1999 SGS-LTER Progress Report

I. RESEARCH

During 1998 and 1999 we produced 58 papers in refereed journals, 16 book chapters, 9 dissertations and 25 abstracts from national and international meetings. 17 graduate students and 22 undergraduates work on research related to the shortgrass steppe LTER. Scientists at our site are involved in a number of new experiments in addition to continuing our long-term projects. This section is organized by a modified version of the LTER core areas including: Populations and Processes, Biogeochemistry, Paleoecology/Paleopedology, Disturbance, and Water and Energy Dynamics. An online version of this document is also available at our website (http://sgs.cnr.colostate.edu).

1. Populations and Processes

Our work since our last progress report has focused on continuing to sample our long-term projects and to continue several new studies initiated with our latest grant. The new plant work consisted of studying the spatial distribution of weeds and initiating a seed bank study. The new animal work involved expanding the work on prairie dogs begun in 1997. Belowground work centers on understanding the effects of grazing on microbial communities.

Plants

Spatial distribution of weeds: Weeds, especially exotic plants, represent one of the most serious challenges to the current structure and function of ecosystems. A key first step in understanding the problem in a particular area is to investigate which species are present, where they are located and how abundant they are. This research focused on the distribution of exotic plant species or weeds, in the Pawnee National Grassland. Forty-five paired roadsides and rangeland sites were surveyed to estimate the species richness, percent canopy cover and number of individuals in 3 x 1 meter plots. The results demonstrated that roadsides contain significantly fewer native species than the rangeland (p-value<.0001). Very few exotic species were found on the range (average per 3 m^2 plot = .42 species) while the roadsides contained significantly more (average = 4.6 species). It appears that the roadside exotic plant species are not encroaching on the native rangeland. The results also suggested a spatial relationship that exotic species, especially grasses, may be less prevalent in the northern part of the Pawnee, possibly due to less dense agricultural activity in the north. In addition, this study showed a significant difference (p-value=.01) in native species richness when grazed and ungrazed roadsides were compared. A higher percent of canopy cover of native grasses, blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*), occurred on the grazed roadsides. In conclusion, upland sites in the Pawnee National Grassland at this time are not experiencing a problem with invasive plant species. However, it is difficult to tell if this will persist.

This field season we are conducting a seed bank study looking at the relationship of distance to the roadside to the abundance of exotic plant species. In addition, soil moisture dynamics up to 90 centimeters on the roadsides and range will be analyzed throughout the field season. To isolate why roadside exotic plant species have not encroached onto the native rangeland, we have begun a field manipulative experiment. Two exotic species, cheatgrass (*Bromus tectorum)* and Dalmation toadflax (*Linaria dalmatica)*, have been planted in the Pawnee National Grasslands and a matrix of treatments: grazing, irrigation, nitrogen, and disturbance, has been applied.

Animals

Animal Monitoring Programs**:** Since 1994, we have estimated population sizes of nocturnal small mammals, rabbits, and, to a lesser degree, terrestrial carnivores, on the SGS-LTER site in north-central Colorado. These monitoring programs continued in 1998-1999, including live-trapping studies in May and roadside counts of rabbits and canids in October, January, April, and July. We continued monthly warm-season surveys of terrestrial macroarthropods, studies that were also initiated in 1994. Captures of major insect taxa are counted in 90 pairs of pitfall traps placed along a 1 km topographic gradient as part of new long-term monitoring studies. In addition, we continued arthropod pitfall trapping studies on trapping webs established for monitoring abundance of small mammals. Twenty traps were placed on each of three upland grassland and three saltbush sites. Pitfall traps are run for 4-5 consecutive days on three occasions during summer months to track temporal changes in abundance of arthropods, which are important food items for rodents in shortgrass steppe, as a possible determinant of trends in rodent numbers.

