Responses of Methane (CH_4) Cycling to Grazing and Velvet Mesquite (*Prosopis veluntina*) Expansion and Removal in the Santa Rita Experimental Rangeland

ARID-LAND AGRICULTURAL RESEARCH CENTER

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Introduction

• Extremes in soil aridity led to the traditional belief that semiarid rangelands do not contribute strongly to atmospheric greenhouse gas concentrations, but recent efforts show that these soils, in fact, do cycle vast amounts of trace gases (Striegl *et al.*, 1992; McLain and Martens, 2006).

• We are studying the influences of mesquite growth and control on methane (CH_4) production and consumption in the Santa Rita Experimental Range (SRER). Such rangelands cover more than 200 million ha of land area in the Western US (Mitchell, 2000).

Why Methane?

• Atmospheric CH_4 is a radiatively active trace gas that is second only to carbon dioxide (CO_2) in its contribution to anthropogenically-induced global warming.

• Since the beginning of the Industrial Revolution, levels of atmospheric CH_4 have more than doubled. Much of this rise has been associated with human activities, including natural gas production, livestock domestication, and rice farming.

• Microbial activity in soils can be both a source (Figure 1) and a sink (Figure 2) for CH_4. Soils are the largest terrestrial CH_4 sink, in the absence of which, atmospheric CH_4 concentrations would rise at 1.5 times the current rate.

• Structured monitoring of CH_4 fluxes across different dryland systems is needed to increase current understanding of the role that semiarid soils play in the global CH_4 budget. Because semiarid soils cover 33% of the terrestrial land mass, research examining environmental controls on CH_4 production and consumption is of particular importance.

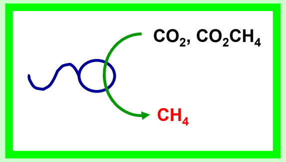

Figure 1. Methanogenic (CH_4-producing) organisms, which reduce precursors, including CO_2 and acetate, to CH_4. Methanogenic activities are strictly anaerobic and will not occur in the presence of molecular oxygen.

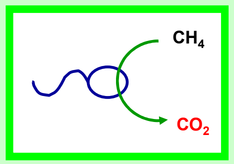

Figure 2. Methanotrophic (CH_4-consuming) microbes oxidize CH_4 to CO_2. Substrate sources include CH_4 diffusing into the soil from the atmosphere, or CH_4 produced in nearby anaerobic soil particles.

SRER Field Research Sites

• We monitored CH_4 fluxes over two monsoon seasons (2004 and 2007) in sites beneath a mature mesquite (LIVE site) (Photo 1), an open site dominated by grasses (OPEN site) (Photo 2), and a site under a mesquite skeleton that was killed with herbicides 40 years earlier (DEAD site) (Photo 3).

• Sites for each mesquite vegetation type were duplicated. One set was located in a grazed area (Pasture 2S, SRER), where animal stocking has been maintained at 0.03 animals y^{-1} since the 1970s. The second set of sites were located within the nearby Rodent Station grazing exclosure, an area that has been fenced to prevent grazing for nearly 100 years.

Photo 1: LIVE Site

Photo 2: OPEN Site

Photo 3: DEAD Site

Methods

• Static chamber gas fluxes were measured once weekly. Lids were affixed and sub-samples of the chamber atmosphere were removed every 10 min for 40 min (Photo 4).

• Samples were analyzed using a Shimadzu GC14-A Gas Chromatograph (GC), fitted with a Flame Ionization Detector and a Supelco 80/100 HayeSep-Q column.

• Soil moisture was measured using a Delmhorst KS-D1 Digital Soil Moisture Tester and model GB-1 gypsum blocks permanently installed in the soil at 10 and 20 cm depths. Soil temperature was measured at 3 depths to 15 cm using a digital stem thermometer (Indoor Products)

• Porespace gas concentrations were collected using probes of our own design installed at 10, 20, 30, 50, 75, and 100 cm depths (Photos 5 and 6). Gases were collected from sampling ports on each probe and analyzed by GC.

