Part A. Education

I. REU: Results from Prior Support

Christine Byrne, University of California – Berkeley

Ms. Byrne worked with Dr. William K. Lauenroth and PhD candidate Ms. Kerry Byrne to estimate aboveground net primary production (ANPP) in grasslands using three non-destructive techniques at two grassland sites. Plots on the shortgrass steppe in Colorado and mixed grass prairie in Hayes, Kansas, were assessed using photography, point frame analysis and a greenness index measured radiometrically. Results indicate that digital photography was rapid, but did not accurately or precisely predict biomass. Radiometric analysis was rapid and precise, but not highly accurate. The point frame method was rapid, precise and potentially accurate at both sites. These results were presented orally by Kerry Byrne at the Society for Range Management Annual Meeting in 2010. C. Byrne, K. Byrne and W.K. Lauenroth are preparing a manuscript for publication.

Kristina Tosic, Colorado State University

Ms. Tosic worked with Dr. Alan Knapp and PhD student Ms. Karie Cherwin to investigate the recovery of shortgrass ecosystems form prolonged drought. Ms. Tosic assisted an on-going project which addressed the impacts of global climate change on the productivity and invasibility of shorgrass steppe. She successfully completed a separate project that compared levels of plant-available soil nitrogen (NH_4 and NO_3) in plots receiving varying levels of precipitation. Results showed higher levels of NH_4 and NO_3 in plots that received less precipitation than the ambient control plots. Her results were used to compliment the larger investigation of productivity and invasibility of shortgrass steppe.

REU: Proposal for 2010

We request funding to support two REU students during the 2010 summer field season. Students will work directly with PI's and their graduate students from the Shortgrass Steppe Long Term Ecological Research project. More information about our REU program can be found on the SGS LTER website: http://sgslter.colostate.edu/education_ug_g.aspx

II. RET: Results from Prior Support

We have an established program for a group of K-12 teachers. RET fellows spend 80 hours during the summer and 50 hours during the academic year on their research under the supervision of a senior SGS LTER scientist. Teachers submit written reports of their research and of lesson plan(s) developed from their experiences.

RET: Proposal for 2010-2011

We are working with five LTER sites (AND, NWT, SEV, CCE, PAL) to establish a collaborative RET cross-site project to provide opportunities for all RETs to share experiences with colleagues and to strengthen partnerships among LTER K-12 programs. Andrews LTER will host a three-day workshop for RETs from the five sites in summer, 2011. RETs will be involved in one day of field research on long-term forest dynamics and help each other refine their own projects before taking them to their students. By exposing teachers to multiple ecosystems and to LTER sites that conduct the same core measurements despite very different site-level questions, teachers and their students will benefit more from the breadth of the national LTER program. A cross-site RET project should create stronger linkages among LTER sites from which we can expand future education efforts. Kari O'Connell, Andrews LTER education representative will coordinate the workshop.

III. Schoolyard LTER: Results from Prior Support

Funds were used to purchase Vernier probes and data loggers for K-12 teachers to use in their classrooms, several GPS units and various field supplies for teachers to continue field work at their schoolyard research sites. We also purchased a digital SLR camera for use at the new field station to document events as well as to update the digital photo library for outreach and research reports.

SLTER: Proposal for 2010-2011

Over 40 teachers in 20 schools in five districts and two states are involved in our SLTER partnership. School-based activities aligned with state science content standards that emulate SGS field research are the centerpiece of the SGS-SLTER program. Teachers will purchase supplies for their students that cannot be purchased with the annual budget supplied by school districts (i.e., SLTER funds will not supplant district funds). We are requesting funds to provide teachers with the items needed to continue their SLTER activities in their classrooms. Teachers will work with SGS graduate student partners to develop proposals which include plans to connect SGS field research to an activity or series of activities to be implemented during the 2010-2011 school years. Proposals will include a budget for purchasing needed materials, and be submitted in early August. Proposals will be reviewed around September 1st, and vetted by a panel of peers much like a typical NSF review panel. Panel reviews and summaries will include specific recommendations on how to improve the plans. All teacher-graduate student teams will present a mid-year summary of their work at the January All SGS-SLTER Meeting.

