Livestock Development and Rangeland Conservation Tools for Central Asia

Narrative Summary

Central Asia represents a large region in the center of the Eurasian continent that encompasses the territories of Turkmenistan, Uzbekistan, Kazakhstan, Tajikistan, and Kyrgyzstan. Rangelands occupy nearly 80% of the territory and provide the main source of forage for livestock. The sustainability of extensive production and human nutritional welfare was negatively impacted by socio-economic changes immediately following independence. Division of state and collective herds into smaller private units caused erosion of animal stocks that started in the early 1990s and is in contrast with the long-term increase of livestock population in the region. The decline in livestock numbers can be attributed to the deterioration of the terms of trade for producers. Lack of winter forages, collapse of marketing networks, and poor maintenance of livestock water wells have resulted in hand-harvesting of range plants for feed and fuel, and concentration of livestock around populated areas and active wells. In spite of declining livestock numbers, rangeland degradation is accelerating near surface water and populated areas. The rangelands of Central Asia may constitute a significant part of the "missing sink" that attenuates the increase in atmospheric carbon dioxide. Additionally, restoration of degraded lands may constitute a source of carbon credits for the region. This project addresses the immediate need to improve the welfare of small landowners, to prevent further deterioration of rangelands, and to document their role as carbon sinks.

We take an integrated multi-disciplinary approach to improve the welfare of herders, involving not only on-farm solutions for technical aspects, but also the assessment of alternatives and policy instruments to support them. Alternatives are evaluated from the point of view of sustainability, impacts on the global carbon budget, and economic profits. Models incorporating ecological and policy scenarios are used to explore the regional impacts of various technical alternatives.

The activities proposed for 2002-2003 were directly linked to the original problem model with minor modifications. Geographic information systems (GIS) and continuous monitoring of carbon dioxide (CO_2) fluxes are the core components, supplemented by animal production and socio-economic modules.

Accomplishments for this year were significant because they brought us very close to the original goal of integration across modules. Carbon flux measurements were integrated with the United States Department of Agriculture-Agricultural Research Service (USDA-ARS) AgriFlux network, yielding better models and more precise predictions for both United States and Central Asian rangelands. We produced maps of estimated carbon flux over extensive areas of Central Asia, and provided policymakers with a clear roadmap to position the region in the carbon credit market. Rangeland forages were characterized nutritionally and the information was disseminated in publications. A biologically detailed model of sheep

production was integrated with an economic model, yielding support to the hypothesis that livestock production in Kazakhstan is severely limited by availability of credit to smallholders. Small investments on supplementation and forages for the winter should result in sizable returns. This trend of practical results is accelerating and is expected to have full impact one or two years after the end of the project, as the information finally reaches dissemination outlets.

A summary of accomplishments for the 2002-2003 year follows by research activity. The planned activities were accomplished with slight departures from the original plans. Some activities had to be cancelled due to reduced funding.

Research

Activity One: GIS and Basic Resources Module

Problem Statement and Approach. The GIS and Basic Resources Module is designed to serve as the basis for regional application and modeling of research results. The main activities of this component are the creation of a GIS for Kazakhstan, Uzbekistan, and Turkmenistan. Information is used for direct dissemination and as a basis for the other modules and components. During the sixth year of the project we have augmented the regional GIS in Uzbekistan, created and distributed a spatial tool for Central Asia (ACT A-Where), and established regional estimates of carbon balance in rangelands by integrating the GIS and CO_2 flux modules.

Augmentation and refinement of the databases emphasize the integration of meteorological and remote sensing data. Integration of project components was done to build, synthesize, and calibrate spatial models, validate these models against ground truth and Moderate Resolution Imaging Spectroradiometer (MODIS) data, and to use these models to test alternative scenarios and predict the outcome of management actions. Existing models will be extrapolated to Central Asian grasslands and then integrated in the GIS over the spatial extent of the region to produce landscape-level estimates of total carbon flux.

Progress. Ecoregional estimates of carbon (C) balance in rangelands were established for the growing seasons using CO_2 flux and remote sensing data from three study sites. The goal of mapping 1998–2001 carbon fluxes in Central Asia has been delayed as USDA-ARS AgriFlux data sets are utilized to strengthen Central Asian predictions and partition net ecosystem CO_2 exchange (NEE) into gross primary production (GPP) and ecosystem respiration (Re) components. GPP algorithms have been developed and Re and NEE algorithms will be developed using northern Great Plains flux towers. Quantification and mapping of seasonal dynamics of NEE, GPP, and Re have been published for the year 2000 growing season in the Journal of Environmental Management.

