Rapid transpiration accompanies soil carbon loss in the rhizosphere of *Populus fremontii*

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### Introduction

The production of soil organic carbon (SOC) stocks under various management regimes will become increasingly important as more political effort is applied to the mitigation of climate change. However, our current tools for predicting SOC stocks are limited by our ignorance of critical belowground processes. In the presence of plant roots, the rate of SOC decomposition can be greatly accelerated or inhibited, depending on plant species and phenology. For example, Cheng et al. (2003) found that decomposition of SOC in pots planted with *Glycine max* and *Trifolium alexandrii* L. was accelerated respectively by as much as 38% and 287% relative to pots without plants. This rhizosphere priming effect (RPE), if sustained, could dramatically alter future SOC stocks. Unfortunately, rhizosphere priming is currently difficult to measure in the field because of the need to separate root and soil components of belowground respiration. There is consequently a need to determine the factors controlling the magnitude of the RPE, and the seasonal changes to SOC stocks due to the RPE. In this study, we measured the RPE of *Populus fremontii*, a riparian tree common at low altitudes in California.

The respiration rate of the controls were correlated with temperature (Fig. 5a). However, the respiration of *soc* from the *P. fremontii* treatment was not correlated with temperature (5b), but with the transpiration / evaporation quotient (Fig. 6). This quotient is a measure of how much water was lost because of the presence of the plant. This implicates plant architecture as an important factor regulating throughfall soil respiration, and suggests the importance of both leaf area index (perhaps related to photosynthetic production of rhizosphere) and root surface area. Other researchers have noted the importance of phytosynthesis (Kuzyakov, 2002) and plant biomass (F. Dijkstra, pers. comm.) as controls of rhizosphere priming. The influence of plant roots on temperature and moisture effects cannot be ruled out as important factors. We are currently measuring temperature and moisture distribution differences in the planted and unplanted treatments to assess the significance of these effects.

### Materials and methods


Briefly, plants are grown in leach-proof PVC containers rather than standard greenhouse pots. Before sampling, the soil surface is sealed with a silicon rubber mold (Fig. 1). This isolates the soil atmosphere from the ambient atmosphere. Residual CO₂ is then removed from the soil atmosphere before sampling by circulating the isolated air through a CO₂ scrubber.


The respiration is then replaced with a NaOH trap and the soil atmosphere is periodically circulated through the system (Fig. 2). The NaOH trap captures greater than 99% of the CO₂ in circulation, thus reducing the potential pitfall of preferential isotope absorption (Cheng 1996). Next, the CO₂ gas is the NaOH trap is converted to CO₂, which is mixed free of NaOH and analyzed for stable C isotopes in a mass spectrometer.

### Results

All data analysis and graphs were prepared with the R language (R Development Core Team, 2003). Plant-dried soil respiration was very high compared to soil-dried respiration (Fig. 3). Differences in soil-dried respiration are summarized in Table 1.

![Fig. 2. Diagram of the apparatus used in the experiment. Modified from Cheng (1996).](image)

In the pots planted with *P. fremontii*, the plant-derived C can be separated from the soil-derived C with the following relationship (from Cheng, 1996):

$$ C_{3} = C_{tot} - C_{plant} - C_{pot} $$

where $C_3$ is the total carbon derived from the C3 plant, $C_{plant}$ is the total amount of carbon trapped, $C_{pot}$ is the 0°C value of the trapped carbon, $C_{tot}$ is the 0°C value of the C3 plant, and $C_{pot}$ is the 0°C value of the C4 soil.

### Conclusions

The pattern of rhizosphere priming shown in Fig. 4 is in agreement with Bhatia et al. (1986) and Saib and Bhatia (1986), who reported that planted treatments showed reduced decomposition during the first 150 days and accelerated decomposition thereafter, compared to non-plant controls. Because both positive and negative priming effects were measured, the expected net effect of P. fremontii roots on SOM decomposition was not significantly different from zero. However, numerous researchers have noticed only positive priming effects that peak during the growing season, with no initial suppression, or small negative priming effects that persist throughout the growing seasons (e.g. Cheng et al., 2003). In such a case, the presence of roots might reduce SOC.

### Literature cited


Table 1: Net rhizosphere priming effect. The dotted line represents the background respiration, i.e. the respiration of the no-plant controls.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>C pot</th>
<th>p (day)</th>
<th>P. fremontii</th>
<th>Sig*</th>
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<tbody>
<tr>
<td>Control</td>
<td>9.58±3.34</td>
<td>7.80±1.20</td>
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<td>36</td>
<td>15.62±2.77</td>
<td>2.88±0.90</td>
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<td>72</td>
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<td>5.33±1.20</td>
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<td>138</td>
<td>4.44±1.02</td>
<td>12.33±1.60</td>
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<tr>
<td>216</td>
<td>10.00±1.22</td>
<td>27.90±1.73</td>
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</tr>
<tr>
<td>264</td>
<td>6.75±1.83</td>
<td>15.10±7.61</td>
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<tr>
<td>36</td>
<td>1.94±0.52</td>
<td>4.10±0.10</td>
<td>***</td>
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</tr>
</tbody>
</table>

*Significant differences at α = 0.05.

**Significance of the difference at α = 0.01.

***Significance of the difference at α = 0.001.

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