IV. ROA (UNC – Scott Franklin)

Classification and Mapping of Vegetation at the Shortgrass Steppe LTER

Classification of vegetation provides an inventory to assess change, a common language to compare communities with other LTERs, and a baseline for land stewardship decisions. Several initial efforts toward mapping and vegetation data collection have already been started, but not a structured community analysis and subsequent mapping. The initial phase of this project would use the thousands of previously collected plot data to develop a vegetation classification. Data will be analyzed using a variety of classification and ordination techniques to determine the most parsimonious classification system and subsequently compared to the National Vegetation Classification Standard (NVCS) at both the Alliance and Association levels. Any new Alliances or Associations will be proposed for modification of the NVCS. All plot data will be input into VEGBANK for anyone to use. The classification will be related to environmental factors on the landscape and mapped in GIS. We expect a gradient-driven distribution of vegetation that is related to a complex of environmental factors, including soil characteristics and topographic characteristics. Environmental data (soil type, aspect, slope position, disturbance history) will be related to vegetation classification groups.

Several questions linger in regard to transferring the NVCS to mapping units, including appropriate scale that often depends on the research or management question. We will map the vegetation at the Alliance, Association and Group levels to determine which is most appropriate and for what questions. Despite previous efforts, parts of the area may have been missed by previous sampling, so mapping of plots will be used to determine further sampling efforts to fill in gaps. Subsequent sampling of additional plots will be the second phase of this study, and these plots will be used to examine the efficacy of the classified Associations and Alliances and their mapped units, thus validating the classification.

Part B. Social Science

Maps **a**nd **L**ocal**s** (MALS): A Cross-Site LTER Comparative Study of Land-Cover and Land-Use Change with Spatial Analysis and Local Ecological Knowledge

Overall Project Coordinators: Gary Kofinas, BNZ & ARC; Robert (Gil) Pontius, PIE; Nathan Sayre, JRN.
Project Website: http://www.lter.uaf.edu/bnz_MALS.cfm

MALS is a collaborative effort of LTER sites that seek to study changing social-ecological systems using a mixed methods comparative approach. The project was launched in 2009 through the Social Science Supplement funding opportunity of the LTER Network. We first describe below the current Social Science Supplement request and the activities common to sites participating in the MALS project. The section that follows describes progress to date and the proposed activities specific to the LTER site making the request for funding.

Background and Previous Activities: The objective of MALS is to: 1) use spatial representation of land cover and land use to identify patterns of landscape change in regions in and around LTER sites; and, 2) integrate Local Ecological Knowledge (LEK) and other existing social data into theories and models of social-ecological change and their implications for human livelihoods. Progress to date involves eleven LTER sites that were funded last year by NSF to participate in the first year of MALS activities (Table 1), and other LTER sites and groups participated at various levels (e.g., ASM MALS workshop).

The leaders of the project (Kofinas, Pontius, and Sayre) convened several meetings to discuss methods, learn from each other's experience, and coordinate activities. A workshop on MALS was organized in September at the 2009 All Science Meeting in Estes Park, CO, with 17 LTER sites participating and contributing to a cross-site database about activities relevant to MALS and providing helpful discussion on proposed methods for spatial analysis and the integration of local knowledge.

Significant progress was made in the land surface change analysis. During the 2009-2010 academic year, Pontius and students compiled maps of change from eleven LTER sites based on land-cover maps, ranging from 1860 to 2009 (Table 1). These maps were used in two consecutive graduate-level seminars at Clark University concerning GIS & Land Change Science and involving 40 students. This research led to the conceptual foundation for three journal articles concerning new statistical methods to analyze land change over time. Two of these articles will serve as dissertation chapters for a student who was named "Scholar" by the Coupled Human and Natural Systems (CHANS) network. The third article has served as the topic of a Masters thesis for another student. The group at Clark also produced computer code to automate all these statistical analyses. We conducted a well attended session at the 2010 Association of American Geographers (AAG) meeting in April 2010 that was sponsored by the CHANS network. Project leaders gave papers about the conceptual foundations of MALS; students made two oral presentations and delivered 8 posters – and two posters won awards. In addition to the AAG meeting in Washington DC, MALS results were presented at the Georgia Coastal Ecosystems meeting in Athens GA and the Jornada Experimental Range Annual Symposium. The documentation and integration of local knowledge and social scientific data was initiated and in some cases completed by participating sites, but the progress in this area was less than the efforts of the spatial analysis described above. Several sites are compiling more maps and conducting interviews with local residents this summer as a complement to their current map analyses.

