Carbon Sequestration in Relation to Shrub Size in the Desert Ecosystem

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Introduction

Desert ecosystems have been reported as the location of the long-sought 'missing sink' for atmospheric carbon dioxide and as a potentially important area for carbon sequestering from fossil fuel combustion in the future (Stone 2008). Researchers have found that net uptake of carbon in the Mojave Desert ranged from 102 to 127 g C m^2/yr during a 3-year period, which is equivalent to the net ecosystem production of many forest ecosystems with a much higher biomass (Luyssaert *et al.* 2007; Wohlfahrt *et al.* 2008). Shrub is the dominant plant of desert ecosystems (Gratani *et al.* 2011); hence, it is important to understand the dynamics of carbon sequestration by shrubs as well as their role in desert ecosystem carbon balance. Information on the carbon sequestration associated with shrub size is limited. Our objective was, therefore, to find out the relationship between carbon sequestration potential and size of shrubs.

Methods

Site description and experimental design

The study was carried out at a steppe desert in the eastern reaches of Alxa Plateau (E 105° 38' 19.18, N 38° 59' 38.40), in an arid continental climate characterized by cold winters and hot summers. The annual precipitation varies from 60 mm to 150 mm, and mean annual temperature is approximately 9°C (Pei *et al.* 2006). The plant community, with *Reaumuria soongarica* as the most common species, is a typical vegetation system in this region that has a vast distribution area. Accordingly, we chose the shrub *R. soongarica* as the research focus, and three distinct size shrub groups (the large, middle and small group) were established, based on the plant crown breadth. Each shrub group had three individuals as replications, and a square plot (80 × 80 cm) was set surrounding each individual.

Ecosystem CO_2 exchange measurements

In August 2012, a square metal base rim (80 × 80 cm in area and 10 cm in height) was installed in each plot, with 3 cm left aboveground for the measurements of ecosystem CO_2 fluxes. Ecosystem CO_2 fluxes, including net ecosystem exchange (NEE) and ecosystem respiration (ER), were measured by a cubic chamber (80 cm × 80 cm × 80 cm) with an attached infrared gas analyzer (LI-840, LI-COR Inc., Lincoln, NE, USA). Gross ecosystem photosynthesis (GEP) was calculated as the difference between NEE and ER. When monitoring the ecosystem CO_2 fluxes, the chamber was sealed to the base surface closely.

Results

Diurnal dynamics of NEE and ER of shrubs in different size groups was investigated on a sunny day on August 6, 2012 (Fig. 1). For different size shrub groups, both of diurnal NEE and ER fluctuations showed relatively high single-peak curves and asymmetric patterns (Fig. 1). The diurnal dynamics of ecosystem CO_2 exchange showed negative peak values for NEE, while positive peak values for ER, at midday. The high numerical value of NEE (Fig. 1a) during the period between 9:00 and 15:00 in a day with intense sunlight may greatly benefit the carbon sequestration of shrubs. With the comparison among the different size shrubs, NEE for the shrubs in

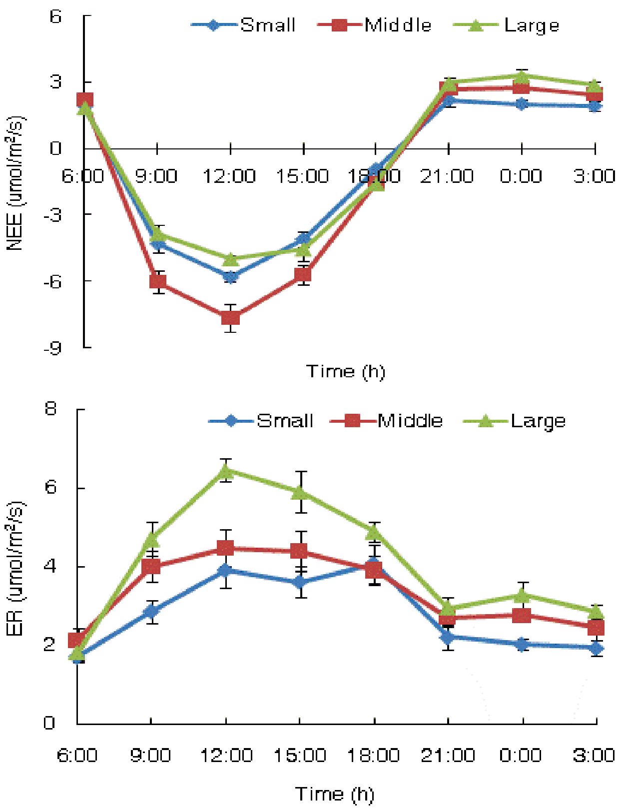

Figure 1. Diurnal dynamics of NEE (top) and ER (bottom) in different size shrub groups, with Standard Error.

Table 1. Carbon budget of different size shrub groups.

Different size shrub group	NEE (g C /m^2/d)	ER (g C /m^2/d)	GEP (g C /m^2/d)
Small	0.020	0.066	0.086
Middle	0.032	0.079	0.111
Large	0.015	0.097	0.112

middle size group maintained a significantly higher numerical value from 9:00 to 15:00 (Fig. 1a), while the large shrub group had the lowest NEE numerical values. Diurnal dynamics of ER were closely related to the size of shrub groups, with large > middle > small (Fig. 1b). Moreover, GEPs of the large and middle groups were similar in August (Table 1), the large group had a greater ER value (Table 1), which can account for the lower NEE by the shrub in the large size group.

Conclusion

Our results indicate that diurnal NEE and ER fluctuations showed relatively high single-peak curves and asymmetric patterns. NEE and ER in the desert were closely associated with shrub size with the middle sized shrubs having greater C sequestration potential per unit area.

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