Beginning to integrate measures of soil respiration across spatial and temporal scales along a woody plant encroachment gradient using traditional and innovative techniques

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ABSTRACT: * The physiognomic shift in ecosystem structure from a grassland to a woodland may alter the sensitivity of CO_2 exchange of entire ecosystems to variations in growing-season temperatures and precipitation inputs.

* Understanding ecosystem carbon flux dynamics and identifying whether landscapes are sources or sinks for atmospheric carbon is especially important in light of climatic and vegetative cover change. This source/sink status may change greatly as vegetation cover shifts from a grassland to a woodland.

* Soil respiration (R_{soil}) has been shown to be the largest component of ecosystem ecosystem efflux and the primary determinant of net carbon exchange in forests.

* Rsoil is a function of both biotic (vegetation cover type, litter quality, rooting depths) and abiotic (resource availability, temperature) factors, but the relative importance of each drivers has not been fully quantified. Such investigations are particularly of interest within the semiarid southwest where the major environmental drivers (temperature and available moisture) vary and covary throughout a year and vegetative cover change is rampant.

* *We have begun integrating multiple methodologies to yield a spatially and temporally extensive estimation of soil respiration within a grassland and mesquite shrubland.*

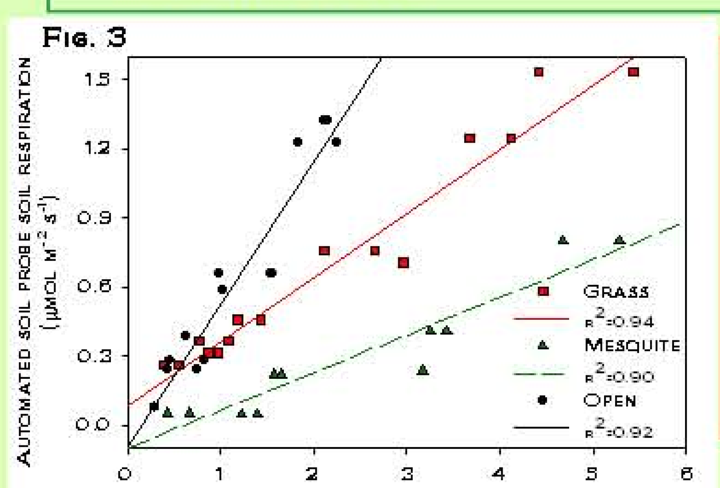
Fig. 1 Soil CO_2 probes housed in PVC tubes that allowed for near-continuous estimation of soil respiration. Similar installations were made under bunchgrasses and in intercanopy spaces.

Fig. 2 An overhead view of the automated soil respiration chamber with two static soil collars. The automated chamber closed over the soil patch and estimated soil respiration every 15 minutes.

MATERIALS AND METHODS:

- *Sites: A mesquite woodland savanah wtihin the* Santa Rita Experimental range and a grassland at the Walnut Gulch Experimental Watershed were used in this study. Both sites contain an eddy covariance tower that continuously logs carbon flux and environmental data. Within each site R_{soil} was measured in the three dominant microhabitats: under mesquite, under grasses, and in the bare open space.
- *R_{soil} measurement techniques:*
  - •**Soil CO_2 sensors** (Figs. 1 &3) were placed at different depths within the soil to allow for a calculation of R_{soil} based on a gradient-diffusion method (Tang et al 2003). Soil moisture, temperature, and an estimate of R_{soil} were recorded every 5 minutes throughout the year under each of the microhabitats.
  - •**Automated Soil chambers** (Figs. 2&3) were also used to continuously estimate R_{soil}. Soil moisture, temperature, and an estimate of Rsoil were recorded every 15 minutes throughout the year under each of the microhabitats.
  - •**Static soil collars** were installed in conjunction with each of the automated systems (Figs. 1-3) and along two 50m transects at each tower site (Fig. 4). Soil respiration, temperature, and moisture were measured every 2 weeks throughout the growing season under each of the microhabitats.

