4.7 ANNUAL CARBON DIOXIDE FLUXES ON NATIVE SAGEBRUSH RANGELAND IN EASTERN OREGON

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1. INTRODUCTION

The world's temperate deserts and semi-deserts are important ecosystems and occupy about 5.85×10^8 ha worldwide (West, 1983). More than 10% of the worldwide total, about 7.8×10^7 ha, is located in North America and more than 50% of the North American total is classified as the Western Intermountain sagebrush steppe ecosystem (4.5×10^6 ha). Although these ecosystems have relatively low annual aboveground net primary production (West, 1983), they are extensive and are important as watersheds, wildlife habitat and animal forage.

Because of the extent and variability of these ecosystems, they may play an important role in the worlds carbon (C) balance, even though maximum carbon dioxide (CO_2) flux rates are often limited by inadequate precipitation.

One suitable approach for determining CO_2 flux on rangelands is to employ micrometeorological techniques. The Bowen ratio energy balance is suited to rangelands, and has been shown to compare well to other methods (Dugas et al., 1997; Angell et al., 2001).

The objective of this research was to quantify daily CO_2 fluxes above an intact, ungrazed sage brush steppe in the northern Great Basin.

2. METHODS

Measurements were made from 1995 through 1999 over sagebrush steppe at the Northern Great Basin Experimental Range, Range (43° 29'N 119° 43'W; 1,380 m elev.), about 64 km west of Burns, OR. The study site was a 65 ha ungrazed Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *Wyomingensis*) community (canopy cover=10%). Understory species include Thurber's needlegrass (*Stipa thurberiana* Piper), bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Löve), Sandberg's bluegrass (*Poa sandbergii* Vasey.), bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) Smith), prairie lupine (*Lupinus lepidus* Dougl.), hawksbeard (*Crepis occidentalis* Nutt.) and longleaf phlox (Phlox longifolia Nutt.). Livestock have not grazed the community since 1995. Mean annual precipitation (61-yr) is 294 mm, and mean annual temperature is 8 °C (NOAA, 1999). Soils are coarse-to-fine sandy loam and classified as Aridic Duric Haploxerolls and Orthidic Durixerolls in the Holte-Milcan complex with 0-2% slopes.

Above-canopy 20-min average CO_2 fluxes were measured continuously using Bowen ratio energy balance (BREB) instrumentation (Model 023/CO_2, Campbell Scientific, Inc., Logan, UT, USA). Methods for calculating fluxes followed those detailed elsewhere (Dugas, 1993; Angell et al. 2001). 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 CO_2 fluxes were calculated as the product of turbulent diffusivity and the 20-min CO_2 gradient, correcting for vapor density differences at the two heights (Webb et al., 1980). Negative values indicate plant uptake of CO_2 (flux toward the surface).

We were not able to maintain the equipment during winter, and start/end dates for data collection varied each year, with the shortest interval in 1999 (235 days) and the longest in 1997 (320 days). Daily flux totals were determined, and monthly fluxes were calculated as the product of average daily flux and days in the month. For this presentation, wintertime flux was assumed to be 1.3 g CO_2 m^{-2} day^{-1}.

Above-ground biomass was measured by clipping 25 1-m^2 plots at approximately two-week intervals. Plant cover and density was measured along 30-m transects. Shrub biomass was estimated by harvesting all plants along four 30-m transects. Precipitation was recorded at the BREB site.

3. RESULTS AND DISCUSSION

This region is characterized by a short period of adequate soil moisture in spring, followed by summer drought. Plants begin growth in April, with peak growth in late May and June (Fig. 1).

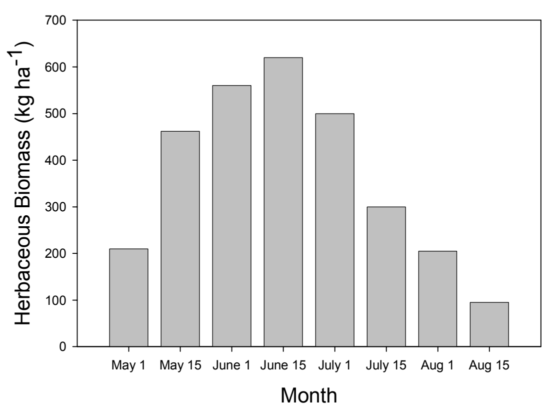

Figure 1. Typical pattern of live herbaceous standing crop development on sagebrush rangeland in eastern Oregon. Data are based on the 1998 growing season.

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Active CO_2 uptake generally began in April, and continued through August (Fig. 2). Average daily uptake peaks in May at about 5 g CO_2 m^{-2} d^{-1}, just as maximum forage yield is being reached. As summer drought began fluxes rapidly declined, approaching zero in September. Plant growth, especially during July and August, varied greatly among years, causing large

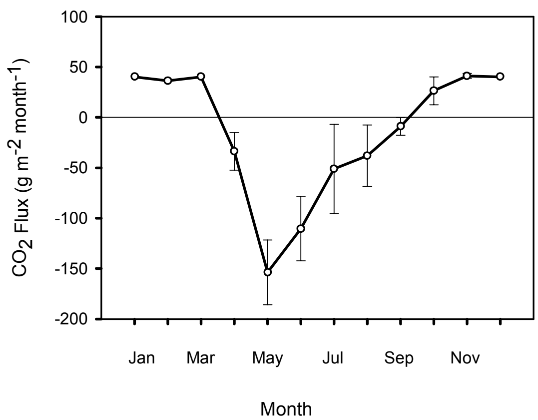

Figure 2. Mean monthly flux of CO_2 over ungrazed sagebrush steppe near Burns, Oregon between 1995 and 1999. Negative flux is toward the surface.

interannual variation in flux. This region can experience freezing night-time temperatures during the growing season. Plants are not hardened to frost at this time and damage can occur (Larcher, 1975; Smith and Knapp, 1990). In June 1996, freezing nighttime temperatures (-6 °C) occurred during peak growth two consecutive nights (DOY 170-171). Following that, average daily fluxes were positive for the remainder of the growing season, with the site becoming a source of CO_2 for the year. Large interannual variation in response to environmental fluctuation and irregular events requires that flux measurements be obtained over several years (Goulden et al., 1996).

During the five years presented here, annual CO_2 flux averaged -0.2 kg CO_2 m^{-2} y^{-1}, indicating that this plant community is likely a small sink for carbon dioxide, although they may be inflated because annual precipitation was near normal each year. This region commonly experiences multi-year droughts during which plant growth is severely limited. Annual fluxes from 1995 through 1999 were 0, 0.3, -0.3, -0.5, and -0.3 kg CO_2 m^{-2} y^{-1}. These values are smaller than the 1.1 kg CO_2 m^{-2} y^{-1} reported for tallgrass prairie (Suyker and Verma (2001), reflecting the lower lower productivity on these semiarid rangelands.

4. CONCLUSIONS

During this study sagebrush steppe vegetation assimilated enough CO_2 to provide a small sink for C in three of five years. Annual summer drought generally limits plant growth to the April-June period, with only limited growth in fall. The magnitude of the sink reported here may be larger than the long-term average because we did not measure fluxes during an extended drought. However, even a relatively small level of sequestration over the 4.5×10^8 ha sagebrush steppe is significant. Further research is needed to measure the dynamics of winter CO_2 flux. Additionally, long term (10-y or more) data records are needed to determine the amplitude of interannual flux variation on these Great Basin rangelands.

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