Satellite imagery, meteorological data, and Bowen ratio-energy balance (BREB) data at CO_2 flux sites in Kazakhstan and Uzbekistan have been collected, along with a long-term study from the western United States. Together with the CO_2 component, grassland models were parameterized based on these data. Quantification and mapping of Kazak steppe seasonal fluctuations of CO_2 have been published in the Journal of Environmental Management.

Generation of GPP and Re from Turkmenistan and Uzbekistan was given low priority due to low CO_2 fluxes and poor sunlight-CO_2 flux response curves at these sites. However, 2001 Uzbekistan fluxes were

processed into GPP and Re components and agreed fairly well with normalized difference vegetation index (NDVI) early in the spring, but later season fluxes may indicate abiotic (e.g., inorganic soil physico-chemical) processes that may absorb atmospheric CO_2 during the hot, dry summer.

Additionally, satellite data (NDVI) and meteorological data (precipitation, temperature) at non-BREB sites were collected from Kazakhstan and Uzbekistan along with AmeriFlux sites in the western United States. Analysis of Kazakh biomass data indicates location and/or footprint problems and thus was not used.

Spatial data sets (NDVI, elevation, ecoregion) have been prepared in a manner consistent with the U.S. data sets. This includes the temporally smoothed NDVI data sets 1998–2001 and NDVI metrics. Exceptions are the photosynthetically active radiation (PAR) data sets, which are only produced for North America (http://www.atmos.umd.edu/~srb/gcip/), and the U.S. STATSGO soils data sets. Regression tree analysis indicated minor use of the soil moisture anomaly maps for the Re algorithm in the northern Great Plains. We are procuring full field soil moisture data sets for further testing.

Algorithm development for the mapping of winter fluxes that would allow closure of annual carbon budgets has been problematic. The winter fluxes from Shortandy, Kazakhstan were pooled with winter flux values from Mandan, North Dakota and Miles City, Montana. The regression tree algorithm accounted for 72% of the variation observed in winter fluxes. However, the model used the site variable to group Miles City and Mandan fluxes separately from the Shortandy winter fluxes. One possible explanation for this is that the Shortandy fluxes were measured with an eddy covariance system, which had been recently discovered to have a timing error in the measurements of densities of CO_2 and water vapor. This error was confirmed to underestimate CO_2 fluxes with the eddy covariance system. This is apparently significant for winter fluxes when magnitudes of CO_2 fluxes are small. Until these issues are resolved, scaling of winter fluxes would not be warranted.

Based on data of aboveground biomass collected throughout the 2002 growing season, the potential carbon assimilation of the different agroecosystem types was analyzed. The data was collected in all four ecosystem types (wheat, abandoned land, virgin land, and crested wheatgrass) from the four blocks used for the CO_2 flux experiment. For this analysis, the three samples taken at every field each time were averaged and the highest value of the season was taken as the potential biomass production for each ecosystem (N=4 for wheat and abandoned land; N=3 for virgin land and crested wheatgrass). Wheat and abandoned land are the ecosystem types that assimilate the highest amount of biomass in one year (both 4.6 t ha^{-1}), compared to crested wheatgrass (3.0 t ha^{-1}) and virgin land (2.2 t ha^{-1}). The variability of these estimates, measured through the coefficient of variation (CV), shows that wheat and virgin land have very stable productions throughout the landscape (CV= 15%), whereas the abandoned lands are much more variable (CV=55%). Crested wheatgrass was found to be at an intermediate level of variability (CV=34%). Further calculations are needed to estimate the real carbon assimilation because two of these ecosystems (wheat and crested wheatgrass) export a big percentage of their biomass production as grain and forage, respectively, and part of the biomass from the previous year is lost via decomposition and/or respiration.

From these data it seems that the abandoned lands have the highest potential to capture CO_2 from the atmosphere in northern Kazakhstan.

The Country Almanac (Almanac Characterization Tool or ACT) was completed for Kazakhstan. The ACT is an integrated spatial information system designed for agriculture and natural resource management. The ACT's analytical and visualization tools enable the rapid characterization of areas within the target geographic regions.

The ACT software for Turkmenistan and Uzbekistan (completed Summer 2002) was complemented by the construction of a foundation database for Kazakhstan in the fall of 2002 by the Central Asian Regional Environmental Center (CAREC) and currently includes climate, meteorological, infra-structural, demographic, topographic, and political data. CAREC has developed an Ecological GIS for all of Central Asia based on the ACT Software. CAREC plans to include existing information in the ACT software for Tajikistan and Kyrgyzstan as well.

