# Moisture Controls on Trace Gas Fluxes From Semiarid Soils

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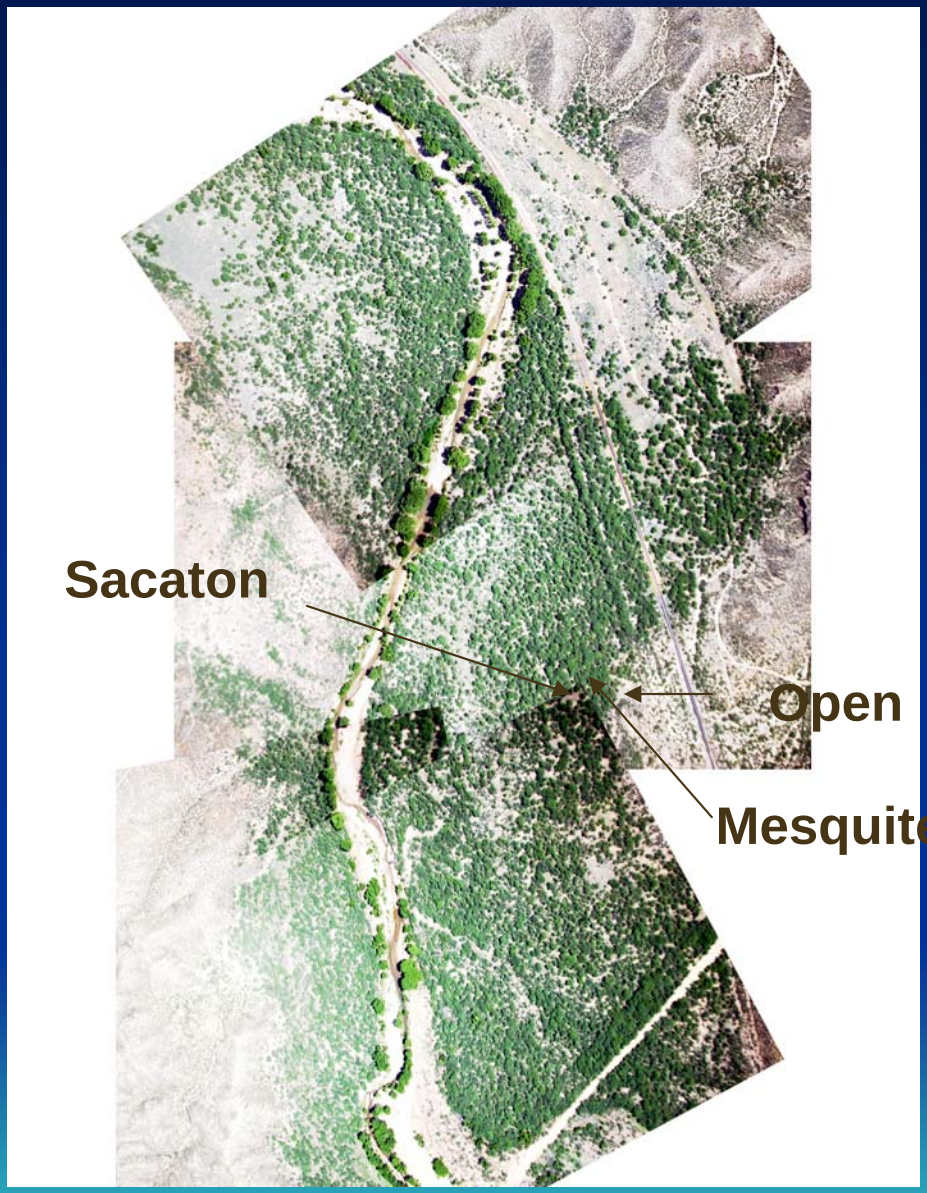
# Semiarid Concepts

- **Due to limited rain and high seasonal temperatures that limit plant productivity, semiarid systems are not important in global C dynamics?**
- **Semiarid ecosystems do not contribute to or mitigate atmospheric C concentrations involved in potential climate disruptions**