Beginning in July 1997, we modified our roadside census route to include areas of the Pawnee National Grasslands (PNG), taking advantage of the 1996 SGS-LTER site expansion. We have continued to utilize this new route which includes more upland prairie habitats used by white-tailed jackrabbits *(Lepus townsendii)* and swift foxes *(Vulpes velox)*, while continuing to allow us monitor rabbit and canid populations on portions of the Central Plains Experimental Range.

Prairie Dog Studies: Prairie dogs (*Cynomys ludovicianus*) influence their surroundings in many ways. These herbivorous mammals change local plant community structure by cropping vegetation, and they modify the soil structure by burrowing and building mounds. These changes in vegetation and edaphic factors may influence insects such as beetles and grasshoppers that live in prairie dog towns.

We have completed two years of research aimed at understanding the relationship between short-horned grasshoppers (Orthoptera: Acrididae), darkling beetles (Coleoptera: Tenebrionidae) and prairie dogs. In the summers of 1997 and 1998, we found lower densities of grasshoppers on prairie dog towns than on off-town sites. In 1997, all four sampling dates were different, however in 1998 only July and August were significant by month. We also found that prairie dog activities alter the composition of grasshopper species. While off-town sites are composed of 47% Gomphocerinae, 39% Oedipodinae and 14% Melanoplinae, prairie dog towns were 37% Gomphocerinae, 50% Oedipodinae and 12% Melanoplinae. Looking at these groups will be a step toward determining the importance (including possible keystone species status) of prairie dogs in the shortgrass steppe.

We have also begun an experiment aimed at understanding how prairie dogs in the shortgrass steppe regulate body temperature during the winter months. Observational data suggests the black-tailed prairie dogs do not hibernate, but rather enter a state of deep torpor. We implanted several prairie dogs with small thermometers in an attempt to track changes in body temperature relative to air temperatures. In addition, we sampled fatty tissues from these animals to better understand how they utilize fat reserves in coping with low temperatures. Preliminary data appears to confirm that black-tailed prairie dogs do not hibernate.

Belowground Processes

Impacts of Grazing on Soil Biota and Processes: This project involves manipulating cattle grazing in historically non-cattle grazed and cattle grazed pastures and tracking the changes in above and belowground communities. We moved fences in 1991 to expose previously ungrazed exclosures and to create new exclosures on historically grazed pastures. Yearly sampling has shown a marked shift in the microbial community. Grazed pasture that was taken out of grazing now possesses a community structure that is similar to the ungrazed pasture, and ungrazed pasture that was allowed to be grazed is similar in structure to the historically grazed pastures. The microbial communities began to diverge from one another two years following the manipulations. The complete shift has taken six years to materialize, and was only evident after the last growing seasoning. We are in the middle of processing this year's samples from these sites.

2. Biogeochemistry

In the past year, we have continued our long-term investigations into the controls over biogeochemical pools and fluxes, at several temporal and spatial scales. Below, we summarize our most recent results.

CO_2 Fertilization Study

SGS LTER investigators have successfully received renewal funding for our CO_2 fertilization study, which is also supported by the SGS LTER project. The study utilizes open-top chambers to address three objectives: 1) to determine the impact of doubling CO_2 in shortgrass steppe mixed C_3/C_4 plant communities on net primary production, net ecosystem CO_2/H_2O exchange, C and N allocation both above and below ground, and water and N use efficiency; 2) to determine the impact of doubling CO_2 on soil water and N dynamics on soil water content, C/N distribution in soil organic matter, changes in mineralizable N, NO and N_2O emissions, and consumption of atmospheric CH_4; and 3) to incorporate the knowledge gained from these studies into simulation models that will allow for realistic extrapolation through time and space of soil moisture, nutrient cycling, and plant productivity. Preliminary results from this study indicate that aboveground production in ambient chambers (214 g m^{-2}) exceeded that in control plots (155 g m^{-2}) by 38% for the growing season. Seasonal aboveground production under elevated CO_2 (278 g m^{-2}) was 30% greater compared to that in the ambient chambers. Significant growth enhancements from elevated CO_2 were realized for both C_3 and C_4 grasses. These CO_2-induced growth enhancements were related to improved water relations as well as higher photosynthesis rates. Soil water content was often greater in elevated chambers. Leaf water potentials, determined weekly via pressure chamber, were generally greater in leaves of *B. gracilis* and *P. smithii* grown at elevated CO_2 compared to ambient chambers. Leaf intercellular CO_2 (C_i) photosynthetic response curves indicated that photosynthesis of *P. smithii* was unsaturated at C_i concentrations exceeding 700 L L^{-1}, whereas photosynthesis in *B. gracilis* leaves appeared saturated at approximately 300 L L^{-1} C_i. Photosynthetic capacity of both species was sometimes reduced in plants grown at elevated CO_2, although this response was considerably more noticeable in the C_3 species, *P. smithii*.