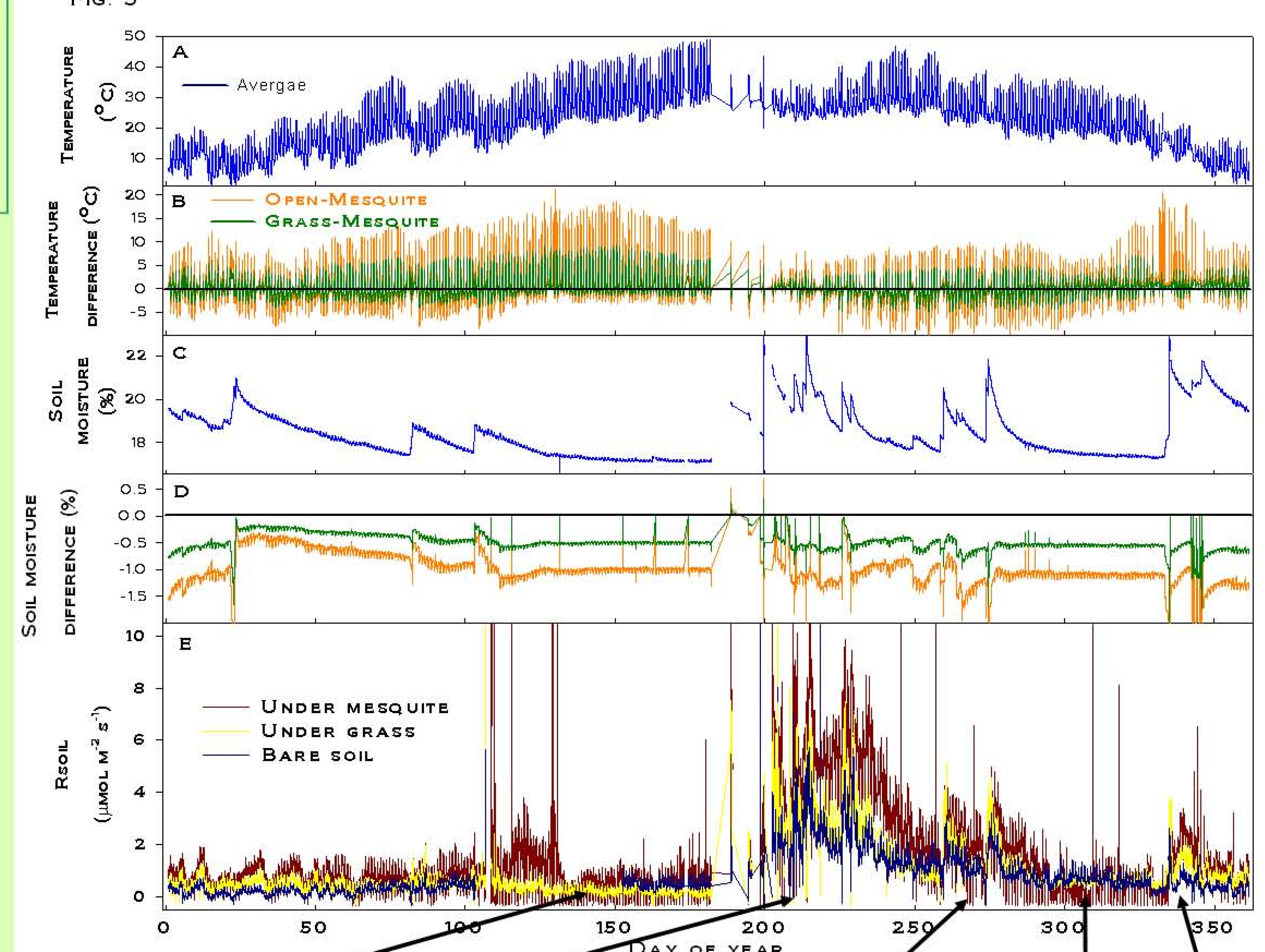
Fig. 3



RESULTS: Comparison of the automated soil CO_2 probe estimation of R_{soil} and that of the traditional static collar method. There was strong congruency among the methods across the entire growing season, suggesting that integration among the spatially extensive (static) and temporally extensive (automated) methods is appropriate.