The software was distributed to government and non-governmental agencies in Kazakhstan, Turkmenistan, and Uzbekistan through a workshop held together with CAREC. Participants received a copy of the software, licenses for the software, and the ACT manual (Russian translation) upon completion of the workshop. Since the workshop, CAREC has continued to distribute the software. CAREC reported that many agencies expressed interest in the software but preferred to receive additional training in addition to just the software. Questions to CAREC on use of the software continue and the English-only platform has presented problems to the users.

The Uzbekistan GIS data set has continued to grow with extensive work on the creation of vegetation and soil maps. The vegetation map was completed along with a soils map (scale 1:2500000) using CartaLinks software. Maps were created in the Gaus-Kruger projection. The Uzbek GIS team organized a GIS seminar for faculty and students of the Biology and Ecology Departments at Samarkand State University. Presentations included: 1) general directions of GIS; 2) methods of using GIS and its potential; 3) methods of processing and analyzing data using GIS tools; and 4) using A WHERE-ACT software for studies of desert ecosystems and rangelands. Twenty-nine faculty and students attended. In addition, lessons and seminars on GIS methods were taught at the Academy of Sciences for postgraduate students and students in the bachelors and masters programs of the Department of Ecology of Desert Pastures.

Activity Two: Range Forage and Carbon Flux Module

Problem Statement and Approach. The main objectives of the Range Forage and Carbon Flux module are to: 1) quantify annual net primary production (ANPP) on representative Central Asian rangelands; and 2) assess the role of Central Asian rangelands in the global carbon budget. Accurate estimates of ANPP from these rangelands will provide important information on carrying capacity to sustain livestock production in the region and are important for evaluating whether Central Asian rangelands are net sources or sinks for atmospheric CO_2. Our studies in Central Asia will provide data necessary to quantitatively assess the role of Central Asian rangelands in the global carbon budget.

The Central Asian region is dominated by vast rangelands, and we hypothesize that these extensive rangelands may constitute a

significant portion of the "missing sink" that attenuates the increase in global atmospheric CO_2. The capacity of rangelands to sequester atmospheric CO_2 could be increased with better rangeland management practices, thereby improving the welfare of small landowners and, if acceptable treaties and protocols can be developed, providing opportunities to trade "carbon credits." Daily and seasonal carbon balances of rangeland ecosystems are measured with a Bowen ratio-energy balance (BREB) technique that calculates net ecosystem CO_2 exchange (NEE) between a terrestrial surface (including soil and vegetation) and the atmosphere. The NEE was monitored continuously during the 2003 growing season in the following study sites in Central Asia (described in the GL-CRSP annual report for 2001).

Shortandy site. This represents the "typical steppe," which consists of the vast area of the true steppe spreading from the lowlands of the northern Black Sea through the southern parts of the Russian plains to the steppes of northern Kazakhstan. This site is located in the field experimental station of the Barayev Kazakh Research Institute of Grain Farming, near the town of Shortandy, about 60 km NNE of Astana, Kazakhstan (51°40' N, 71°00'E, 367 m a.s.l.).

Karnap site. This represents the "sagebrush-ephemeroidal" arid rangelands of the foothills of Central Asia. This site is located in the territory of the agricultural enterprise "Razzok Jahangirov," 150 km NWW from Samarkand, Uzbekistan (40°N, 65°30'E, 310 m a.s.l.).

Karrykul site. This represents the "shrub sandy desert," which includes the majority of the rangelands of Turkmenistan (26 million ha.). This site is located in the southern part of the Central Karakum Desert, 80 km to the north of Ashkhabad, Turkmenistan (38°36'N, 58°24'E, 90 m a.s.l.). The site is part of the Karrykul Research Station of the National Institute of Deserts, Flora and Fauna of the Ministry of Nature of Turkmenistan.

Progress. Fluxes of energy, water vapor, and CO_2 may differ within rangeland ecosystems and among types of land. To assess the spatial variability of fluxes across a landscape, two state-of-the-art eddy covariance (EC) systems were deployed for continuous measurements of fluxes in two rangeland ecosystems: abandoned cropland and crested wheatgrass hayland. This is a follow-up data collection in conjunction with the roving EC measurements that were done during the 2001-02 growing seasons. The study sites were located within the research experiment station of the Barayev Kazakh Research Institute for Grain Farming near the town of Shortandy in northern Kazakhstan. Data processing and analyses are ongoing for the roving EC measurements obtained during the 2001-02 growing seasons.