Photo 4

Photo 5

Photo 6

Results

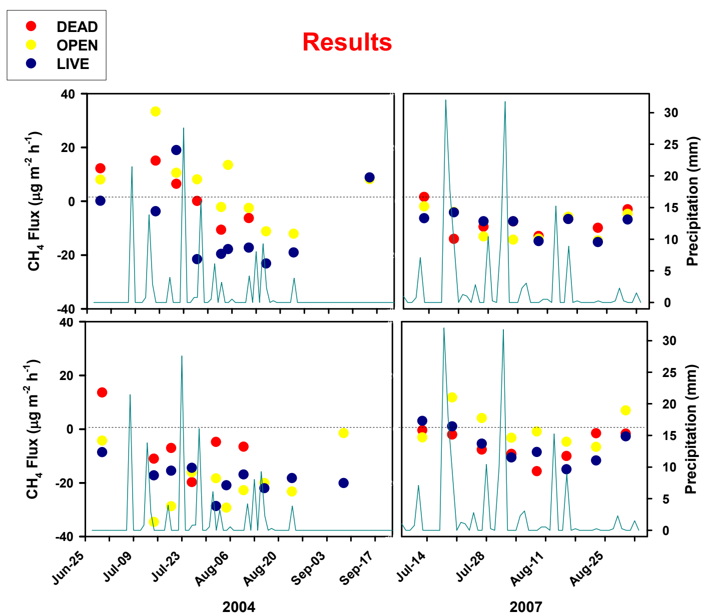

Figure 3. Net surface flux of CH_4 in Grazed (top) and Rodent Station (bottom) sites over the Monsoons of 2004 (left) and 2007 (right).

• Both the grazed and non-grazed sites showed net CH_4 production in the early monsoon of both years. As the monsoon progressed, the CH_4 source became a net CH_4 sink (Figure 3).

• The non-grazed Rodent Station sites consumed CH_4 at a rate nearly double that of the grazed sites (-9.4 and -4.6 µg CH_4 m^{-2} h^{-1}, respectively).

• The strongest contributors to the CH_4 sink were the LIVE mesquite sites, where flux averaged -10.8 µg CH_4 m^{-2} h^{-1} over both monsoon seasons, while flux in the OPEN and DEAD sites averaged -5.7 and -4.4 µg CH_4 m^{-2} h^{-1}, respectively.

Results, Continued

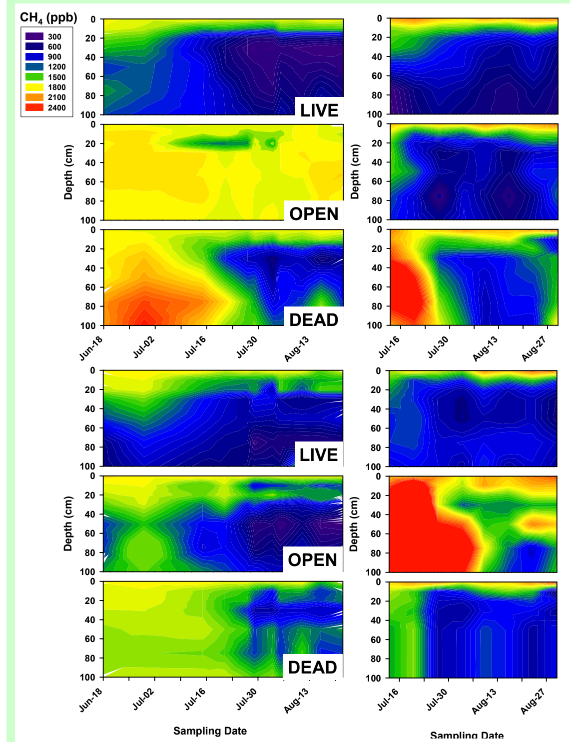

Figure 4: Porespace CH_4 to 100 cm in Grazed (top) and Rodent Station (bottom) sites in the Monsoons of 2004 (left) and 2007 (right).

• The strengthening of the CH_4 sink with the progression of the monsoon that was evident in surface flux measurements, was also found in nearly all sites over both monsoons (e.g., Figure 4 LIVE Grazed, 2004 and 2007; OPEN Rodent Station, 2004 and 2007).

• It is apparent that the strength of the LIVE CH_4 sink (Figure 3) is due not only to methanotroph activity in the upper soil layers, but also to an absence of CH_4 production in deeper soils.

• The CH_4 production in early monsoon, evident in surface flux measurements, was also apparent in porespace CH_4 concentrations (e.g., Figure 4 DEAD Grazed, 2004 and 2007; OPEN Rodent Station, 2007).

Additional Work

• Soil and environmental data collected throughout the 2-season study are being incorporated into models to test the ability of these factors to account for variability in net CH_4 surface fluxes. Such models may be useful in predicting CH_4 sources and sinks in semiarid soils through the Southwestern US.

• CH_4 production is most likely due to methanogen activity in the guts of subterranean termites, which produces 20 – 150 Tg of CH_4 per year on a global scale (Bachelet and Neue, 1993). We are currently exploring the feasibility of using insect tracking techniques (Hagler and Jackson, 2001) to quantify the contributions of termites to CH_4 production in the SRER.

References

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