Table 1

Site	Phase 1 Participant	Phase 2 Participant	Year of Maps contributed	Funding Contribution to Synthesis*
Arctic	Yes	Confirmed	in progress	$2000
Andrews	Yes	Confirmed	1938; 1992; 2001	$2000
Bonanza Creek	Yes	Confirmed	in progress	$2000
Central AZ-	Yes		1912; 1934; 1955; 1995	

Phoenix				
CA Current	Yes			
Coweeta	Yes	Confirmed	1986; 1991; 1996; 2006	$2000
GA Coastal	Yes	Confirmed	1974; 1985; 1991; 2001; 2005	$2000 (subcontract directly to Clark U)
FL Coastal	Yes	Confirmed	1994; 2001; 2006	
Harvard Forest	Yes		1971; 1985; 1999	
Hubbard Brook	Yes	Confirmed	1860; 1930; 2001	$2000
Jornada	Yes	Confirmed	1915;1928;1998	$3000
Konza	Yes	Confirmed	1990; 2005; 2009	$2000
Luquillo	Yes	Confirmed	1977; 1991; 1996	$2000
Niwot	Yes	Confirmed		$2000
N. Tmp. Lakes	Yes	Confirmed	1937;1962;1995 1930;1960;1990	$2000
Plum Island	Yes	Confirmed	1971; 1985; 1991; 1999	$20000 (full budget)
Shortgrass Steppe	Yes	Confirmed	In progress	$2000
*Contributed totals are not received by sites, with the exception of Georgia Coastal Ecosystems (GCE). Contributions are used for cross-site comparative synthesis of mapping and local knowledge, with funds received by Clark U and UAF. GCE contributes to Clark as a subcontract.				

Proposed Future Activities of MALS: Phase Two of MALS has three focused objectives: 1) We will develop approaches to document local knowledge and social scientific data, and to advance our map studies; 2) We will use these data to advance understanding of change through an integration of maps, local knowledge, and cross-site synthesis; and 3) We will develop and submit a cross-site NSF funding proposal that builds on our efforts for a more in-depth study.

Objective 1. Participating sites will submit documentation on approaches to documenting LEK along with available relevant social scientific data and key findings. The focus will be on types of local knowledge, perceived changes over time and links with livelihoods. We will advance our statistical analysis of the maps through another graduate level seminar at Clark University in which the focus will be on creating metrics for cross-site analysis. This is different from last year's work that produced methods used at individual sites. In this year's seminar we ask: How can we measure the level of stationarity across sites in a manner that we can rank the sites from less stationary to more stationary? "Stationary" is defined as a characteristic of the process of land transition between multiple time intervals. It means that the mathematical relationship that describes the change during one interval is the same as the mathematical relationship that describes the change in another time interval. Some of the collaborating sites may produce additional land cover maps, so that more dates and sites will be available to assess the concept of stationarity. The maps will be designed for use in conjunction with the LTER's web-based map browser www.lternet.edu/sites1.

Objective 2. We will use a cross-site comparative framework for the integration of map analysis, local knowledge, and social scientific data, as presented by Sayre at the 2010 AAG. The framework: i) identifies key processes of change for each site; ii) estimates the spatial and temporal scales of each process; iii) identifies key mechanisms that link observed changes to drivers; and iv.) identifies interactions among drivers, and serves to estimate the spatial and temporal scales of each driver.

Objective 3. We will draw on our experience with MALS to produce an cross-site, interdisciplinary proposal to the NSF Coupled Human and Natural System program. To help meet objectives #1-#3, we will hold at least two meetings in the coming year. The LTER Network Office has already awarded funds to convene one meeting of the MALS group to be hosted by the BNZ LTER and scheduled for October 7 and 8 in Fairbanks, Alaska. The October 2010 meeting will focus on initiating our cross-site synthesis of results, establishing a time and place for the second meeting for additional progress, and conceptualizing the CNH proposal and establishing key members of the proposal writing team. Based on the success of the MALS session at the AAG in 2010, a follow-on session on MALS will be organized for the 2011 AAG Meetings in Seattle. In addition, we will continue to update the MALS website to help communicate important research questions and our findings.