A timing error was recently discovered in the flux measurements from the open path infrared gas analyzer (IRGA) (model LI-7500, Li-Cor Inc.) being used with the EC systems. The main effect of this timing error is an underestimation of water vapor and CO_2 fluxes. Fluxes from EC measurements obtained in 2001-02 are being recalculated using time series (10 Hz) data. A program has been written to maximize the eddy covariances using the 10 Hz data sets. Additionally, recent developments for correcting EC fluxes (e.g., coordinate rotation, frequency response, and Webb, Pearman, Leuning equation corrections) are incorporated to the quality assurance protocols for EC data. Pre-existing flux processing programs have been re-coded for computer programs PC-SAS and MATLAB.

The BREB measurements were continued for the 2003 growing season at two rangeland sites: sagebrush-ephemeroid semidesert at Karnap, Uzbekistan, and shrub sandy desert at Karrykul, Turkmenistan. Data at 20-minute intervals have been received at Utah State University where data processing and quality assurance will be performed.

A mathematical model has been developed for predicting energy, water vapor, and CO_2 fluxes. This model is based on basic principles of thermodynamics and biophysics of carbon fixation and respiration. The model was developed from an extensive literature survey and discussions with experts in carbon flux research. A novel method of extracting ecosystem-specific parameters has been incorporated into the model. This model has been parameterized with data collected from a pristine grassland that represents the Kazakh steppe ecoregion. We will use this model as a tool for estimating and interpreting the dynamics and magnitudes of CO_2 fluxes in the Kazakh steppe.

The CO_2 scaling up project has integrated the flux tower measurements from the USDA-ARS AgriFlux network and this project (LDRCT) in Central Asia. Temporal and spatial scaling up of flux tower measurements to ecoregion levels is achieved through the use of modeling, remote sensing, and GIS techniques. NEE was partitioned into fluxes associated with gross primary productivity (GPP) and ecosystem respiration (Re) as demonstrated in the Kazakh steppe ecoregion. GPP and Re were mapped from May to October 2000. Maps of regional fluxes were developed for a whole growing season and included the 10-day temporal dynamics that were generated from normalized difference vegetation index (NDVI). A predictive algorithm to estimate GPP from NDVI and other spatial/temporal GIS data sets ($R^2 = 0.92$) was developed from North American flux tower sites in Texas to southern Canada. This algorithm was tested using the flux tower data from Shortandy, KZ (1998-2000) and found to have good agreement ($R^2 = 0.63$) between observed versus predicted GPP. This indicated that carbon fluxes at the Shortandy site were similar to the rangeland sites in the United States, thus flux tower data will be pooled to develop a more robust algorithm.

A web page has been created to showcase the scaling up project through South Dakota State University (SDSU) and the United States Geological Survey Earth Resources Observation Systems (USGS EROS) Data Center (http://edc.usgs.gov/carbon_ cycle/). This web page supplements the original web page (http://edcintl.cr. usgs.gov/carboninfo sheetca.html). It provides a chronological presentation of SDSU and EROS research including publications, an interactive presentation of GPP and Re maps of the Kazakh Steppe, and links to the USDA-ARS AgriFlux and GL-CRSP project on scaling up of carbon fluxes.

A brochure entitled "The potential of Carbon Credits," specific to Kazakhstan, was published and distributed to U.S. and Kazak agencies. The brochure is based on data from the LDRCT project and other studies in the U.S. and Central Asia that have shown that the rangelands of Central Asia are sequestering carbon at a significant rate. Based on this data, carbon credits and policies to promote sustainable use of rangelands are valid options for the Kazak government. The brochure contains tangible examples and a basic road map for leaders to make carbon credits a reality for Central Asia. It is likely that the market of carbon credits will reach a point of exponential growth, and early positioning will have substantial payoffs.

Activity Three: Animal Production Module

Problem Statement and Approach. The animal production module pursues two major objectives: (1) determine the production potential of the semi-arid and arid regions of Uzbekistan and Turkmenistan for sheep production, thereby facilitating the design of appropriate development programs for the livestock sector; and (2) create modern planning capabilities in the host countries by establishing laboratories, providing training to host country scientists, and developing computer-based maps of production and development potential.

Activities are comprised of research on the diet composition of sheep, determination of the nutritional quality of the range and its dynamics throughout the forage year, development of GIS map layers for soil types, range type, range primary production (availability and quality) and range secondary productivity (potential animal performance levels for specified management systems), and the application of a bio-economic simulation model of small ruminant production systems. Our project will produce data essential for an improved match between animal genotype and environmental resources in Central Asia. This is the basis for long-term sustainable production. The methods developed in our project are highly relevant for extensive sheep production systems in the United States. The host countries will benefit by acquiring appropriate planning and analysis tools that will help them address the grave environmental problems of livestock production on Central Asian rangelands.

Progress. The animal production module made important progress during the 2002-03 year. Monitoring of range condition and trends on all major range sites in Uzbekistan was completed this year. In June of 2001 the first season of fieldwork was conducted. On three field expeditions, six sites for monitoring of range condition were set up, and extensive vegetation surveys were conducted. These sites are: Karnap, Bukhara (two sites), Kultshuktau (Kyzelkum desert), Tamditau (Kyzelkum), and Nurata Mountain Sheep Reserve. All sites are visited three times per year. On all sites, the vegetation is surveyed for cover, density, species composition, biomass, and brush utilization. Samples of range plants are collected for laboratory analysis of nutritional properties. The last survey in the project was conducted in October of 2003; therefore, there are now two years of range monitoring data available. These data are currently in analysis for publication in scientific journals.

Data from previous studies conducted in Soviet times in Uzbekistan were computerized. A database containing four years of range inventory (condition data) from the Karnap site was computerized and the results of the analyses reported at the International Rangeland Congress.

The determination of the diets of sheep and goats on the Uzbek range made important progress this year. Trials to determine the diet composition of sheep and goats on rangelands, using the alkane marker method with controlled-release devices, began on one site. Comprehensive sets of species from the Kazakh steppe were characterized for ruminant nutrition. Results were published in the proceedings of the International Rangeland Congress.

Only three animal experiments were conducted, however, because import restrictions for animal samples increased the cost of these experiments beyond the limit of the project budget. The samples collected for determination of intake and digestibility are currently assayed in a collaborating laboratory in Israel (Newe Ya'ar Research Center, ARO, Israel).

All forage samples for the determination of nutritional quality of Uzbek range plants have been prepared for analysis and catalogued. They are currently in Samarkand. An attempt to import whole plant specimens was unsuccessful, as the Animal and Plant Health Inspection Service (APHIS) detected spores of a listed fungus on some samples. Destruction of two years' worth of fieldwork was narrowly avoided. A Wiley mill for on-site sample preparation was purchased and shipped to Uzbekistan. Because of a clerical error, it took almost six months to release the mill from customs and begin processing in Samarkand. Samples are scheduled to arrive in the Davis lab in November.

All GIS layers except those for primary and secondary range productivity are completed and ready for release. The missing layers depend on the pending completion of Activities Three and Four.

The planned work in Turkmenistan had to be cancelled, however, due to the reduction in available funding. Part of the planned investments into laboratory facilities in Uzbekistan will also not be possible.

Activity Four: Socio-Economic Module

Problem Statement and Approach. The goal of the socio-economic (SE) module is to provide a set of policy recommendations for the future development of livestock production in Kazakhstan that are consistent with the new market system and resource endowment. To achieve this goal, our analyses focused on the following two aspects. First, we analyzed the behavior of the Kazakhstan livestock sector during the last decade of transition (from a central planning to a market economy) to understand the current situation for livestock producers. Using published statistics and reports and information from field interviews in 1999 and 2001, we seek to explain why the livestock sector followed the observed transition path, which was characterized by a sharp decline in the livestock population and output and a change in the dominant farm types (from collective entities to subsistence units).

The second part of our analysis derives policy implications from a livestock production model. From the results of the first part of the analysis, we chose to model extensive livestock production by family farms, which we hypothesize have the potential to significantly increase output. A stochastic dynamic programming (SDP) model was developed for a sheep producer in southeastern region of Kazakhstan. The model is used to analyze optimal management, given model parameters, and to evaluate policy alternatives.

Progress. We completed the first part of the analysis and explained how Kazakhstan's livestock population and production declined dramatically since 1991 with the transition from a centrally planned to a market economy. As a result of market liberalization, input prices rose and output prices fell, sharply reducing the profitability of livestock production. The price effect was exacerbated by a government decision to tax the livestock sector implicitly by requiring producers to sell meat to state purchasing agencies at lower than market prices. A poorly designed and implemented farm privatization program, combined with the collapse of the Kazakhstan capital market, caused massive liquidation of livestock capital. Large farms sold nearly all their livestock. Rural households received many of these animals, but could not profitably maintain most of them. Although nearly all livestock are now on small farms, government livestock planning and policies often still seem focused for large farms with a capital-intensive structure. Commonly observed rangeland

institutions also encourage livestock holding by subsistence rural households that probably cannot become viable commercial producers. Although this form of livestock holding had an important role during transition, policies for future development of the sector should promote the emergence of commercial producers and efficient rangeland management.