**Study site was the San Pedro Riparian zone near Tombstone AZ.**

**The San Pedro is the last nearly perennial, non dammed semiarid stream in the southwest.**

**It occupies an important avian – North – South flyway between the Rio Grande and the Colorado Rivers**

# Vegetation Response to Seasonal Moisture

**July 2002**

**15 mm rain in 7 months**

**August 2002**

**200 mm rain in 1 month**

# Three Vegetation Sites

**Mesquite Community**

**Annual grasses and forbes**

**Sacaton site**

# Instrumentation and Methods

Ambient $CO_2$ and soil factors

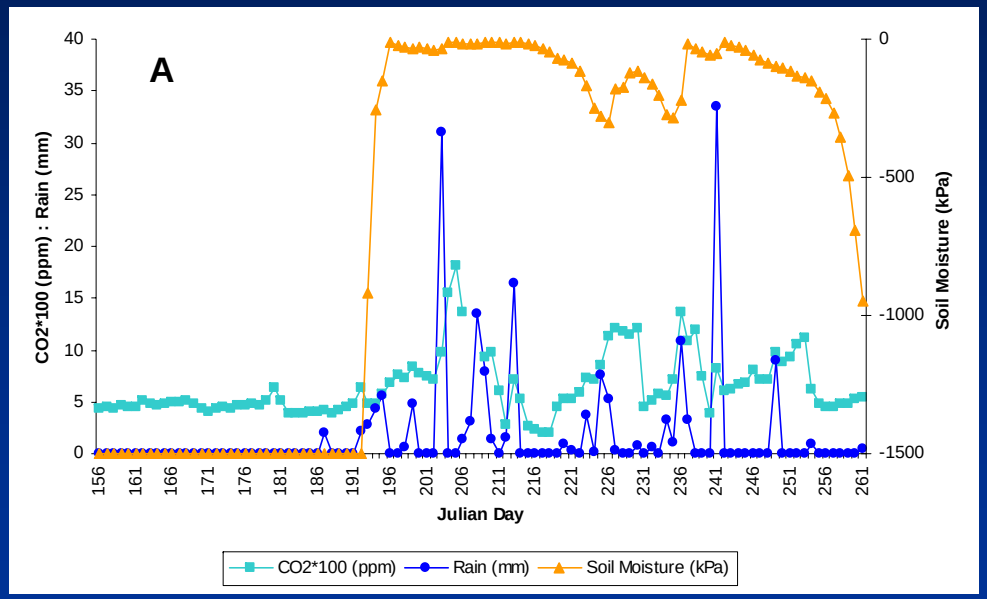
$CO_2$ flux and isotope collection

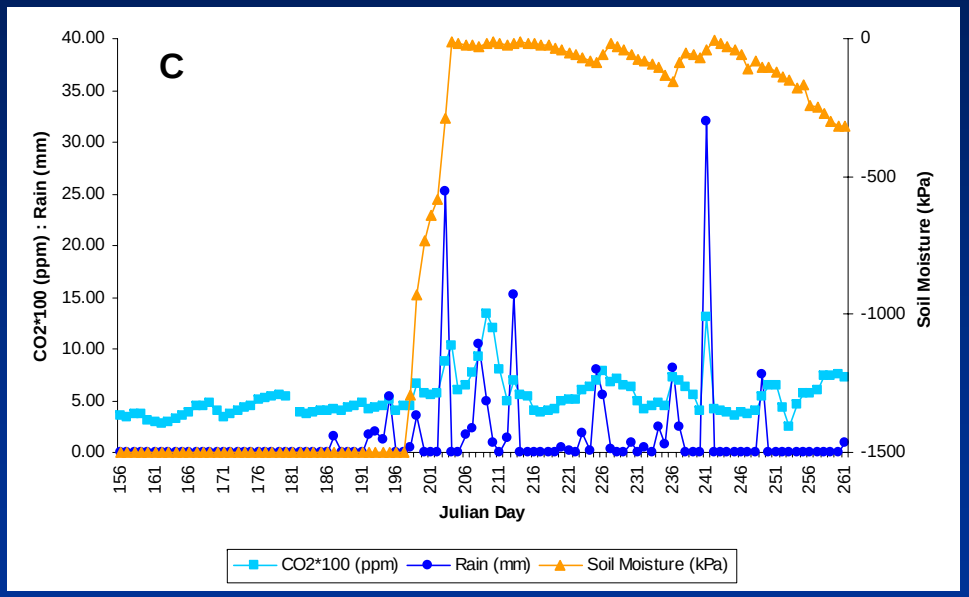
Trace gas sampling

# Soil Properties

| Soil | Depth | Organic C ($g\ kg^{-1}$) | δ13C (‰) | Total N ($g\ kg^{-1}$) | C/N |
|---|---|---|---|---|---|
| **Mesquite** | Plant | -- | -27.1 | -- | -- |
| | O-H | -- | -22.7 | -- | -- |
| | 0-5 cm | 29.9 | -20.2 | 3.08 | 9.7 |
| | 5-10 | 12.7 | -18.9 | 1.36 | 9.4 |
| | 10-20 | 10.5 | -18.7 | 1.01 | 9.8 |
| **Open** | Plant | -- | -19.9 | -- | -- |
| | O-H | -- | -18.4 | -- | -- |
| | 0-5 cm | 5.83 | -18.3 | 0.63 | 9.2 |
| | 5-10 | 6.04 | -18.8 | 0.58 | 10.3 |
| | 10-20 | 3.76 | -17.1 | 0.37 | 10.3 |
| **Sacaton** | Plant | -- | -13.5 | -- | -- |
| | O-H | -- | -13.4 | -- | -- |
| | 0-5 cm | 17.6 | -16.0 | 1.81 | 9.7 |
| | 5-10 | 11.6 | -15.3 | 1.21 | 9.6 |
| | 10-20 | 10.9 | -14.5 | 1.23 | 11.0 |

