# Carbon Dioxide Flux on Sagebrush Rangeland in Eastern Oregon

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## Introduction

Atmospheric carbon dioxide ($CO_2$) is taken up by plants and is utilized through photosynthesis to create sugars that are later used to grow leaves, stems, and roots. Carbon dioxide concentration in the atmosphere is steadily increasing for various reasons, but burning of fossil fuels provides the major contribution to this increase. Plants buffer this increase by assimilating atmospheric $CO_2$. Scientists have attempted to balance the distribution of $CO_2$ between what are called sources and sinks. Sources release $CO_2$ into the air; sinks remove it from the air.

Rangelands occupy about 50 percent of the world's land surface area and could play an important role in the global carbon cycle. They are less productive than forested systems, but because of their extensive distribution they have the potential to sequester significant amounts of carbon. Sagebrush-steppe occupies more than 88 million ha in western North America, but very little is known about the magnitude and seasonal dynamics of $CO_2$ uptake by plants. We initiated this study to measure the flux over this important ecosystem as influenced by environment and management.

## Experimental Protocol

Measurements began in 1995 and are continuing through 2006 in an effort to determine the effect of climatic variability on $CO_2$ fluxes. The study was established on sagebrush-steppe at the Northern Great Basin Experimental Range (43° 29'N 119° 43'W; 1,380 m elevation), about 64 km west of Burns, Oregon. The study site was a 160-ha ungrazed Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *Wyomingensis*) community (10 percent canopy cover). 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. Above-canopy 20-minute-average $CO_2$ flux was measured continuously using Bowen ratio energy balance instrumentation (Model 023/$CO_2$, Campbell Scientific, Inc., Logan, Utah, USA) (Fig. 1). 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

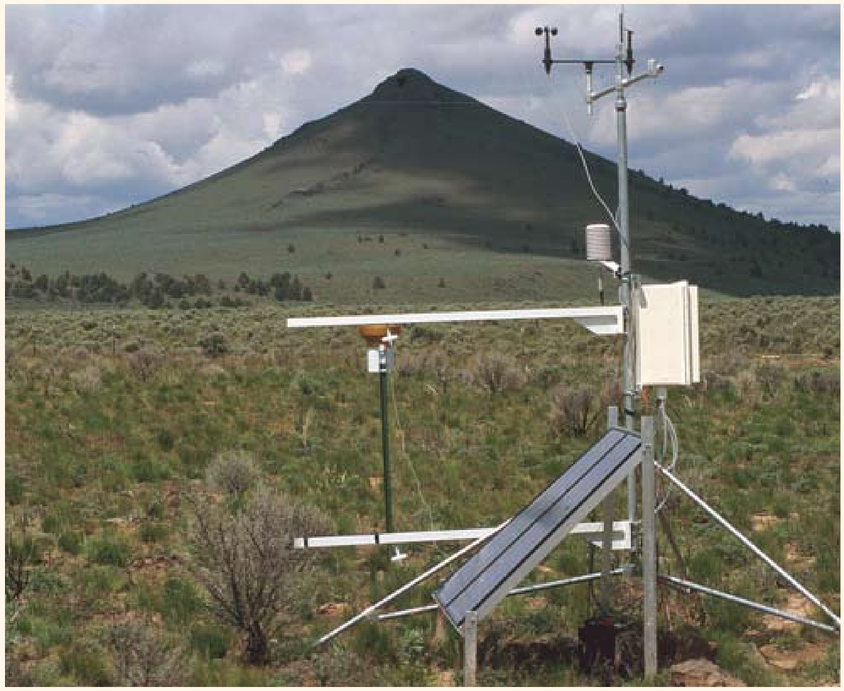

*Figure 1. Bowen ratio energy balance instrumentation (Model 023/$CO_2$ Campbell Scientific, Inc., Logan, Utah, USA)*

turbulent diffusivity and the 20-minute $CO_2$ gradient, correcting for vapor density differences between the arms of the system. Samples were obtained at 75 and 175 cm above the ground. Negative values indicate plant uptake of $CO_2$ (flux toward the surface).

## Results and Discussion

This region is characterized by a short period of adequate soil moisture in spring, followed by summer drought. Active $CO_2$ uptake generally begins in April. Peak $CO_2$ uptake occurs in May and June, with lower flux rates in July and August (Fig. 2). Coincident with maximum forage yield, average daily uptake usually peaks in late May at about 5 g $CO_2$ $m^{-2}$ $d^{-1}$, and then steadily declines, approaching zero in September. Plant growth during July and August varies greatly among years, based on soil water content and results in large variations of $CO_2$ flux between years. Also, this region can experience freezing nighttime temperatures during the growing season, resulting in damage to plant tissues. In June 1996, freezing nighttime temperatures (-6°C) occurred during peak growth on two consecutive nights. Following the frost, $CO_2$ released to the atmosphere exceeded uptake by plants and the site became a source of $CO_2$ for the year.

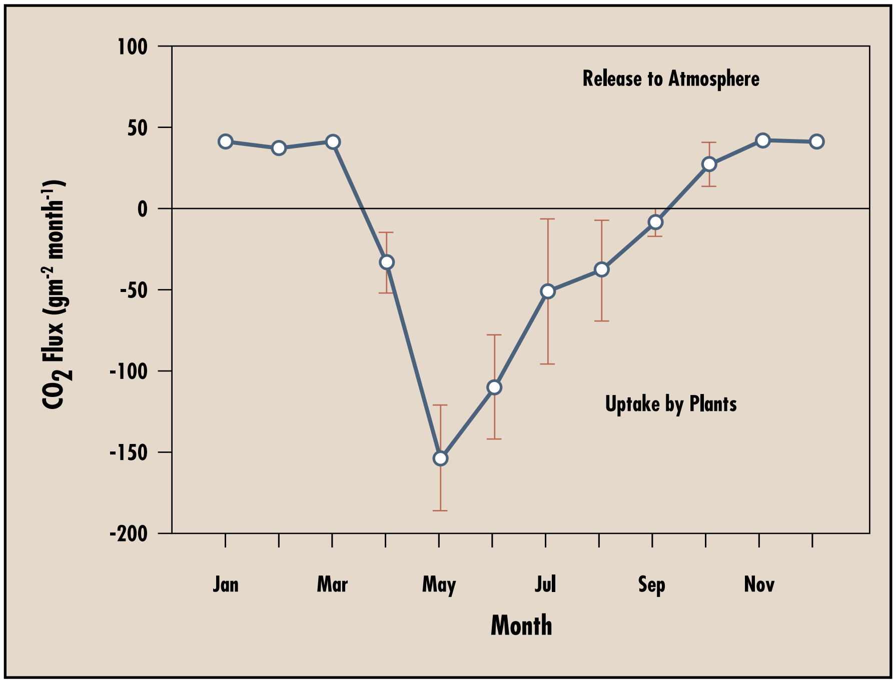


*Figure 2. Five-year average monthly carbon dioxide flux over ungrazed sagebrush-steppe on the Northern Great Basin Experimental Range in southeast Oregon. Negative flux is toward the surface.*

Annual $CO_2$ flux on this site has averaged -0.2 kg $CO_2$ $m^{-2}$ $y^{-1}$, indicating that this plant community is a $CO_2$ sink, although this may be an overestimate because we have not experienced a severe drought during this study. Annual $CO_2$ fluxes have ranged from 0.3 to -0.5 kg $CO_2$ $m^{-2}$ $y^{-1}$. These values are about half of the 1.1 kg $CO_2$ $m^{-2}$ $y^{-1}$ reported for tallgrass prairie, reflecting the lower productivity of these semiarid rangelands.

## Implications

Based on data obtained here, sagebrush-steppe ecosystems in the northern Great Basin usually are sinks for atmospheric $CO_2$, and are sequestering carbon in the soil. Even though the magnitude of annual $CO_2$ uptake is smaller than in ecosystems with longer growing seasons, this uptake is important because of the large number of acres covered by sagebrush-steppe in western North America.