We successfully completed parameterizing the bio-economic SDP model. The model involves a maximization of expected net present value of profit stream from a sheep enterprise given forage, sheep biology, and economic parameters. Since producers do not know the future levels of forage production at the time that decisions are made, the decision problem has a stochastic nature. The specifications of forage production and sheep biology were derived from a sheep simulation model developed by E.A. Laca. Economic parameters (output prices and costs of production) were obtained from published statistics, farm surveys, and monitoring activity conducted during this project.

Preliminary results of the model exercises suggest the following. First, in a series of model runs with different constraints on feed availability, we found that feed supplementation during the grazing season has the potential to significantly increase producer welfare. Without supplementation, the simulated flock size fluctuates significantly in response to fluctuations in forage production and, when a more nutritious alternative (barley in our model) to grass hay is not available during the winter feeding period, the sheep production system is not sustainable. Supplementation, by mitigating the shocks of poor forage production on animal productivity, allows maintenance of production at a high level. We estimate that making one ton of hay available during the grazing season would increase the capital value of the flock by up to $700. The estimated cost of producing such hay is much less.

The optimal feeding strategies suggested by the model do not resemble the current practices observed on family farms in Kazakhstan. Typically, feeding in our study area consists of grass hay during the winter at a low level and no supplementation during the grazing season, whereas the model suggests that feed supplementation should be profitable. We hypothesize that family farms face difficulty in financing a higher level of feeding. A capital constraint limits the scope and the level of feeding during the winter and regular grazing seasons. When the model is altered to include a capital constraint, the model produces a feeding regime much similar to that currently observed. According to our preliminary estimates, if the capital to finance feeding of a flock of 1,368 sheep is limited to $1,000, relaxing the capital constraint by $1 would increase the capital value of the flock by $6 to $17, depending on forage production levels.

Our preliminary results suggest that the currently observed practices of sheep production by family farms are consistently explained by a lack of working capital to finance winter and supplementary feed, including haymaking and conservation. The state's livestock policies currently seem to focus on the introduction of purebred animals. Unless the new breeds introduced are suitable for use under severe feeding conditions, the animals will likely face a feed limitation. The appropriate direction of intervention may be to assist in the development of lending institutions for small farms. Haymaking and conservation for its use as a supplement during the grazing season should be encouraged. Assistance in the development of efficient feed markets may also be appropriate.

Dissemination of results. Host country scientists were briefed and consulted on the progress and plans of the project. Host country scientists also presented results of the LDRCT project at national meetings in their respective countries.

Several scientific articles were produced detailing results on CO_2 sequestration and animal production and rangelands in Central Asia. Research Briefs were produced as well in this reporting period, and project participants attended several conferences where they presented posters. These publications are available through regular library services and through the Internet.

The ACT A-Where software was distributed to several governmental and non-governmental agencies in Central Asia, including the ministries of ecology from the five Central Asian states, the Geography Departments at Kazak National University and Almaty State University, the Institute of Space Research in Kazakhstan and Uzbekistan, United Nations Development Program (UNDP) Kazakhstan, Uzbekistan and Kyrgyzstan, the Organization for Security and Cooperation in Europe (OSCE) office in Kazakhstan, Committees on Land Resources of Kazakhstan and Uzbekistan, Hydrology and Meteorology Departments of Kazakhstan and Uzbekistan, Global Mechanism of the International Fund for Agricultural Development, German Development Agency (GTZ), and the Kazak State Institute of Science and Technology.

The software has also been presented at international meetings by the Central Asian Regional Environmental Center (CAREC), including the Committee on the Challenges of the Modern Society (CCMS) Working Group Meeting (Nov. 19-21, 2002), the Asia Pacific Environmental Innovation Strategy (APEIS) Workshop on Integrated Environmental Monitoring of Asia-Pacific Region (Sept. 20-21, 2003) in Beijing China, "Current Livestock And Environment Interactions In The Commonwealth Of Independent States And Mongolia," held in the Kyrgyz Republic (May 4-7, 2003), and the Sub-Global Scenarios Workshop of the Millennium Ecosystem Assessment in Penang, Malaysia (March 4, 2003).