# Ambient $CO_2$ Response to Rainfall




**Open annual grass site – 697 ppm average**

**Mesquite site – 448 ppm average**

**Jan 1 – July 2002 = 15 mm; 2002 monsoon = 238 mm; Total for 2002 = 293 mm**

**Jan 1 – July 2003 = 40 mm; 2003 monsoon = 95 mm ; Total for 2003 = 232 mm**

# Carbon Dioxide Flux 2002 – 2003

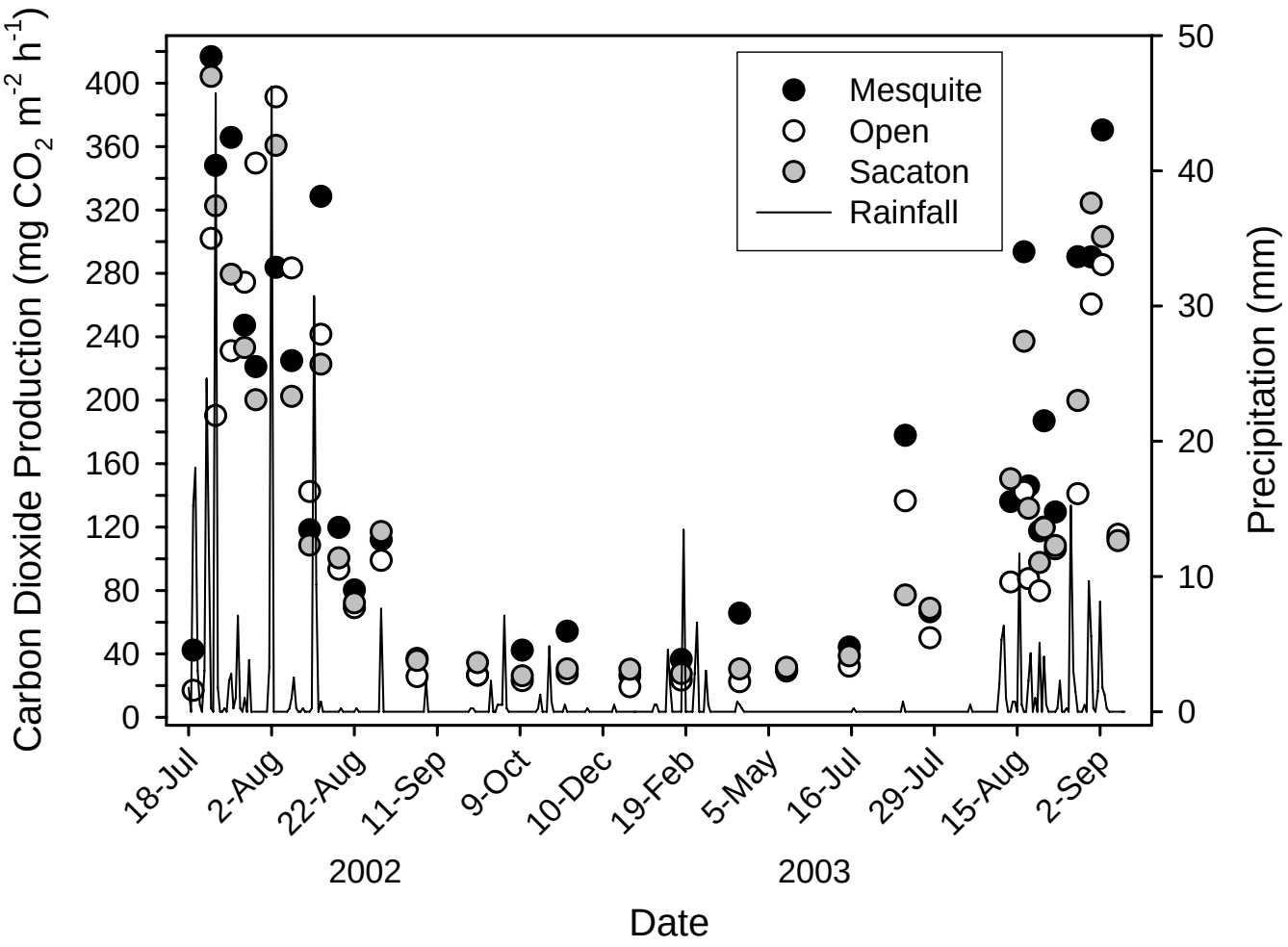



**Figure 3.** Carbon dioxide efflux from three SPRNCA vegetation sites on measurement dates during 15-month monitoring period (July 2002 through September 2003). Symbols are averaged values from 2 or 3 flux collars installed at each site.

**2002 Monsoon = 123 - 126 mg $m^{-2}$**

**Winter = 80 -109 mg $m^{-2}$**

**2003 Monsoon = 72 – 105 mg $m^{-2}$**

**2002 vs. 2003 40% reduction, yet during the 2002 season the 5X difference in soil C did not impact fluxes**

# Isotopic Composition of $CO_2$ Flux

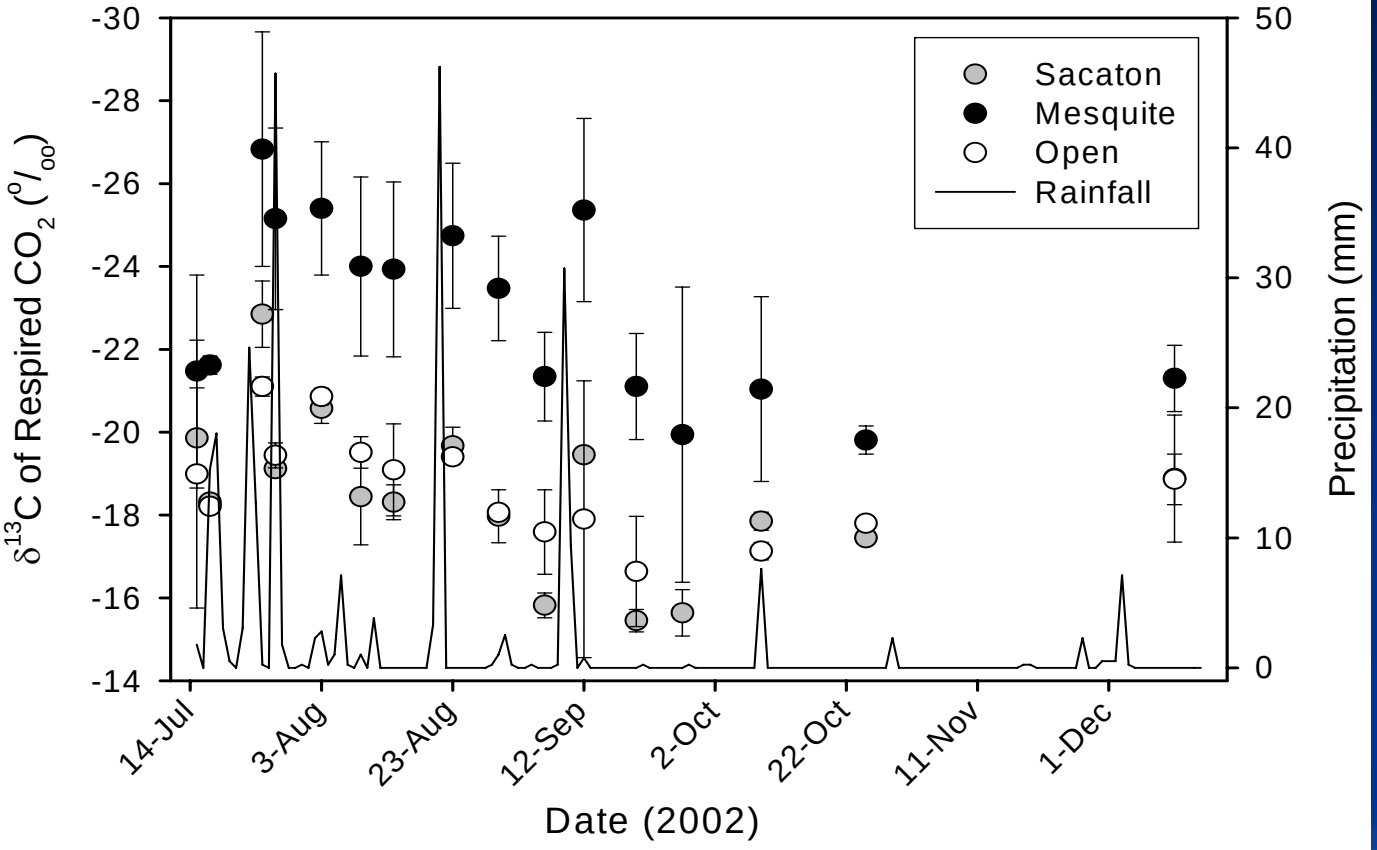



**Figure 4.** Isotopic composition of carbon dioxide respired from soil surface in three SPRNCA vegetation sites on measurement dates during monsoon and post-monsoon (July through December) 2002. Symbols are averaged values of two carbon dioxide collections per site on each sampling date, plus or minus standard deviation.

**Mesquite site = 63 to 98% $C_3$-C**

**Open and Sacaton site = 50 to 65% $C_4$-C**

# Methane Oxidation Rates 2002 – 2003

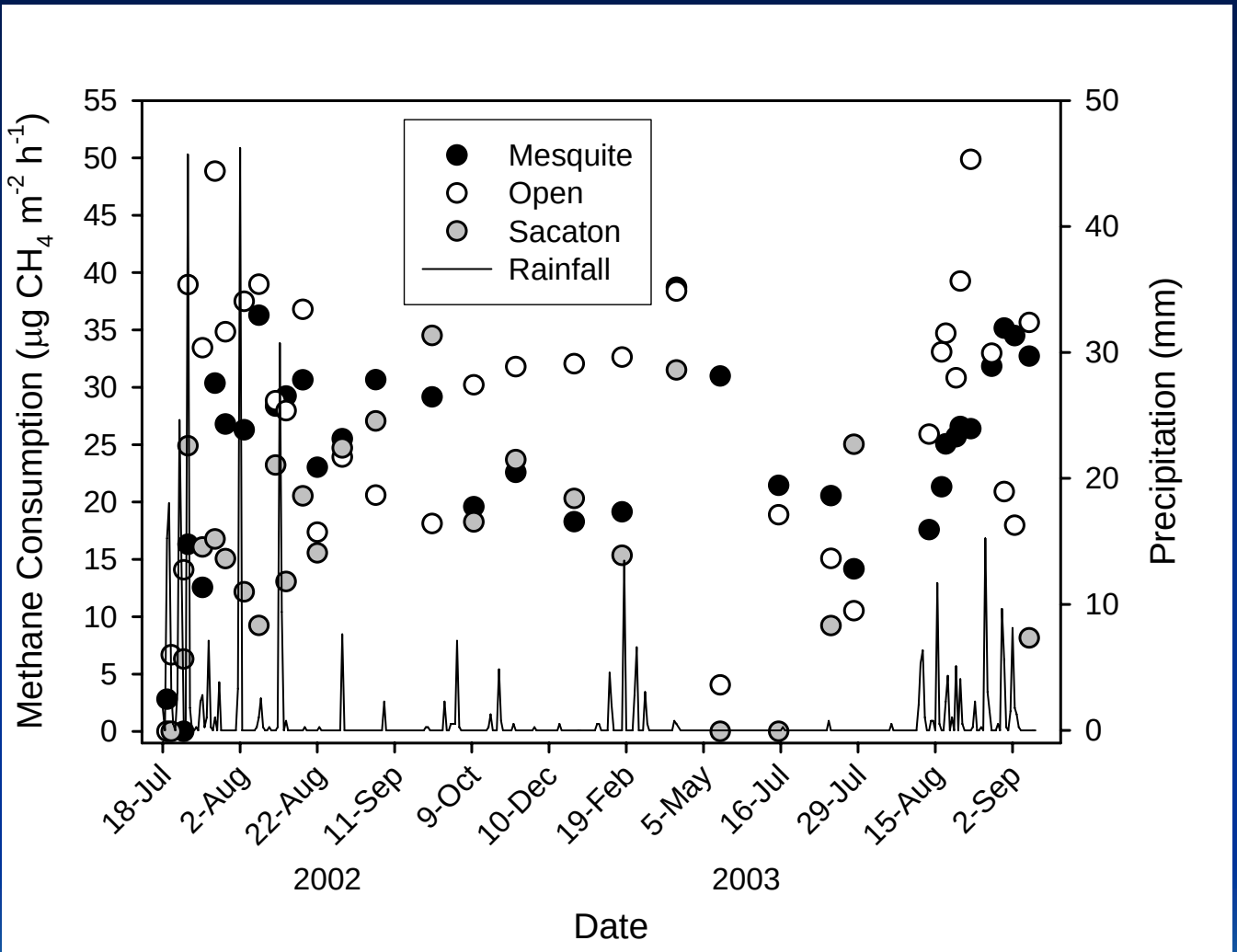


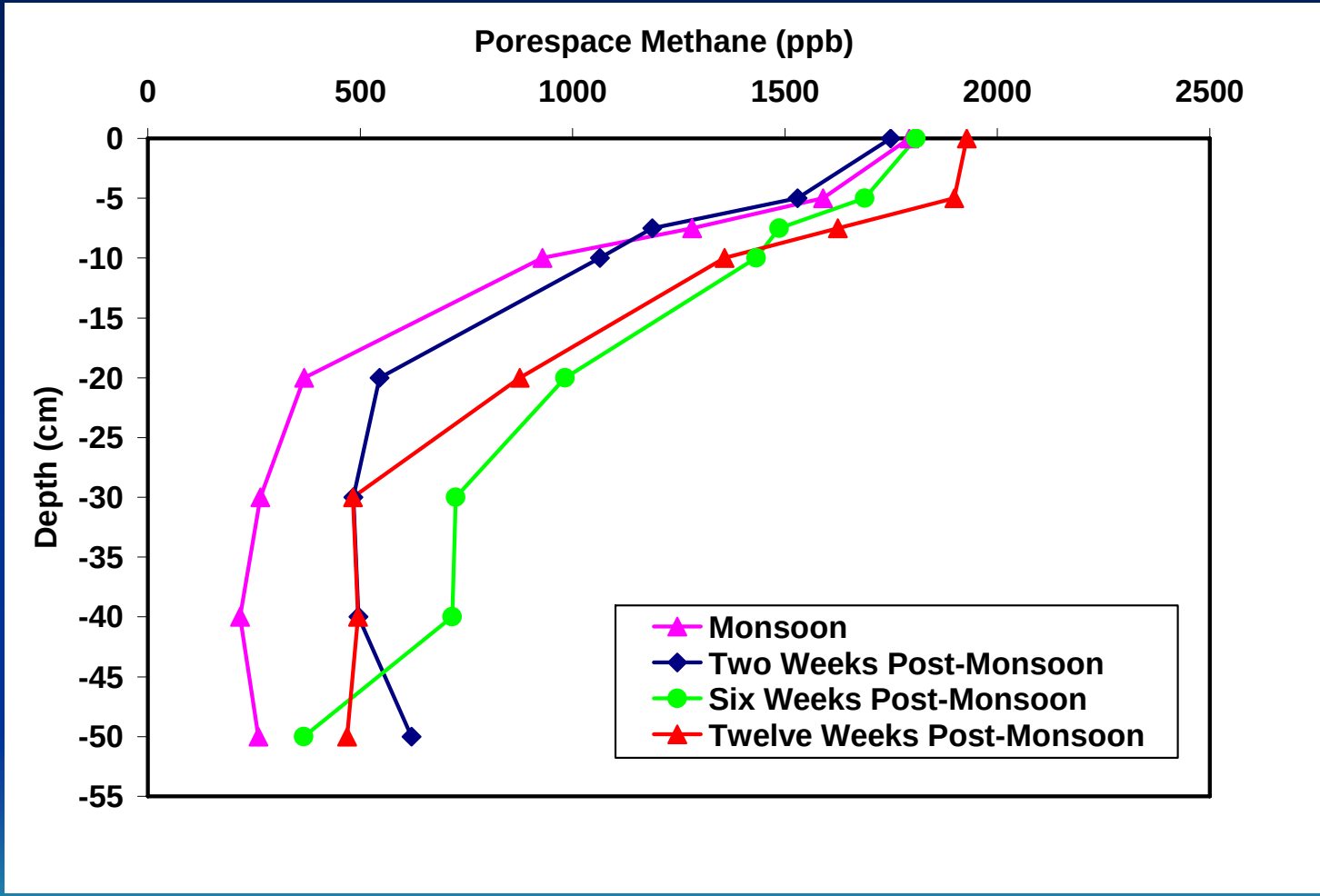

**Figure 6.** Methane consumption in three SPRNCA vegetation sites on measurement dates during 15-month monitoring period (July 2002 through September 2003). Symbols are averaged values from 2 or 3 flux collars installed at each site.

**2002 Monsoon = 29 – 61 mg $m^{-2}$**

**Winter = 118 – 160 mg $m^{-2}$**

**2003 Monsoon = 62 – 70 mg $m^{-2}$**

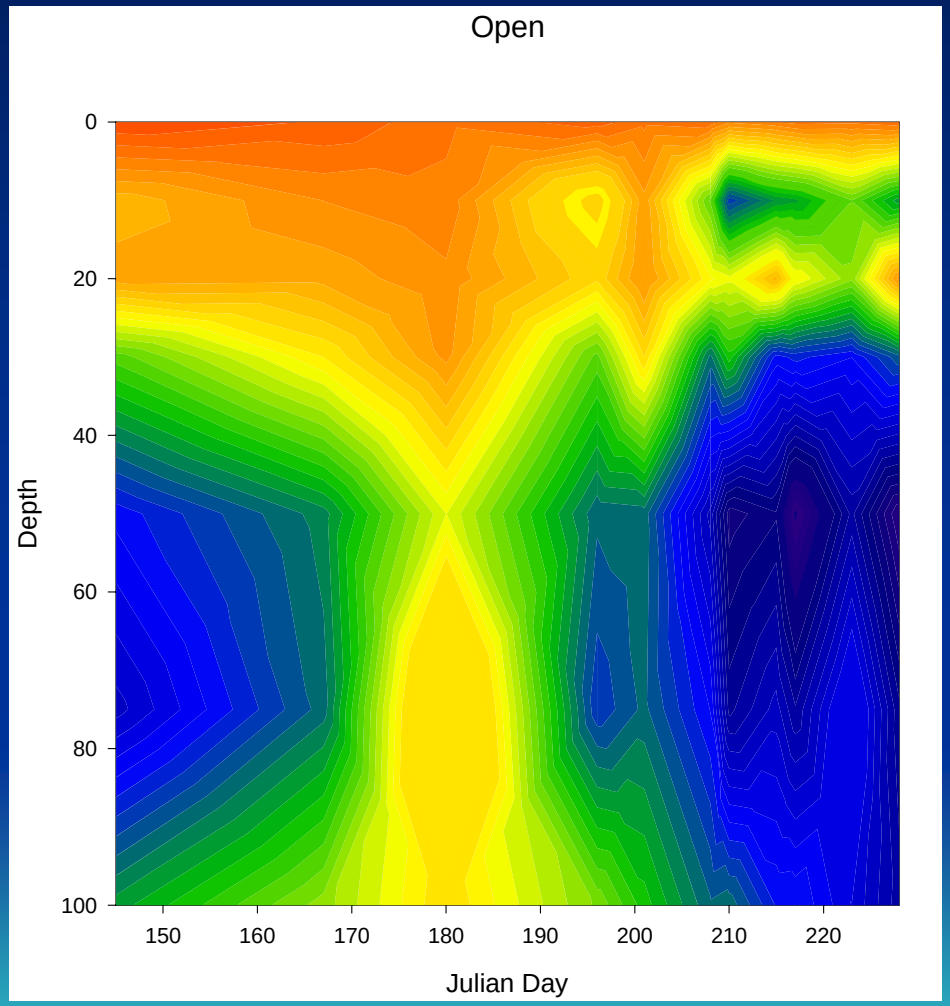
# Methane Oxidation with Soil Depth



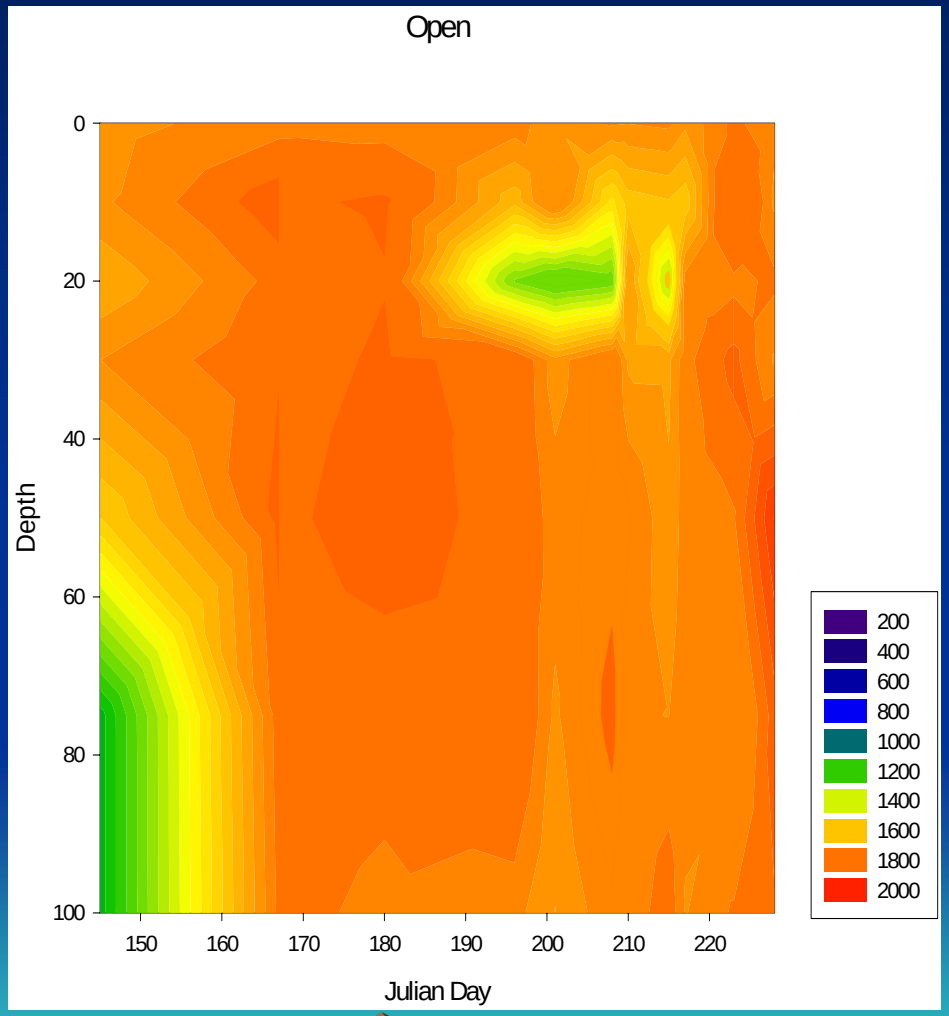

**Cool season may limit surface oxidation, but warmer temps in the subsoil continue to promote oxidation – also when surface is dry, subsoil active**

# Impacts of Grazing on $CH_4$ Oxidation

## 100 yr exclosure




## “Moderate” grazing for 50 yr



# Nitrous Oxide Fluxes 2002 – 2003

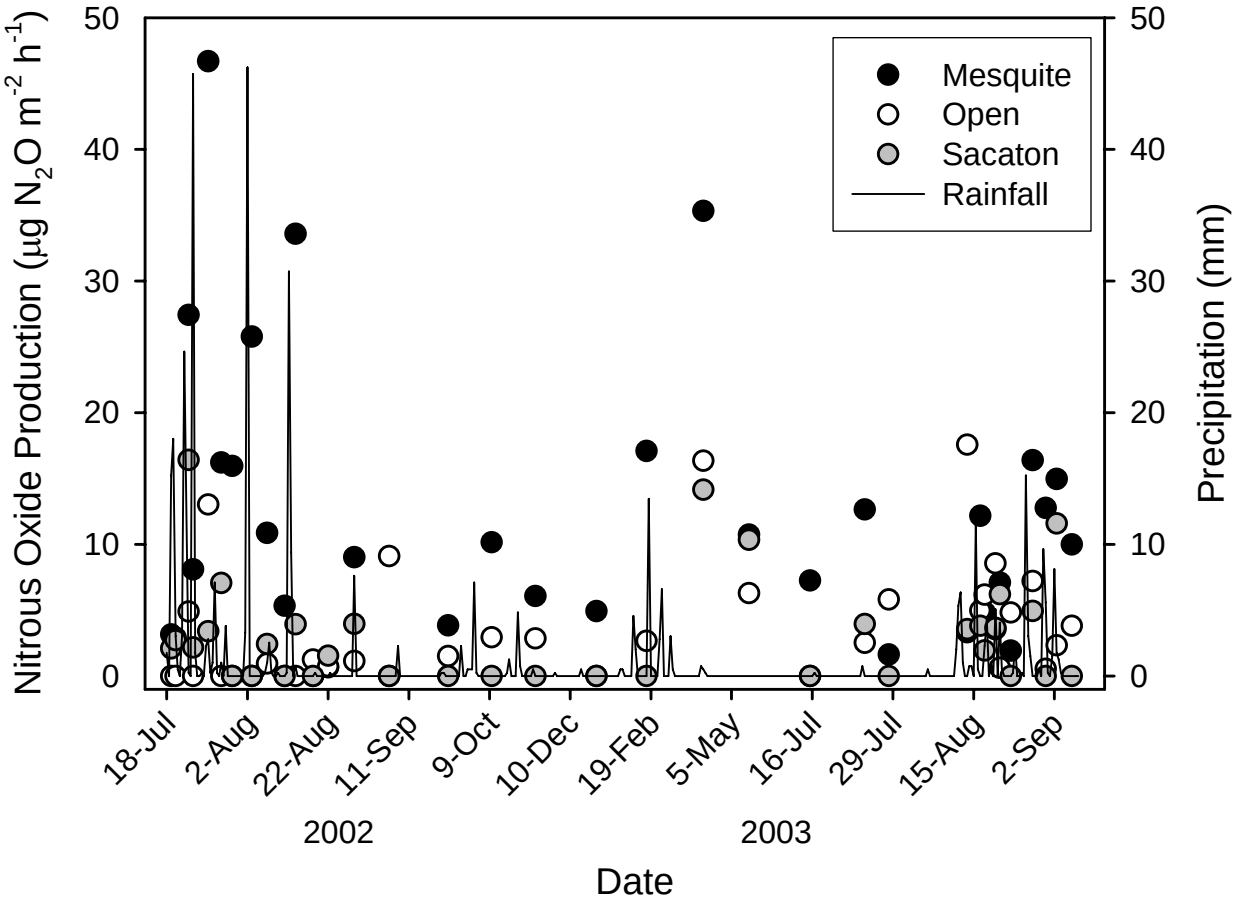



**Figure 5.** Nitrous oxide efflux from three SPRNCA vegetation sites on measurement dates during 15-month monitoring period (July 2002 through September 2003). Symbols are averaged values from 2 or 3 flux collars installed at each site.

