INFLUENCES OF CANOPY PHOTOSYNTHESIS AND SUMMER RAIN PULSES ON ROOT DYNAMICS AND SOIL RESPIRATION IN A YOUNG PONDEROSA PINE FOREST

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ABSTRACT

The first objective of this paper is to make the link between the seasonality of fine root dynamics and soil respiration in a ponderosa pine (*Pinus ponderosa* P. & C. Lawson) plantation located in the Sierra Nevada of California. The second objective is to better understand how canopy photosynthesis influences fine root initiation, growth and mortality in this ecosystem. We compared CO_2 flux measurements (NEE, soil CO_2 efflux) with aboveground and belowground root dynamics. Soil respiration was measured in a control and a trenched plot to separate heterotrophic and autotrophic soil respiration.

RESULTS AND DISCUSSION

One of our hypotheses was that fine root development at our site is a high priority and is tightly coupled to canopy photosynthesis and available soil water. Our second hypothesis was that fine roots exert a major control over the seasonal patterns of soil respiration, and that such control is most apparent when roots are actively growing. We compared CO_2 flux measurements with aboveground and belowground root dynamics. Fine root growth initiation coincided with tree stem thickening and shoot elongation, preceding new needle growth (Fig. 1c). Root, shoot, and stem growth in the spring was simultaneous with the increase of canopy photosynthesis (Fig. 1ac). Initial growth rate of fine roots was the highest and their growing period was the shortest compared to the other components (Fig. 1c). Both above and belowground components accomplished 90% of their growth by the end of July, and the growing season lasted ~80 days (Fig. 1c). The time period for optimal growth is short at our site due to low soil temperature during the winter, and soil water stress during summer (Fig. 1b). Large rates of photosynthesis were observed following unusual late summer rains, however tree growth did not resume (Fig. 1ac). The autotrophic contribution to soil respiration was 49% over the whole season, with daily contributions ranging between 18% and 87%. Increases in soil and ecosystem respiration were observed during spring growth; however the largest variation in soil respiration occurred during summer rain pulses when no growth was observed (Fig. 1b). Both the respiration pulses magnitude and persistence were positively correlated with the amount of rain. These pulses accounted for 16.5% of soil respiration between day 130 and 329.

CONCLUSION

Our second hypothesis was partially supported and mainly holds for the first part of the vegetation period when increases in photosynthesis and root growth were coincident. We found that the time period for optimal root growth is short at our site due to low soil temperature during the winter and soil water stress during summer. High rates of photosynthesis were observed following summer rains during the second part of the vegetation period when temperature was optimal, but root growth did not resume and mortality rates did not decrease. Our second hypothesis was also partially confirmed because increases in soil and ecosystem respiration corrected for temperature variations were observed during the active root growing period. However, increases in respiration during root growth were relatively small. The largest variation in soil respiration at our site occurred during unusual rain pulse events in the summer, while root growth did not resume. Such increases can mostly be attributed to the stimulation of heterotrophic respiration. However, the activity of these heterotrophs was highly dependent on the earlier soil inputs of fresh labile carbon by the roots. This provides evidence for an indirect link between canopy photosynthesis, root growth and soil respiration.

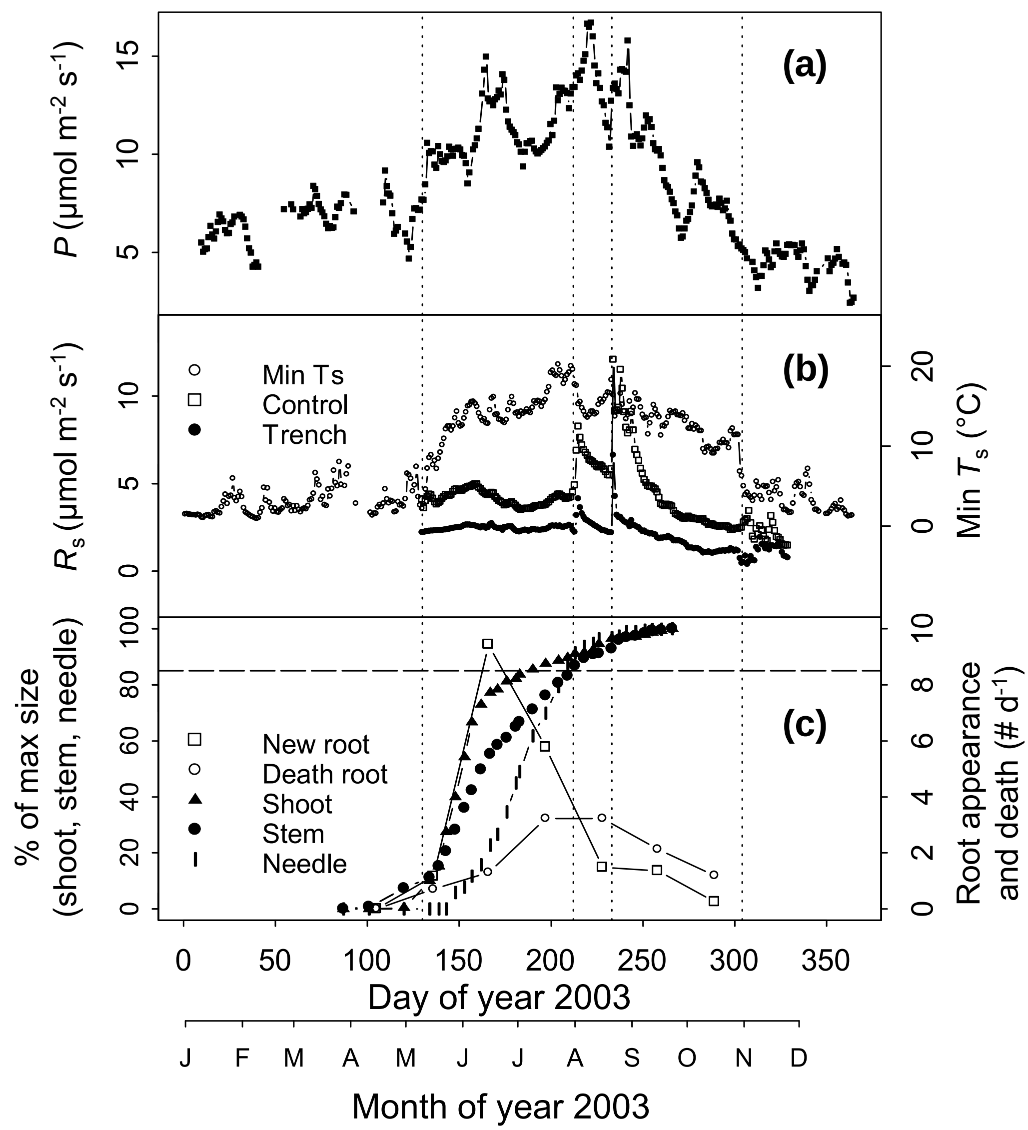

Fig. 1. (a) Seasonal variation in canopy photosynthesis (*P*). (b) