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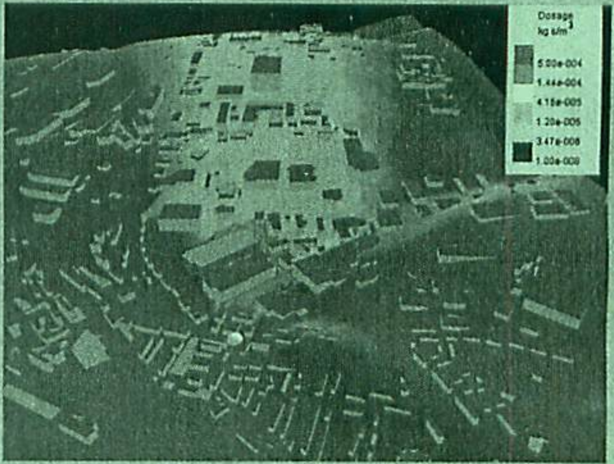

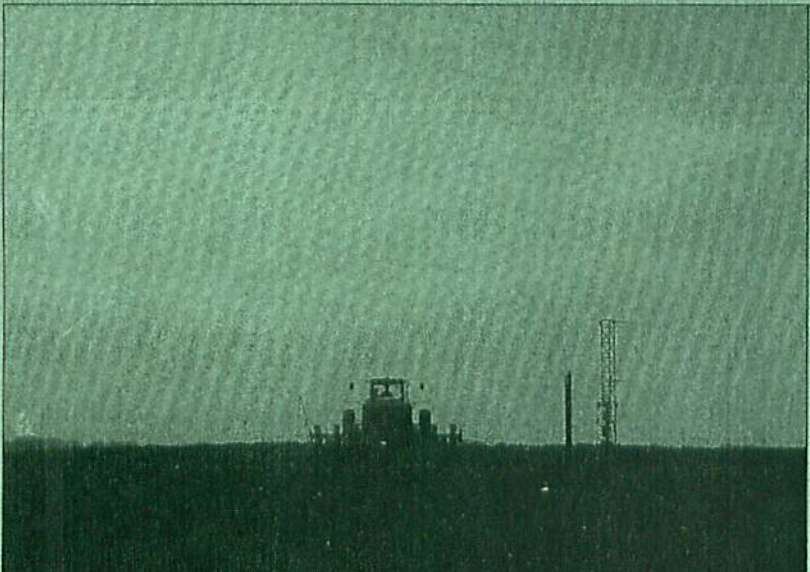

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AMERICAN METEOROLOGICAL SOCIETY

4.1 THE USDA-ARS CO_2 FLUX NETWORK: VARIATION IN RANGELAND CO_2 FLUX ACROSS YEARS AND ECOSYSTEMS

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1. INTRODUCTION

The public debate over climate change and CO_2 sequestration has caused increased scientific interest in CO_2 flux of terrestrial ecosystems. Much of the CO_2 flux research has focused on forested systems because of their high potential for CO_2 sequestration. However, rangelands (grasslands, savannas, and shrub steppes) occupy about 50% of the Earth's land surface, and depending on how one groups categories, 34 to 50% of U.S. land area (Box, 1990). Even if the CO_2 fluxes of these plant community types are low compared to forests, the large area occupied by rangelands requires that they be considered in developing terrestrial CO_2 flux budgets.

The research described in this paper is a joint effort among ARS rangeland and pasture scientists from ten western states in cooperation with the Texas Agricultural Experiment Station, Temple, TX, (Svejcar et al., 1997). The project is focused on an assessment of CO_2 fluxes over native rangelands at each participating location.

2. METHODS

The locations involved included Tucson, AZ. (both a shrubland and grassland site), Ft. Collins, CO., Dubois, ID., Miles City, MT., Mandan, ND., Woodward, OK., Burns, OR., Temple, TX., Logan, UT. (scientists at this location cooperated with Dubois), and Cheyenne, WY.