Anthropogenic additions of Nitrogen

We are continuing several new studies on the long-term effects of additional N on ecosystem structure and function. Two years ago we manipulated some long-term SGS-LTER N-addition plots, under funding from a separate NSF grant, in an effort to study processes responsible for N retention and availability. In a large-scale, replicated design, we are adding humus precursors to soils to stimulate N stabilization, as well as adding microbial C sources to stimulate immobilization. 15_N labeled additions are being tracked through soil organic matter pools using NMR. We are following N mineralization and plant community composition, with respect to weedy vs. native species. A graduate student associated with this project is conducting greenhouse studies to assess the influence of N and water availability on weed recruitment for shortgrass steppe soils. We examined the response of above and below-ground biomass, plant height, and nitrogen and carbon tissue concentrations in two different species, *Bromus tectorum* (exotic) and *Bouteloua gracilis* (native), to a gradient in nitrogen and competition. The two species were grown in the greenhouse under five levels of nitrogen and five levels of competition. Both species had a significant response to the nitrogen gradient, with *Bromus* having a much stronger response to increasing nitrogen availability than *Bouteloua*, which did not respond to added nitrogen after a certain level, supporting the hypothesis that exotic weeds have a physiology that is primed to take advantage of high nitrogen conditions. Competition significantly affected the aboveground biomass accumulation of both species, although mean separation tests showed that intraspecific competition was the only competition affecting *Bromus*, while the opposite was true of *Bouteloua*. The other measured response variables reacted to the gradients in competition and nitrogen in the same manner as aboveground biomass. Both species exhibited physiological responses that were expected to occur because of the respective differences in their evolutionary histories.

Species effects on biogeochemistry

We continue to focus a number of studies on the impacts of plant species composition on biogeochemical cycling. Much of our earlier work focused on the spatial patterns in biogeochemistry created by plant distributions. Recent studies (Epstein et al 1998a, Epstein et al 1998b, Epstein et al. 1998c) have demonstrated that plant function type (C_3 vs. C_4) can affect both the spatial and temporal patterns of nitrogen cycling in shortgrass steppe. Phenological and nutrient use efficiency patterns result in seasonal patterns of interactions between plants and soil microbial communities with respect to N cycling and uptake, with significant impacts on nitrogen and carbon trace gas fluxes. These differences may result in long-term and large-scale impacts on N cycling, retention, and storage.

SGS-Konza Transect

This project involves characterizing biogeochemical parameters at five locations across a naturally occurring precipitation gradient from the SGS-LTER to Konza LTER in eastern Kansas. We will be measuring soil respiration, in situ nitrogen mineralization, litter decomposition rates, above- and belowground production and C/N ratios, and potential carbon and nitrogen mineralizable pools. We are also interested in how these different systems respond to changes in the quantity of growing season precipitation. We will design and implement precipitation treatments to determine the sensitivity of the different ecosystems (shortgrass steppe, mid-grass prairie, and tallgrass prairie) to alterations in the precipitation regime. Control plots have been established at all 5 locations and we have begun to take the biogeochemical measurements mentioned above.