The automated R_{soil} systems allowed for a *temporally* extensive estimation of R_{soil}, enabling us to capture immediate responses to precipitation throughout the year. However, the traditional soil collars allowed for a *spatially* extensive quantification of R_{soil}, enabling us to understand the spatial heterogeneity at the sites.

Fig. 5



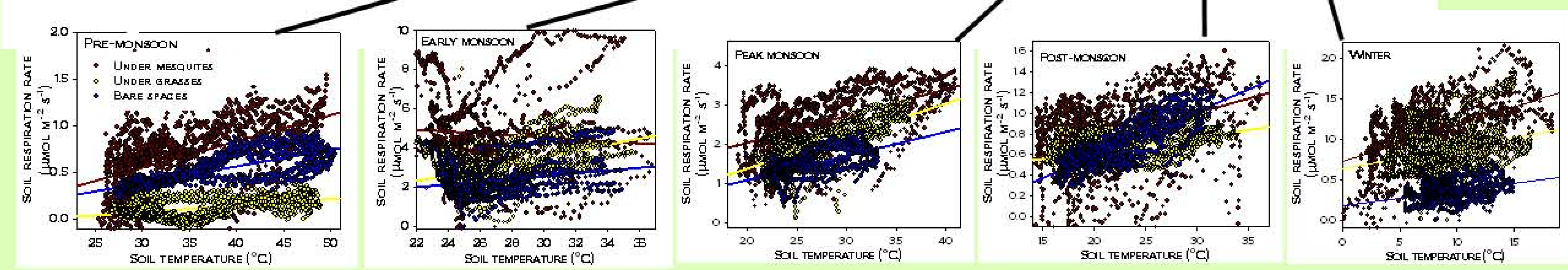


Fig. 4 An aerial view of the entire tower research site illustrating the spatially extensive transects from which soil respiration was estimated. Traditional soil collars were installed every ~10m along a 50m transect within the microhabitats. Manual measurements at the collars were made times prior to, during, and post-monsoon (n=15 dates).

RESULTS: Soil temperature varied greatly throughout the year, peaking between DOY 150-190, when the monsoon began (Fig 5A). Daily temperature fluctuations were greater under the grasses and in the open spaces than under mesquites. As expected, soil temperatures were greatest in the open spaces, and greater under the grasses than the mesquites (Fig 5B).

RESULTS: Soil moisture increased in response to monsoonal and winter rain events, remaining highest between DOY 190-280 after the monsoon began (Fig 5C). Soil moisture was greatest under the mesquite and lowest in the open bare spaces (Fig 5D), suggesting more soil moisture was available to drive R_{soil} under both plant types.

RESULTS: * R_{soil} varied significantly throughout the growing season. Rates peaked in the early monsoon, but remained high throughout the end of the monsoon (Fig 5E).
* Average R_{soil} was greatest under the mesquites throughout the year (when R_{soil}>0).
* Pre-monsoon R_{soil} was greater under grasses than in the open areas, presumably dues to the breakdown of winter annual plants. This pattern was reversed once the monsoon began and the grasses became active.
*Total annual CO_2 efflux under the mesquites = 1792gm^{-2}, under grasses = 1127gm^{-2}, and in open spaces = 853gm^{-2}.

RESULTS: * The temperature dependence of R_{soil} was greatest in the peak monsoon.
* Though R_{soil} rates were greatest in the peak monsoon, there was little influence of temperature.
* A second pulse of R_{soil} activity was detected during the wet winter, and temperature again became a driving factor of R_{soil} rates.

CONCLUSIONS: * R_{soil} rates and the temperature dependence of R_{soil} varied significantly throughout the year, suggesting a single modelling parameter would be in sufficient for such a precipitation-pulse driven ecosystem.

* R_{soil} was greater under mesquites (59% on the annual scale) than under grasses, suggesting that as vegetative cover transitions to more woody plants, R_{soil} will become a larger component of the ecosystem carbon flux. This significantly greater efflux of carbon may cause these woodland systems to be net carbon sources on an annual scale.

* Developing a better understanding of when respiration rates are temperature sensitive and when they are not will help in predicting carbon status of these ecosystems as they experience predicted climatic change

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