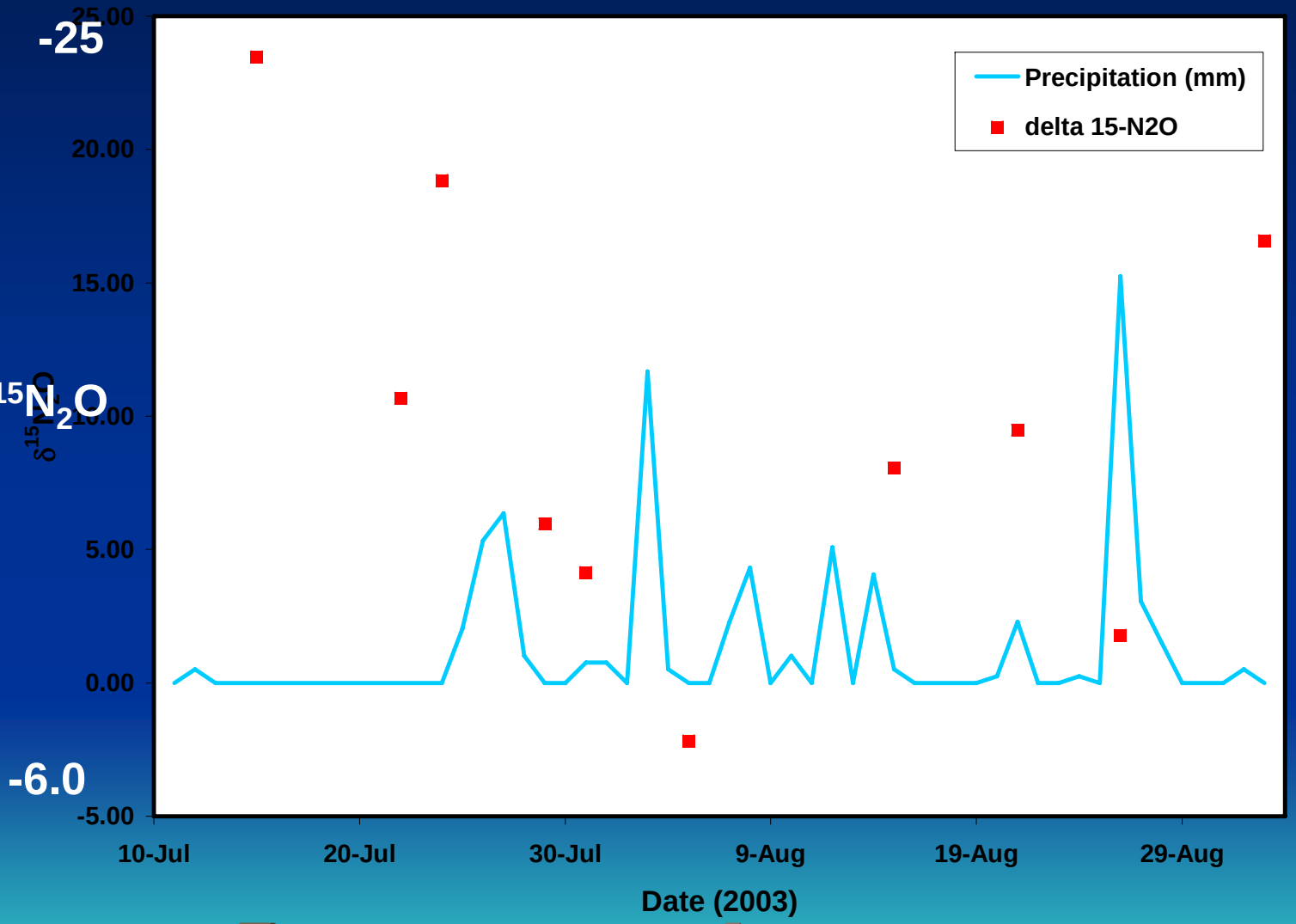
**2002 Monsoon = 4 to 38 mg $m^{-2}$**

**Winter = 17 to 54 mg $m^{-2}$**

**2003 Monsoon = 8 to 20 mg $m^{-2}$**

**2002 vs. 2003 30% reduction**

# $\delta^{15}N_2O$ Flux From Mesquite




Isotope values with dry surface soils suggests subsoil activity and during monsoon represents surface activity

# Greenhouse Gas Production

- 2002 monsoon season averaged 303 mg $CO_2$ equivalents $m^{-2}$ (57 d)
- Cool season averaged 390 mg $CO_2$ equivalents $m^{-2}$ (307 d)
- 2003 monsoon season averaged 185 mg $CO_2$ equivalents $m^{-2}$ (57 d)
- 60% reduction of warm season rain reduced $CO_2$ equivalents by 39%

# Implications

- Recent work has emphasized the increased contribution of terrestrial C sources to atmospheric C pools if temperatures increase – positive feedback to climate change
- For the SW region, climate change models differ on whether future climate scenarios will be wetter or drier and possible shifts from summer to winter rains

# These Results Suggest

- If rainfall shifts to greater winter events, overall reductions in surface dominated $CO_2$ and $N_2O$ fluxes and prolonged spring $CH_4$ subsurface oxidation
- Higher warm season precipitation will increase $CO_2$ and $N_2O$ fluxes due to rapid oxidation of labile C pools that would not be off set by higher $CH_4$ oxidation rates