By the end of this field season, we will have initial samples collected and ready for lab analysis. We will begin work on the precipitation manipulation this fall.

3. Paleoecology/Paleopedology

Pedology/Biogeochemistry: Soil processes play a crucial role in governing the atmosphere-ecosystem exchange of CO_2, water, and energy. Quantifying these exchanges would further our ability to project responses and feedbacks to global climate change and increasing atmospheric CO_2 concentration. To isolate climatic and edaphic influences on the carbon balance of ecosystems we sampled and characterized along a bioclimatic sequence in the front range of Colorado. The bioclimatic sequence established on two parent materials spans elevations of 1600 m to 3500 m with a corresponding precipitation gradient of 30 cm to 105 cm. Temperatures vary considerably throughout the year. Growing season temperatures from 11 ^{0}C to 21 ^{0}C at the lowest elevation range and from 0 ^{0}C to 18 ^{0}C at the alpine sites. The dominant vegetation at the low, middle and high elevations sites consists of grassland, coniferous forest, and tundra, respectively. Atmospheric, ecological, pedological and geochemical analyses were integrated for each ecosystem to assess the seasonal variability and relative importance of ecosystem processes, namely, photosynthesis, respiration, transpiration and evaporation, that control terrestrial carbon exchange with the atmosphere. Our initial results suggest that differences between measured and modeled interannual variability are the direct result of edaphic controls. Results of this ongoing research will add to our understanding of the relationship between CO_2 and H_2O fluxes, enhancing our ability to model regional C dynamics and soil-atmosphere interactions.

Studies of Paleoclimate: To date we have studied many sequences of buried soils in the western extreme of the Pawnee National Grasslands. These buried soils, or paleosols, record the vegetative and climatic conditions which prevailed during the last 10,000 years. These soils, which formed as the uppermost layer of the earth's surface, were buried by the widespread deposition of Holocene eolian, loess, and alluvial deposits. Buried soils are considered to contain information on pre-historic changes in climate and how the earth changed in response. This record provides perhaps the most reliable indication of how the earth may respond to future climate change. To establish vegetative and climatic histories, the stable carbon and oxygen isotopic compostion of various paleosol components were analyzed. We have recently begun a reconnosance survey of soils and landforms of the eastern sector of the SGS. Based on these surveys we have discovered that the geologic substrate and Pleistocene terrace expression differ significantly in the eastern sector of the PNG relative to findings at the CPER. We are applying our current working model of Holocene landscape development to this portion of the grasslands and have selected and sampled sites that will allow us to evaluate a continuous record of Holocene paleoclimate and landscape evolution. In this research we have identified a series of six terraces (a chronosequence) that dates back nearly 1 million years. Our goal for this year is to push our paleoclimatic record into the Pliestocene.

Biogeochemistry of Si in Grasslands: Quantification of processes that control losses and gains of Silica is admittedly difficult since they occur at many spatial and temporal scales. We initiated collaborative research with scientists at the University of California-Santa Barbara which involves the use of isotope geochemistry to integrate the biological and hydrological cycles of terrestrial ecosystems. We have completed two experiments which include the following: In the <u>first experiment</u>, a variety of C_3 and C_4 plants (corn and wheat) were grown in subsamples of the same soil at constant moisture (field capacity) and temperature. These have been chosen for their fast growth rate and propensity to form relatively large amounts of phytoliths compared to other families. The initial d^{30}Si signature of the irrigation water and the water that pass through the soil will be measured periodically as a baseline value against possible Si fractionation. The leaves have been harvested and phytoliths separated (Kelly , 1990) for Si isotopic analysis. In a <u>second experiment</u>, the same suite of grasses will be grown hydroponically in a solution where the d30Si has been previously determined. Once again, thed^{30}Si was monitored periodically for any potential changes in d^{30}Si of the solution Si over time. This particular variation will ensure that the Si taken up into the plant is coming from only one known Si source, thus ruling out any potential competing Si sources that could contribute different d^{30}Si signals. Variations in environmental stresses such as max and min temperature were tested and we will assess their impact on Si fractionation. Regardless, these results will be compared against previously published phytolith values (Douthitt, 1982) to either support or refute the use of δ^{30}Si as a means of refining the study of Si biogeochemistry in soils.Samples are being processed and sent to the UCSB for isotope analyses.