SGS-LTER MALS Activities 2010-2011: During 2009-2010 period we designed a survey to evaluate reasons why farmers and ranchers decide to put land in CRP programs and remove land from dryland cropping systems. We are currently talking to farmer/ranchers in Weld county Colorado and anticipate having the survey completed by the end of this summer. The activities proposed for the 2010-2011 time include: 1) making land use and other spatial data set from the SGS site available for the MALS group, 2) completing the analysis of CRP/reclaimed land use change survey, 3) starting a survey of farmers/ranchers land use patterns for the NIH historical photograph land use analysis, and 4) contributing to the cross-site comparative framework for the integration of map analysis, local knowledge, and social scientific data, as presented above. The SGS-LTER is also interested in participating the development of the CNH proposal.

We will build on the approach we adopted in 2009. We have been using arial photographs from 1930-2000 to determine land use changes from sites near the SGS LTER site. We propose to contact landowners for the agricultural land being analyzed in the arial photographs and determine reasons for the land use changes that have been documented via the arial photographs. We will also attempt to evaluate the accuracy of the land use patterns determined using our land use classification scheme.

Part C. Request for an International Travel Supplement in Support of a New LTER International Research Collaboration

US LTER Sites/Collaborators	South African Site/Collaborators
SGS-LTER (Alan Knapp and Gene Kelly)	SEAON (Tony Swemmer, Lousie Swemmer)

Introduction, Background and Justification: Of the myriad threats that global climate change poses to species, ecosystems and the ecological interactions that bind them, arguably none is more dramatic than when ecosystems and their inhabitants become “climate refugees”. Although the term climate refugee was originally coined for people displaced from their homes by climate change, the concept can be applied to ecosystems as well. In general, any ecosystem or species is vulnerable if their distribution abuts an uninhabitable boundary and if climate change renders its current locale unsuitable and pushes it towards that boundary. Since migration is not always possible, some species and even ecosystems may disappear locally, regionally or globally. Particularly at risk are ecosystems surrounded by uninhabitable landscapes due to human impacts (i.e., conversion of land for agriculture, urbanization, etc.). This is often the case for nature reserves originally set aside specifically with the goal of providing a refuge for species and ecosystems, but now embedded in human-dominated landscapes. Such ecosystems are extremely vulnerable because migration is not an option. A striking example of an ecosystem in peril of becoming a climate refugee is the *Acacia-Combretum* savanna in the 18,989 km^2 Kruger National Park (KNP) in northeastern South Africa. The *Acacia-Combretum* savanna ecosystem within KNP provides habitat for most of the original large ungulates and carnivores that inhabited the savannas of sub-Saharan Africa. This includes the endangered black rhino and African wild dog, white rhino, elephant, African buffalo, cheetah, leopard, lion, blue wildebeest, and hippopotamus. The *Acacia-Combretum* savannas, of which there are many sub-types, were once widespread across southern Africa but today KNP protects the last extensive intact tracts remaining. Within KNP, strong rainfall and temperature gradients (warmer and drier in the north, wetter and cooler in the south) structure the two dominant ecosystem types, with the purportedly frost-intolerant Mopane (*Colophospermum mopane)* savannas (or veld) occupying much of the northern half of the park and the *Acacia-Combretum* savannas dominating in the more mesic southern half.

Compared to *Acacia-Combretum* savanna, Mopane savanna is reported to have higher woody plant density, lower grass productivity, and reduced diversity of plants and large herbivores. Although conservation action over the past decade has expanded the contiguous savanna habitat of KNP by linking the park with the Gonarezhou National Park to the north (Zimbabwe) and the Limpopo National Park (Mozambique) to the east, resulting in an increase in the size of the protected savanna habitat to 35,000 km^2, KNP is bounded to the south by land-use dominated by a growing human population. This makes the *Acacia-Combretum* ecosystem particularly vulnerable to the effects of climate warming since the Mopane savanna ecosystem has the potential to move south with increased temperatures, but migration is not an option for the *Acacia-Combretum* ecosystem. Although the threat of climate change and the potential consequences of Mopane migration southward in this region are acute, fundamental knowledge of the basic ecology of Mopane and *Acacia-Combretum* ecosystems is lacking, particularly with regard to the mechanisms that delimit these two savanna types and the potential ecosystem consequences of Mopane-dominated savanna extending its range southward in this region.

