herd. Per-capita calories from animal products are substantially lower than the rest of Sub-Saharan Africa and drastically lower than the rest of the world (Trends 2003); therefore, improved productivity and trade outlets are likely to present opportunities for economic growth.

Poor livestock productivity due to disease also fuels the wild bushmeat trade, thereby impacting biodiversity and degrading wildlife tourism potential (Brashares et al. 2004). Wildlife tourism potential has also been impacted by river drying, both for RNP and for the village-managed Lunda-Mkwambi Pilot Wildlife Management Area (LMPWMA). Tourism in this part of Tanzania is concentrated in the dry season, when wildlife is visible near perennial water. The spatial distribution of surface water has declined over 60%, leading to a comparable decline in high-potential area for tourism. This reduction in wildlife viewing area is particularly significant for village economies struggling to diversify their economic base beyond livestock and rice production (Walsh 2000).

**Contributions to and compliance with Mission objectives.** The HALI project is well integrated with other USAID development efforts including the Tanzania Mission. The proposed activities are in line with the Mission's Environment and Natural Resources, Economic Growth, and HIV/AIDS Strategic Objectives designed to encourage livestock productivity, participatory landscape conservation, sustainable use of natural

resources, and wildlife health and wildlife-based tourism. The Mission was extremely supportive of this initiative and provided a strong letter of support that was submitted with the proposal.

**Concern for individuals.** The HALI project is focused on two key determinants of individual health and livelihoods, animal health and water availability. Knowing the extent to which zoonotic diseases are present in the livestock and water sources that rural people depend upon is an essential first step towards improving the health and livelihoods of individuals in this region of Tanzania. Additionally by better understanding the impact of animal disease and water availability on the lives of traditionally marginalized pastoralists and agro-pastoralists, we can raise awareness regarding their potential contributions to strategies for overcoming obstacles facing Tanzania's economic development.

Additionally, HALI places high importance on human capital, thus we are committed to training individuals both through academics and outreach. In our first three months of the project, we have trained 18 game scouts to reduce their occupational exposure to zoonotic diseases, and two Tanzanian veterinarians are starting their Master's degrees.

**Support for democracy.** The stakeholder-driven community-based approach of the HALI project will serve as an example of democratic process. Working with the local village-association and village-based governments to manage local resources and improve animal and public health through participatory planning will help to improve local governance.

**Humanitarian assistance.** Disease affects people's quality of life not only through direct mortality, but also through reduced productivity and therefore livelihood reductions. HIV and tuberculosis often effect people in their prime working years and together have a devastating impact on family stability. Our project seeks to maximize animal health and thereby reduce the transmission of chronic debilitating diseases such as tuberculosis and brucellosis from animals to people.

## LEVERAGED FUNDS AND LINKED PROJECTS

The total value for leveraged funds for the HALI project during 2006 was \$153,000. The sources of those funds were as follows:

*GL CRSP-USAID, Avian Influenza Response Instructor Training Program-Tanzania Pilot Program* with Carol Cardona as project PI, May 1, 2006-September 30, 2006, \$150,000.

*Wildlife Conservation Society-various private donations, Rungwa-Ruaha Living Landscapes Program* with Peter Coppolillo as project PI, 2003-ongoing, \$3,000.

## TRAINING

### *Degree*

John, Julius. Tanzanian, M, Sokoine University of Agriculture, Preventative Veterinary Medicine, MPVM.

Kitambi, Annette. Tanzanian, F, Sokoine University of Agriculture, Preventative Veterinary Medicine, MPVM.

### *Non-Degree*

One day short course on guidelines for safely handling wildlife carcasses and consuming meat products from wildlife, September 28, 2006 at the Wildlife Conservation Society Field Camp-Lunda Mkwambi pilot Wildlife Management Area, Tanzania. Facilitated by Deana Clifford, Michael Clifford, and Bakari Mbano. To teach game scouts how to reduce their risk of zoonotic disease exposure while conducting their jobs by giving them practical guidelines for how to properly handle tissues or blood from wildlife carcasses, and for consumption of meat from wildlife, disseminate knowledge about zoonotic diseases of concern when working with wildlife, including information on how to recognize signs in wildlife, and lastly to teach practical field skills including digital photography and use of hand-held global positioning systems to monitor community-based hunting efforts. Attended by 18 participants (18 male).

## COLLABORATING PERSONNEL

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**PUBLICATIONS AND ABSTRACTS**

No publications, abstracts or presentations have been produced to date, as we are in the inception phase of the HALI project (only three months have passed).

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