4. Disturbance

In 1997, the LTER and the USFS initiated a fire study with the dual objectives of assessing the use of fire as a management practice to increase nesting habitat for mountain plovers, and examining the effects of fire on plant community structure and productivity. Fire is an integral component of many productive grassland ecosystems such as the tallgrass prairie of the North American Great Plains. A large number of comprehensive studies on fire effects have been conducted in these systems. Because of the low fuel loads, pre-settlement fires probably affected less extensive areas in systems such as the shortgrass steppe. However, small lightning fires may have been frequent in shortgrass steppe, and fire impacts in this system are poorly understood. Studies of fire effects in grasslands somewhat similar to shortgrass steppe suggest a potential loss of productivity in dry years following a fire.

Based on two years of data for relatively wet years, a small reduction in forb production was observed in one year, with no significant effects on any functional group in the other year. Unlike reports from more productive grasslands, there were no effects of fire on plant-tissue nitrogen concentrations or N-yields. Furthermore, fire had very small impacts on herbaceous plant community composition. This is consistent with our hypothesis that aboveground disturbances will have relatively minor impacts on this system. Fire may, however, have an effect on cactus population dynamics. Areas that were burnt had a high number of injured cladodes the year after the fire, but the following year there were nearly an equal number of additional new pads sprouting. The effects of fire on shortgrass steppe may manifest through its effect on cactus, which acts as micro-refuges from grazing by large herbivores. Assessing these potential indirect effects will require additional years of data.

5. Water and Energy Dynamics

In addition to continuing to monitor at a number of long-term sites, we completed several short-term studies of land-atmosphere dynamics. The first study was designed to investigate the feedback between the atmosphere and land surface processes. The second study explored the influence of land-use change and doubled CO_2 on the weather over a season. The third study examines the effect of persistent drought utilizing rainout shelters.

Feedback between the atmosphere and land surface processes: We used the RAMS-CENTURY coupled modeling system to investigate the relationship between weather and vegetation growth (Lu et al. 1999). This study has shown that the feedback between precipitation and above-ground vegetation growth results in wetter and cooler weather, than occurs if this feedback is excluded. This suggests that land surface processes associated with changes in vegetation may have significant impacts on regional weather patterns.

Influence of land-use change and doubled CO_2: We used the RAMS-GEMTM modeling system to investigate the effect of 1) changing the central Great Plains from the current land-use to an estimate of the natural landscape; 2) doubling CO_2 in the radiation calculation in the RAMS model; 3) doubling CO_2 the in the GEMTM component of the model. The model simulation was for 210 days during the growing season in 1989. The control experiment (with the current landscape and CO_2 levels) was compared against observed weather and vegetation growth data. Both the change to the natural landscape and the biological effect of doubled CO_2 produced a cooling over current conditions. This suggests that anthropogenic land-use change exerts a major effect on both short- and long-term weather in the shortgrass steppe and that the effect of increased CO_2 on vegetation may have an important and rapid feedback to weather in the shortgrass steppe.

Rainout shelters: Our climatic analyses of the region have indicated that variability in precipitation increases with decreasing average annual precipitation; our site has very high interannual variability. We are interested in understanding some of the effects of persistent droughts, which have not been experienced since the 1950s. In 1997 we constructed two rainshelters and they have been functional during the 1998 and 199 growing seasons. Both shelters automatically close when precipitation is sensed. Within the shelters, we have control plots (all water from this week's precipitation added back in), half precipitation (half the water added back), and one-third precipitation treatments. We plan to sample these plots at the end of this year's growing season to evaluate the impact of persistent drought.