Four years of data (1996-1999) were available for most sites. At all sites, above-canopy 20 min average CO_2 fluxes were measured continuously using BREB instrumentation (Model 023/CO_2 Bowen ratio system, Campbell Scientific, Inc., Logan, UT, USA). Methods for calculating fluxes followed those published previously (Dugas, 1993). In this paper negative fluxes are downward, toward the surface. In brief, temperature and humidity gradients were measured every 2 s at canopy height and one meter above the canopy surface. Concurrently, CO_2 gradients were measured at the same heights using an infrared gas analyzer (LI-6262, LI-COR, Inc.). Other data needed for BREB calculations were obtained from net radiation sensors (model Q*7 net radiometer, REBS, Seattle, WA., USA), soil heat flux plates (model HFT3, REBS), and averaging soil temperature thermocouples (model TCAV, CSI) located above each heat flux plate. Net radiometers were calibrated against a laboratory standard (model 7.2 REBS) above a grass canopy. Bowen ratios were calculated from temperature and humidity data. The turbulent diffusivity, assumed equal for heat, water vapor, and CO_2, was then calculated. Average 20 min CO_2 fluxes were calculated as the product of turbulent diffusivity and 20 min CO_2 gradient, correcting for vapor density differences at the two heights (Webb et al., 1980). For more detailed discussion of the methods, see Angell et al. (2001), Frank and Dugas (2001), and Sims and Bradford (2001).

Aboveground biomass and green leaf area index (LAI) was measured by clipping plot frames (most locations used 0.25 m^2 plots, although plot size varied with location). Leaf material was separated from stems and scanned for area with optical area meters. Number of samples varied from 4 to 20 per sampling period across locations. Sampling was conducted at peak biomass. Roots were sampled with soil cores. Precipitation was measured at each site.

3. RESULTS AND DISCUSSION

We developed correlations between peak monthly CO_2 flux or average CO_2 flux (7 to 9 months of data) and biomass, LAI, and precipitation. Values were averaged over years and the intent was to compare the relationships across locations. The results indicate that both LAI and precipitation are significantly correlated to CO_2 flux (Table 1).

Table 1. Relationships (r^2) between CO_2 flux and other measured variables.

		Annual Precip.	LAI	Above Ground Biomass	Root Biomass
Avg. CO_2 flux	r^2	-0.41	-0.46	-0.21	0.002
	n	10	8	10	7
Peak CO_2 flux	r^2	-0.46	-0.72	-0.37	0.08
	n	10	8	10	7

n= number of sites for which data is available

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Linear multiple regression using LAI and annual precipitation to estimate average CO_2 flux yielded an r^2 of 0.83 (P=0.028).

We have not completed gap-filling for the winter period, but where annual estimates are available, rangelands appear to be a net sink for atmospheric CO_2 during average to above average precipitation years (Table 2). Given the variability over years, long-term weather data will be important in estimating source/sink relations of various ecosystems.

Table 2. Annual CO_2 sequestration estimates (g $CO_2/m^2/yr$). Positive Values indicate net sequestration.

	OR	ID	ND	OK	TX
Mean Flux	177	365	125 to 209[1]	257	1100
Range	-326 to 535	14 to 833	-	-168 to 582	-200 to 3900
Years	1995 to 1999	1996 to 1999	1999	1995 to 1997	1993 to 1999

[1] Winter fluxes were estimated using both BREB and soil flux chamber techniques.

4. CONCLUSIONS

Native rangelands appear to be a sink for atmospheric CO_2, although yearly weather variation controls sink/source relationships. The ability to predict ecosystem peak CO_2 flux from LAI and annual precipitation suggests that remote sensing and meteorological modeling may be useful technologies in estimating CO_2 fluxes at large spatial scales.

5. REFERENCES

Angell, R., Svejcar, T., Bates, J. Saliendra, N., Johnson, D., 2001: Bowen ratio and closed chamber carbon dioxide flux measurements over sagebrush steppe vegetation. *Agric. Forest Meteorol.*, **108**, 153-161.

Box, T.W., 1990: Rangelands. In: R.N. Sampson and Hair, D. (Eds.), *Natural Resources for the 21st Century*, Island Press, Washington D.C.

Dugas, W.A., 1993: Micrometeorological and chamber measurements of CO_2 flux from bare soil. *Agric. Forest Meteorol..*, **67**, 115-128.

Frank, A.B., Dugas, W.A., 2001: Carbon Dioxide Fluxes over a Northern, Semiarid, Mixed-Grass Prairie. *Agric. Forest Meteorol.*, **108**, 317-326.

Sims, P.L., Bradford, J.A., 2001: Carbon dioxide fluxes in a southern plains prairie. *Agric. Forest Meteorol.*, **109**, 117-134.

Svejcar, T., Mayeux, H., Angell, R., 1997: The Rangeland Carbon Dioxide Flux Project. *Rangelands*, **19**, 16-18.

Webb, E.K., Pearman, G.I., Leuning, R., 1980: Correction of flux measurements for density effects due to heat and water vapor transfer. *Quarterly Journal Royal Meteorological Society*, **106**, 85-100.