The project's brochure entitled "The Potential of Carbon Credits" was distributed to U.S. and Kazak agencies and advertised through leading electronic bulletins in Central Asia. This brochure is designed for policymakers and government officials involved in carbon issues, as well as for those in industry who have an interest in preserving the rangelands of Central Asia while promoting their sustainable use. We hope that this brochure will stimulate discussion and development of instruments that assist Central Asia to move towards policies that support economic growth and sustainable use of natural resources.

Gender

Data from this project will provide information that will benefit both the male and female portions of the general population in the region. Results from the project will hopefully encourage women in host countries to become involved in further research that will enhance rangeland primary productivity, develop the livestock sector, and affect regional policies.

This project has continued to support women at all levels: as direct beneficiaries of the research results, as employees to support regional activities (Sidelnikova, Mamedova, Kernshakaya), as collaborating scientists (Karibayeva, Shabanova, Soyunova, Lebed, Gaziantz, Young), as graduate students (Kobayashi, Toderich, Shakirova, Dubovic), and as technical assistants (Zemcova).

Policy

Important linkages developed in the past and reported last year continued to operate. One of the aspects of our research that has attracted the most interest from policymakers has been the study of Central Asian rangelands as potential carbon sinks. We envision that the database collected from the CO_2 flux monitoring sites in Central Asia will serve as the foundation for the development of a technological package to identify, evaluate, and monitor carbon credits. Regional scientists, international collaborators, and policymakers are just beginning to seriously consider agricultural ecosystems as potential sites for mitigation of climate change. We informed regional scientists and policymakers about these possibilities with the publication of a brochure, "Potential of Carbon Credits," and have obtained significant leveraged funding to create a regional network for carbon flux measurement and modeling.

The CO_2 flux module has had an impact on the USDA-ARS National Program for Global Change, and we have been collaborating with the National Program Leader. Further details can be found on the website http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=405809.

Outreach

Outreach was directed at producers, regional students, and research institutions of the region. In continuation of the program partially funded by the International Fund for Agricultural Development-International Centre for Agricultural Research in the Dry Areas (IFAD-ICARDA) and the GL-CRSP, ten of the students from the Kazak Agrarian University supported under this project completed their undergraduate degrees and two doctoral candidates completed their graduate degrees.

Numerous young scientists and doctoral candidates associated with the Baraev Institute of Grain Farming, the Sheep Breeding Institute of Kazakhstan, the Karakul Sheep Institute of Uzbekistan, the Uzbek Academy of Sciences in Samarkand, and the Institute of Desert Flora and Fauna of Turkmenistan were supported and given research opportunities through the project.

The animal production module established a future collaboration with an international NGO operating in Uzbekistan to continue its activities. In addition, new collaboration agreements were established with government agencies.

Developmental Impact

The GIS tool and information distributed will support and facilitate decision-making and development policies. The integrated activities in the carbon-flux module will contribute significantly to the assessment of rangelands as globally important carbon reservoirs and active sequestration agents. Once this takes place, there will be a strong motivation for all projects that link development and positive global impacts to focus in more arid areas instead of northern and tropical forests.

The brochure on carbon credits further promotes the sustainable use of rangelands as a valid option for the Kazak government. It is designed for policymakers and government officials involved in carbon issues, as well as for those in industry who have an interest in preserving the rangelands of Central Asia while promoting their sustainable use. We hope that this brochure will stimulate discussion and development of instruments that will assist Central Asia to move towards policies that support economic growth and sustainable use of natural resources.

The animal production module will contribute to the long-term sustainable production of livestock in Central Asia. The project is producing data essential for an improved match between animal genotype and environmental resources in Central Asia. The planning and analysis tools that will be developed will assist policy makers in Central Asia to address the grave environmental problems of livestock production on Central Asian rangelands.

The socio-economic model provided a good starting point for modification of policies. Specifically, Kazak agricultural policies should promote financing for forage and feeds accessible to smallholders while promoting the rise of larger commercial units.

Linkages and Networking

With strong leadership from the Management Entity of the GL-CRSP, LDRCT organized a key linkage between the U.S. rangeland carbon flux network and the Central Asian network. The GL-CRSP provided additional funds that were matched by USDA to establish a highly synergistic integration. The U.S. network is benefiting from this integration by receiving the techniques to produce maps of predicted annual carbon sequestration developed by LDRCT. LDRCT benefits by the access to a much larger and general database to develop more robust coefficients to produce spatial extrapolations in Central Asia.