II. INFORMATION MANAGEMENT

1. Progress To Date

In a continuing effort to bring all of our datasets in line with NSF's 2-year public accessibility guidelines, we have opened 26 datasets to the public. Currently 180 of 208 datasets are open to the public and the data management staff received all of the closed datasets within the past three years. These datasets are available via our website at http://sgs.cnr.colostate.edu. We continue to contact principal investigators on a regular basis regarding the status of their datasets.

During the past year we received funding to connect our field station to the CSU network via a T1 connection. This link is now fully operational, giving computer users at our field station all of the computing facilities available on campus, including simultaneous connections to email, use of network drives, use of networked software, connection to workspaces stored on campus machines, and simultaneous connections to the internet. We also purchased a new Dell PowerEdge 2300 server to function as our web, database, and groupware server. In addition, this NT machine was configured and connected to the network and will allow us to remotely manage NT machines at our field station.

During the past year we completed our migration of our database from Oracle to MS Access. We are now utilizing an integrated set of software tools to reduce application development time. In addition, we have completely redesigned our entire web site providing users with a more professional and consistent look across all of our pages. In redesigning our website, we have strived to include more effective use of navigation buttons and menus resulting in a website that is much easier to navigate.

2. Goals for the Upcoming Year

In the coming year, we plan to focus on three aspects of our information management system. First, we plan to add more projects to our database. Much of the focus of the past year has been on infrastructure development, but now we plan to focus on working with scientists to incorporate newer datasets into our database management system and complete missing metadata for some of the older datasets. Second, we plan to develop a prototype system to help manage project level information shared between the LTER project and the Agricultural Research Service (ARS). We envision that this system will provide current information about all ongoing experiments at the Central Plains Experimental Range (CPER) and will be web enabled to provide querying and updating capabilities via the internet. Ongoing activities include opening more datasets to public access, entering the abstracts of older publications, and improving our website content and design.

3. Geographical Information Systems

In the past year a large emphasis has been placed on continuing the development of a system to georeference all of the study sites on the Shortgrass Steppe LTER site. We have continued to georeference research sites using a hand held GPS unit. By the end of this field season we hope to have all current research sites incorporated into our spatial database. In addition, we have purchased a Trimble Explorer GPS unit for the SGS LTER, which will allow us to use GPS equipment throughout the year. As noted above, we are currently developing an integrated system for managing experiments on the CPER. This system will be spatially explicit and will utilize an internet map server to provide GIS applications via the internet.

III. OUTREACH ACTIVITIES

1. Education

In the past year we have continued our Research Experience for Undergraduate (REU) program with three students working on the following projects: 1) comparison of plant biodiversity of Conservation Reserve Program fields, abandoned agricultural fields, and rangelands, 2) impact of three carbon treatments on active nutrient pools of historic nitrogen and water manipulation plots, and 3) evaluation of metapopulation variables for blacktailed prairie dogs in the shortgrass steppe. This REU program has been extremely successful and we consider it an integral part of education at the shortgrass steppe LTER.

With funding from NSF-DUE (spring 1998), we established schoolyard LTER demonstration plots on the campus of UNC that mimics an experiment at the SGS LTER site. Our objectives are to study the effects of nitrogen availability on the development of the plant and soil communities following a major disturbance. Baseline samples were taken last summer and the treatments were imposed last the fall. The samples were be taken and analyzed by 7 first-generation low-income high school students that are part of the UNC Upward Bound Program (funded by the DOEd) and that are receiving fellowships from the NSF-RAMHSS supplement we were awarded through the SGS-LTER this spring. We envision the schoolyard LTER program becoming a permanent feature of the SGS LTER.