The overarching goals for the proposed research are to (1) assess the potential for the Mopane savanna to move south in KNP with climate change, and (2) quantify the consequences for ecosystem structure and function of Mopane replacing *Acacia-Combretum*. A critical component of accomplishing the first goal will be to identify the ecological mechanisms that limit the present distribution of Mopane as well as the factors likely to alleviate these limitations in the future. Below we provide additional background information and then describe a series of complementary studies that utilize experimental and observations approaches in both the lab and field to accomplish these goals.

Trajectories of climate change for southern Africa savanna: Climate change forecasts for South Africa are similar to predictions for many other regions around the world: continental warming between 1-3 ˚C and increased variability in precipitation patterns. Increased precipitation variability is expected to occur with no change in annual quantity of rainfall; instead, periods of delivery of rainfall are forecast to be condensed into shorter periods of time and with longer dry periods between rainfall events. For northeast South Africa in particular, predictions of changing precipitation patterns are primarily due to more intense storms. The ecological impacts of more extreme and variable precipitation patterns are well-established in North American grasslands (Knapp et al. 2002, Fay et al. 2008, Heisler-White et al. 2008) with a key consequence being reduced grass productivity and decreased soil water availability in mesic grassland regions. It is not unreasonable to expect similar ecological responses in these South African savannas given the similar precipitation amounts and growing season temperatures (Knapp et al 2006). Thus, a functionally warmer and drier future is forecast for this region, with drier conditions a product of two climate change factors: increased evapotranspiraton due to warming and increased precipitation variability.

***Determinants of the distribution of Mopane*:** Mopane savanna and woodland currently covers 555,000 km^2 throughout southern Africa with tree density ranging between 2,000-5,000 individuals per hectare. At large spatial scales, the most cited explanation for Mopane's southern distributional limit is its inability to cope with low temperatures. Mopane is described as frost intolerant, and the historic distribution of the species is restricted to the south by the 5 ˚C mean daily minimum isotherm. In KNP, Mopane occurrence and distribution has also been characterized as an edaphically-driven factor. Currently, Mopane distribution in KNP occurs further south on granites (with functionally drier, coarse textured soils) compared to the basalts (with functionally wetter, fine textured soils). Data from long-term studies suggest that woody plant cover has increased since the 1970's on soils derived from granite (Trollope et al. 1998, Eckhardt et al. 2000).

There is anecdotal evidence that Mopane savanna is becoming more dense and moving south in KNP (Peel et al. 2007) however, the mechanism(s) that drive this expansion are largely unknown. Warming temperatures provide a proximal explanation for a shift south in the extent of this community type. As the 5 ˚C isotherm moves south at a projected speed of 0.67-1.0 km/year with forecast climate change, the climate barrier that potentially regulates the southern distribution of Mopane will shift south. The combination of a warmer and drier environment may also favor Mopane indirectly, as these conditions should have negative impacts on the growth and productivity of grass species and the more mesic *Acacia- Combretum* savanna. Thus, if the primary barrier of Mopane moving south in KNP is related to competitive interactions within the grass layer of more mesic and productive ecosystems, then climate change will operate through an indirect mechanism. Unfortunately, despite a moderately large literature on the ecology of Mopane (see review below), we lack much of the fundamental knowledge required for assessing the limits to the southern migration of this ecosystem. Such knowledge is critical for evaluating the vulnerability of the species-rich *Acacia-Combretum* savannas in KNP to Mopane expansion, and more generally would provide insight into the mechanisms by which one strongly dominant woody species invades and displaces a more diverse community dominated by the same growth form.