For example, flux data (17 site-years or more) from the ARS AgriFlux network has been shared with LDRCT researchers at SDSU and USGS EROS. Utah State University has filled in missing meteorological data using relationships to other tower data. These parameters are needed for gap-filling of flux data and estimation of respiration and GPP components of NEE. Central Asia and USDA ARS AgriFlux data sets were used to assess the reliability of mapped precipitation, temperature, and PAR products obtained from the National Oceanographic and Atmospheric Administration (NOAA) Climate Prediction Center and GREWEX SRB. With this information, models were developed for the northern Great Plains grasslands and tested using flux data from Kazakhstan. The pooling of the datasets will allow a more robust mapping of the northern grasslands GPP flux in both regions and potentially similar eco-regions in the northern hemisphere. Additional sharing of Landsat TM imagery is enabling localized efforts to scale up fluxes.

A NASA interdisciplinary proposal was prepared by USGS EROS that included ARS AgriFlux and Central Asia flux participants, as well as university involvement. Funding for this proposal was unfortunately not awarded and funding is still being sought.

The LDRCT project participated in initial discussions of the Livestock Environment and Development Initiative (LEAD). LDRCT members from each participating country were proposed as members and have become active in the online discussions and meetings. The work of the initiative targets the protection and enhancement of natural resources as affected by livestock production while alleviating poverty (http://www.lead.virtualcentre.org/en/frame.htm).

Other Contributions

The LDRCT project supports free markets and broad-based economic growth primarily through the socio-economic module and indirectly through the CO_2 work. The SE module has determined important hindrances to the development of a thriving livestock sector for Kazakhstan. The CO_2 module

produced a brochure detailing how Kazakhstan could participate in global carbon credit markets. These markets may provide an important source of government and private investment.

Mission objectives that this project complies with include: (1) the assessment and dissemination of improved livestock and rangeland management technologies to conserve natural resources, mitigate global warming, and improve welfare of smallholders in Central Asia; and (2) the evaluation of alternative policy scenarios to promote dissemination and adoption of environmentally friendly, low-cost livestock production technologies.

The activities of the 2002-03 year will contribute towards these long-term targets by:

- widely distributing the Country Almanac (which includes an electronic database of soil, vegetation, and weather layers) to be used directly by decision-makers and policymakers, also used as the basis for the modeling phase of this project (Activity One).
- developing the human capacity and institutional frameworks necessary for this project to have long-term impacts beyond its active period (all activities).
- creating data-based models of C flux, forage production, and weather for the simulation of ecological scenarios and an assessment of the role of rangelands in the global C cycle (Activity Two).
- modeling smallholder animal production systems and enterprises and identifying limiting factors (Activities Three and Four).
- identifying the role of different agricultural practices on the loss of soil C in northern Kazakhstan, and proposing integrated crop-livestock systems that incorporate rotation with forages that improve soil condition, reduce erosion, and capture atmospheric carbon (Activities One and Two).
- facilitating the direct involvement of producers in conducting research and by disseminating the information both to decision-makers and policymakers and producers.

Leveraged Funds and Linked Projects

We estimate that we obtained $150K in matching (mostly in-kind) and $300K of leveraged funds in cash. These funds include the cash match from USGS-EROS Data Center and the cash from the USDA-ARS for the integration of the United States and Central Asian carbon flux networks.

Funding from IFAD ($205K) continued to support the farm monitoring, alternative forage activities, and animal production modeling activities of the project.

Training

Degree Training

Karen Olmstead, M.S., 2003, Biology and Agricultural Engineering, A Simple Model of Rangeland Productivity in Southern Idaho Using Landsat Images, University of California, Davis.

Mimako Kobayashi, Ph.D., 2003, Agricultural Resource Economics, Livestock Production in a Transition Economy: The Case of Kazakhstan, University of California, Davis.

Jorge Perez, Ph.D., 2004, Agricultural Ecology, Carbon and Water Vapor Flux Patterns in Four Agroecosystems of Northern Kazakhstan, University of California, Davis.

Short-term Training

ACT A-Where workshop for representatives from agricultural government, research, and non-governmental agencies was held in late October 2002 in Almaty, Kazakhstan together with CAREC. 33 participants from Kazakhstan, Turkmenistan, and Uzbekistan with representation from the ministries of energy/oil, natural resources, and economics attended the trainings.

Dr. B. Mardonov was trained at UC Davis in the application of the alkane marker method for diet composition measurements. He was also trained in basic methods of ruminant nutrition field research (total collection, digestibility measurements, and basic laboratory work).

A seminar on the basics of GIS was organized at Samarkand State University with the biological faculty for both teachers and students.

Classes and training on GIS Methods and their use in research were held for postgraduate students, bachelors, and masters of the Department of Ecology of Desert Pastures.

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