2. Field Trips and Other uses of the Shortgrass Steppe LTER field site

One of the important contributions we make in the area of outreach is to lead field trips for interest groups to our research site. In addition, each year we host several non-LTER groups who are conducting classes or research at our field site. 1998-9 visitors included: University Of Northern Colorado, University of California – Davis, National Park Service, United States Forest Service, USDA APHIS NWRC, Argonne National Lab, US DOE, University Of Wyoming, University California - Riverside, University of Colorado, University of Wisconsin, Utah State University, University of Nebraska, Kansas State University, Colorado State University, Colorado Division of Wildlife.

3. Landmark Volunteers

This August 10 high school students will be visiting the Shortgrass Steppe LTER as part Landmark Volunteer's program, which engages students in two-week work projects across the country. The students will be housed at our field station and will spend approximately one week in the field and one week in the lab assisting with various duties. We expect that this will be the start of a long and fruitful relationship between the SGS LTER and Landmark Volunteers.

IV. Cross-site, Synthesis, and Network-level Activities

We have initiated and continued a number of new cross-site and synthesis studies over the past year. We will divide these into Cross-site, Synthesis, and Network Activities.

<u>Cross-Site:</u> We have a number of cross-site projects ongoing at this time, several of which were initiated in the last year. We have established new treatments on a cross-site NSF project looking at the effects of progressive exclosure on ecosystem structure and function (Milchunas and Detling, with numerous other sites). We continue to complete work on a cross-site NSF project with colleagues in Argentina, addressing the controls over net primary productivity and decomposition (Lauenroth and Burke). We are funded to conduct a cross-site study with Noy-Meir to compare the role of cactus in grazing responses in the U.S. and Israel (Milchunas). We were funded on supplemental funds to begin transect work across Konza to the SGS site; we have two students funded to look at biogeochemical cycling across this gradient (Burke, Lauenroth, McCulley, and Bradford). Van Horne and Wiens were recently successful in obtaining a large EPA grant to address scaling of ecological phenomena along this same gradient; work for this project began this summer. Two PhD projects that spanned sites were just completed; Gill compared the effects of plant functional types on soils in 3 semiarid systems of the U.S., and Barrett compared the responses of grassland systems across a temperature gradient (5 sites, Montana to Texas gradient) to N additions. Finally, we have obtained InterAmerican Institute funding to compare grasslands and agroecosystem C balance in the U.S. with those in Argentina (Paruelo et al). Pielke and others are taking the lead on a major new cross-site endeavor with the San Diego computer center, in which sites will be involved in coupling an ecosystem simulation model with a mesoscale model to assess climatic variability.

<u>Synthesis:</u> Perhaps our most important progress to date in the area of synthesis is that our Shortgrass Steppe synthesis book is well under way. The title of the volume is Ecology of the Shortgrass Steppe: Perspectives from long-term research, and we have a contract with Oxford. Eight chapters have been submitted, with 6 more to come. We currently have a deadline of December for drafts to be submitted to the publisher. As a

second major synthesis project, Lauenroth has taken the lead on a new Issues in Ecology feature issue on North American Grasslands.

In addition, we have published several important synthesis papers during 1998 and 1999, including papers on controls over trace gas fluxes in grasslands (Mosier et al. 1998, 1999), the effects of grazing on the fauna and flora of the shortgrass steppe (Milchunas et al. 1998), the effects of prairie dogs on shortgrass steppe ecosystem (Stapp 1998), and an analysis of the pedogenic history of the shortgrass steppe (Blecker et al. 1998).

Network activities: We continue to be very active in network activities. As mentioned above, Pielke is taking the lead on the cross-site modeling project with San Diego computer center. Burke serves on the Coordinating Committee and the Executive Committee, as well as the new Scientific Synthesis committee for the network. Wasser serves on the network Data Management Coordination Committee, in addition to serving as a member of the regular data management committee.

V. PUBLICATIONS

Journal Articles

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