Study site in Kruger National Park: Based on extensive aerial surveys we conducted in July 2009, we identified a central region of KNP between Phalaborwa (N) and the Timbevarti river drainage for this research. This study region has several advantages including (1) its location within KNP (providing security for experiments and equipment not available outside the park), (2) the headquarters and lab facilities of the Ndlovu Node of the South African Ecological

Observatory Network (SAEON) are located in Phalaborwa (see Facilities and Equipment description), (3) the relatively abrupt southern boundary of the Mopane savanna has been mapped here (Fig.2), (4) the two dominant parent materials in KNP both occur here, parallel with the N-S climate gradients and (5) preliminary sampling of soils and plants in this region has allowed us to identify many accessible sites where the ecotone is abrupt and other potential confounding factors can be eliminated.

Research questions and proposed studies: To evaluate the potential for Mopane savanna to migrate southward with future climate change, the research we propose below is designed to address three fundamental questions:

(A) What have been the fine-scale dynamics of the southern Mopane boundary in KNP over the last 400 years on the two major parent material types?

(B) What are the ecological mechanisms determining the present-day southern Mopane distribution growth and establishment in KNP and how will these processes be altered with climate change?

(C) What are the potential consequences of Mopane savanna expansion for ecosystem structure and function?

Transect studies: Four transect will be established on both soil parent materials (granite and basalt). Each of these 8 belt transects will be divided into ten 10 x 10 m plots. In addition, we will establish an additional 10x10m plot at a distance of 1000m from the ecotone on each belt transect to characterize an 'older' site of each ecosystem. Within these 10x10m plots, we will characterize the plant community, estimate aboveground biomass, and collect soil and plant samples for pedological and phytolith analyses.

Plant community composition: We will sample woody plant composition and abundance using a line-intercept method and the herbaceous understory community using a modified Daubenmire method. For each 10 x 10 m plot we will establish three 10 m transects, each spaced 3 m apart. Along each transect, we will estimate cover of each woody plant species based on the length of transect intercepted by each species. Measurements will be conducted both early and late-season and maximum cover values for each species will be used to calculate species richness, diversity and evenness, as well as assess compositional differences (via NMDS and Principle component analysis; Collins and Smith 2006).

Aboveground biomass: Herbaceous ANPP will be estimated from end-of-season harvests of 0.1 m^2 quadrats within 1x1 m temporary exclosures erected at the beginning of the growing season. We have used these exclosures previously for assessing the impacts of grazers on ANPP in KNP. We will sample 5 quadrats per plot in every other 100 m^2 sampling plot along each transect, for a total of 480 quadrats harvested each year on each soil type. Biomass will be sorted into grass, forb, current year's dead and previous year's dead components. For the woody plant component, we will use allometric relationships developed by SAEON personnel for Mopane, *Acacia nilatica* and *Combretum apiculatum* (the two dominant tree species along the ecotone) to estimate standing aboveground biomass of foliage and woody components.

Soil Characteristics and Phytolith Abundance: Adjacent to each 10x10 m plot, three randomly located pedons will be sampled by genetic horizon to the bottom of each soil pit (1m or to bedrock). We will measure particle size, pH, % base saturation, exchange acidity, exchangeable bases, bulk density, and total elemental analyses in each sample (Soil Survey Staff 1994). Nutrient analyses will include organic C, total N and available P. We will quantify total organic C and N and total P and available P pool sizes (Ippoliito et al 2010). Adjacent to each 10x10 m plot used for community composition analysis, soil samples will be collected (in 10cm depth increments to 50cm) at 3 locations and leaf tissue from the dominant woody and herbaceous plant species will be sampled for phytolith determinations (Kelly 1990).

Project Management and Timeline: We will rely heavily on the assistance and expertise of Dr. Tony Swemmer, the SAEON Ndlovu Node Manager. Swemmer's offices and facilities are located at the Phalaborwa Gate of KNP and are equipped with considerable laboratory equipment and field supplies. Kelly (soil ecology), along with a graduate student will take primary responsibility for phytolith analysis, nutrient cycling and belowground sampling, whereas Melinda Smith (plant community and ecosystem ecology) will focus on the herbaceous community and ecosystem consequences of Mopane dominance as well as the field competition studies. Dr. Smith has ongoing research (with Knapp) south of the Mopane boundary near the Satara region of KNP. The CSU budget includes funds to support travel for Dr. Smith to the Mopane research site.

