1.4 OVERSTORY AND UNDERSTORY ENERGY FLUXES OF OAK SAVANNA AND GRAZED GRASSLAND UNDER EXTREME SOIL DEFICIT AND HIGH TEMPERATURE

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1. INTRODUCTION

Due to its heterogeneity and complexity, oak-grass savanna ecosystems are poorly understood by biometeorologists, in term of energy and water fluxes and their response to environmental perturbations. Here we present the results from a study on seasonal variation of energy and water vapor fluxes of an oak-grass savanna and a nearby grazed grassland under the conditions of severe water stress and extreme high temperature.

2. MATERIAL AND METHODS

The experiment site is located on the foothills of the Sierra Nevada Mountains in California (38^o 26'N, 120^o 58'W, and 177 m a.s.l.). The site has a typical Mediterranean climate with wet, cold winter and dry, hot summer. The mean annual temperature is 16.3^{o}C and mean precipitation 559 mm. In the dry summer, weather conditions with air temperature over 40^{o}C and air vapor pressure deficit over 6.0 kPa are not unusually. At the savanna ecosystem, the predominant tree species is blue oak (*Quercus douglasii*). The average tree height is 7.1 m. Leaf out was around late March and in three weeks leaf area index reached a maximum value of 0.6. The grasses of understory and at the grazed grassland are C3 species. Grass germinated around mid-Oct after receiving substantial rainfall, and it grew very slowly in the winter. As the temperature warm up in the spring, there was peak growth period with a maximum LAI of 1.0 for understory grass and 2.0 for the grazed grassland. Then the grass quickly senesced due to soil drought developed in the early summer.

Latent heat (LE) and sensible heat (H) over- and understory of the oak/grass savanna and over the grazed grassland were measured using eddy covariance technique. Each flux system consists of a sonic anemometer (Gill Windmaster Pro) and a open path infrared gas analyzer (Li-Cor 7500). Other meteorological, soil and plant physiological parameters, including solar radiation, net radiation (R_n), PAR, air temperature, soil moisture (θ), predawn oak leaf water potential and stomatal conductance, were also measured at different time intervals.

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3. RESULTS

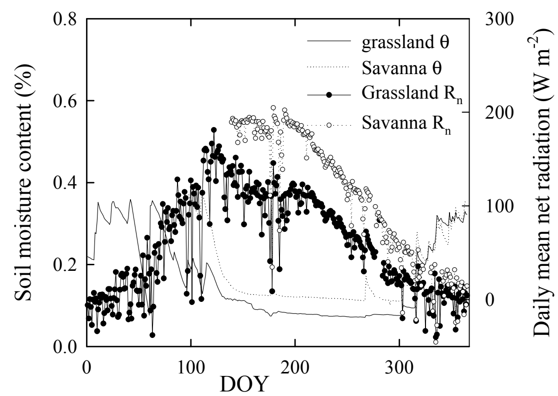

Fig. 1. Seasonal trends of volumetric soil water content (θ) and daily mean net radiation (R_n) at the grassland and the savanna.

Fig.1 illustrates the seasonal trends of surface layer (0-20 cm) volumetric soil water content (θ) and daily mean net radiation (R_n) at the oak-grass savanna and the grassland sites. During the wet season in the winter and early spring, the soil moisture content was very high up to 35 to 40% at both sites. When raining season stopped in early April, the soil moisture quickly dried out to less than 10% due to high evaporative demand. Daily mean net radiation balance (R_n) over the grazed grassland peaked as early, at the end of April, just before the grass senescence. The maximum value was 166 W m^{-2}. While for the oak-grass savanna, overstory R_n peaked more or less around summer solstice with daily mean value of 202 W m^{-2}.

Fig. 2. demonstrates the seasonal variations in sensible heat (H) and latent heat flux (LE) for the grazed grassland (a) and understory (b) of the

savanna. The data presented in the figure were daily mean. We have whole year's measurement at the grazed grassland, while at the savanna, the flux measurements were started in April, 2001. It was found that seasonal variations in LE over the grazed grassland and understory of the oak-grass savanna (Fig. 2a, 2b) followed closely changes in grass leaf area index (LAI), which in turn was controlled by soil moisture. This response is due to the shallow rooting depth of grass. During the dry summer, when the grass was dead, virtually all the available energy was partitioned into H.

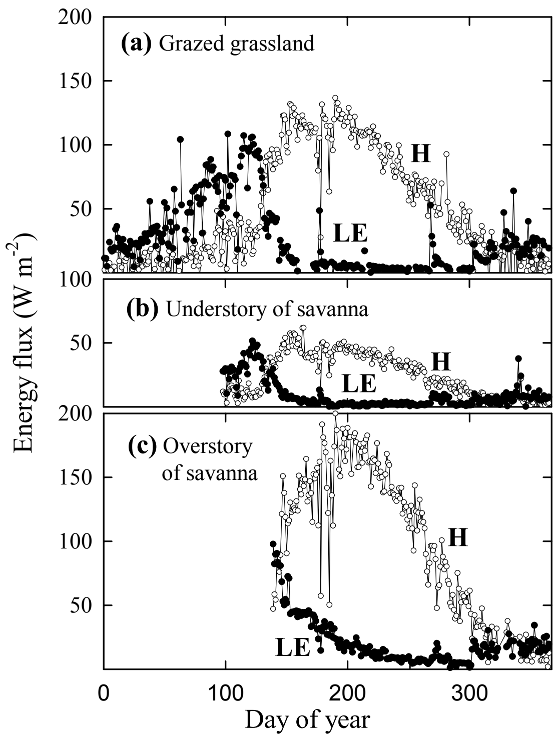

Fig. 2. Seaonal vairations in daily mean sensible (H) and latent heat (LE) flux at grassland, understory and overstory of the savanna ecosystem.

Seasonal changes in LE and H of overstory at oak-grass savanna were presented in Fig. 2c. LE decreased exponentially with time from the beginning of the measurement and it didn't follow the seasonal variation of tree LAI. Instead, stomata of oak tree managed water loss by responding to severe water stress and high temperature during the summer. The leaf stomatal conductance decreased from 0.5 mol $m^{-2}s^{-1}$ in the early summer to less than 0.05 mol $m^{-2}s^{-1}$ in the fall when the predawn leaf water potential reached up to –7.0 MPa. Relatively deep rooting depth is another reason for oak trees to cope with severe water stress.

About 20 to 30% of net savanna canopy energy exchange occurred at the understory during the summer drought period (Fig. 3). This is consistent with previous study from an open boreal jack pine canopy (Baldocchi and Vogel, 1996). This percentage tended to be increase during wet season (Law, et al., 2001).

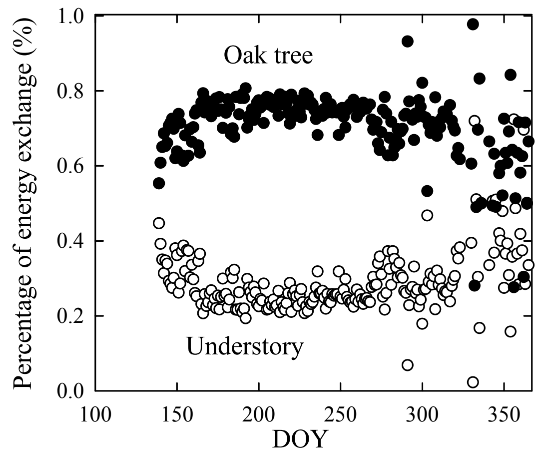

Fig. 3. Seasonal trends in percentage of total energy exchange (LE+H) derived from understory and oak trees at the savanna ecosystem.

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