Significance of proposed research : The proposed research has obvious significance and value for KNP specifically and southern Africa in general. The diverse and charismatic animal communities of the *Acacia -Combretum* savanna are an invaluable regional resource of biodiversity, as well as a major source of revenue for the local economy via ecotourism. Moreover, if adaptive management practices to climate change are to be effectively employed by KNP scientists, the mechanisms controlling Mopane expansion must be identified, as well as the soils type most vulnerable to Mopane migration. Equally important is a rigorous evaluation of the potential ecosystem consequences of Mopane migration – beyond that for the animal community. Regionally, the species-poor Mopane savannas and woodlands cover vast areas and thus represent a more xeric ecosystem capable of displacing more mesic and species-rich communities far outside the boundaries of KNP. From an ecological perspective, understanding the future dynamics of ecosystems – both the nature and pace of change - with chronic and directional alterations in climate represents a key challenge to ecologists today.

Community outreach: The project will employ utilize two research assistants who currently work for the SAEON Ndlovu Node. They are both from a small rural village (Welverdiend) that directly borders the KNP. As is typical of rural villages in the region, poverty and illiteracy are high and unemployment is in excess of 50%. By making use of their time and skills, the project will provide needed justification for the employment of local, rural people by SAEON, and thus contribute to employment in the region. Furthermore, the village of Welverdiend is situated just south of the current boundary of Mopane trees in the region. Villagers there are aware of the value of the species for high quality fuelwood (used for cooking and warmth in these villages) and sustenance (Mopane worms are considered a delicacy in rural areas to the north) but not the potential negative impacts of the loss of *Acacia-Combretum* savanna. Knowledge of global climate change by villagers is at most rudimentary, despite the potential for substantial impacts on their lives. As a means of outreach, we will partner with existing programs at SAEON (see below) to conduct a series of presentations to the people of Welverdiend, explaining global climate change, and using the potential spread of Mopane trees to illustrate how climate change could impact their lives. The SAEON research assistants will be used to liaise with the local community, and translate the presentations into the local language.

The SAEON School-Level Outreach Program: The project will involve collaboration with Louise Swemmer, the Manager for Social and Economic Research in Kruger National Park (KNP), as well as local secondary schools currently involved with the outreach program of the SAEON Ndlovu Node. This collaboration will focus on the impacts of Mopane expansion on tourism. Together with social scientists from KNP, we will design a questionnaire for tourists entering and leaving KNP (through the Phalaborwa and Orpen gates which are the closest to the Mopane ecosystem and experience high volume of tourists). Questions will focus on whether the tourists prefer driving through areas dominated by Mopane vs. other savanna types, and perceptions of wildlife density and diversity in these different areas. Children will also be taken into KNP by the social scientists, and will conduct their own basic assessments of the game-viewing potential in areas dominated by Mopane vs. *Acacia-Combretrum*. We will then work with the children to analyze and interpret the social and ecological data collected and use these results to demonstrate the local consequences of global-scale change.

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Part D. Equipment

From an ecological perspective, the climate of the SGS LTER is defined by cold winters, hot summers and annual evaporative potential that exceeds precipitation by more than three-fold. Both temperature and evaporative cycles are driven by the amount of solar radiation reaching the SGS LTER land surface. The degree to which incoming radiation affects air temperatures is strongly affected by the amount of water available to evaporate. Because the amount of precipitation is relatively low at the SGS LTER, the majority of incoming radiation is converted to sensible heat (Pielke and Doesken 2008). Mean annual temperature at the SGS is 8.8°C, with monthly averages ranging from -2.8°C in January to 21.7°C in July (Hochstrasser et al. 2002). On shorter time scales, the high elevation, low relative humidity and relatively low cloud cover induce wide daily temperature variations, with min to max daily temperature ranges of 7.5 – 8.8°C. Winds buffet the SGS LTER, especially through the growing season, creating a relatively thin boundary layer along the ground surface, and thus high evaporative potential. This combination of insolation, wind and temperature regimes induces a mean annual potential evapotranspiration of 1250 mm per year (Sala et al. 1992 using Penman 1948) as compared to mean annual precipitation of 330mm.

Decades of work on the SGS LTER have documented the importance of interannual variability in climate for the structure and function of the ecosystem (Lauenroth and Burke 2008). From our existing climate record, we have documented long-term trends in temperature and rainfall, and as the effects of climate change become more pronounced, we expect these trends to grow and new trends to emerge. Numerous field experiments and models are currently in place to understand the relationship between climate and ecological function. The accurate and precise measurement of the SGS climate is therefore one of the most fundamental datasets of our site.

We are requesting funds to upgrade and improve our aging weather station which has been in service for nearly 30 years. With our emphasis on responses to climate change, these improvements will allow us to continue our long-term research with a solid and reliable weather monitoring station in place. These upgrades will improve the reliability of our measurements and decrease the incidence of missing data due to instrument problems. More importantly our new instrumentation will match that used by the ARS on other parts of the CPER. This will allow us to make spatial comparisons with LTER and ARS data which we cannot now do because we cannot rule out that any differences are due only to instrumentation.

We are requesting funds for the instruments listed below as well as supports and cables to house them at our existing met station. We are also requesting funds for installation by biological electronics technician Dave Smith who has managed similar instruments on the shortgrass steppe for many years. We do not currently have the necessary expertise for installation within the SGS LTER project.

The requested equipment will allow us to use state-of-the-art equipment to measure not just basic weather information (temperature, wind speed and direction, relative humidity, precipitation, air pressure), but we will also be able to develop a more sophisticated energy budget for the site. This energy budget (including incoming and outgoing radiation, soil temperature and pan evaporation) will allow us to better understand the site's water budget. An array of soil moisture probes will further document these dynamics. The equipment manufacturer, Campbell Scientific, is a recognized leader in this instrumentation.

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Part E. Information Management

Our long-term goals for the SGS Information Management (IM) Team include improving the quality and availability of all SGS-LTER related data, metadata and products, such as integrated cross-site datasets. We propose to facilitate the use of SGS-LTER data online and contribute to Network efforts as well as the broader community with the following activities.

1) To help increase our web delivery and public access to data and EML compliant metadata built on emerging best practices and standards for the LTER Network we are requesting funds to support our assistant field crew leader through the off-season. Our efforts will address both the quality and quantity of data and metadata served online by appending data and metadata content to existing tables, as well as by building new tables for datasets and information that need to be migrated to the new database.

2) Our assistant field crew leader understands our field data and metadata and can help us improve linkages between data and metadata. Our existing database is already built to include researcher's contact information, related publications and datasets, with links to our broader research objectives within the SGS-LTER conceptual framework, as well as LTER core areas. We need a person experienced in the origin of the data to obtain and populate the content, and feel that our assistant field crew leader has the necessary field (4 summers) and lab (3 academic years) experience.

3) The SGS-LTER IM Team will work on issues of how to generate EML for SGS-LTER GIS data, by contributing to the development of proposed LTER spatial data standards, and continuing improvements of location data in our EML metadata for long-term studies. To further these goals we are requesting funds to allow a member of our IM Team to attend a three-day workshop, being organized by the Andrews Experimental Forest LTER site, to improve network-wide cooperation in this effort. Participation by an SGS-LTER representative will allow SGS-LTER GIS data and metadata to be more easily used by Network projects such as LTERmapS.

4) To further cross-site efforts in IM, we are requesting funds to send our Information Manager to an the American Society for Information Science and Technology Meeting, to present ongoing cross-site data integration work and to support preparation of associated materials such as

documentation or a poster. An integrated cross-site dataset produced with net aboveground primary production from four LTER grasslands sites also will be published in the Ecological Society of America's Data Archives. Data integration is a critical process for synthetic research. Sharing our experiences, tools and integrated data sets should have useful applications across the Network and beyond.

This work would enhance the SGS-LTER information management system and the availability of information, as well as contribute to and coordinate with Network-wide developments in GIS, It also would provide a venue for growth and professional development and sharing by presenting different approaches to IM related challenges in performing data integration and supporting synthesis in LTER-wide research.

Part F. Release of Funds Withheld for Budgetary Reasons

We are requesting release of the 15% of funds withheld from our 2008 proposal due to budgetary constraints when the award was issued. We will use these funds as detailed in the renewal proposal.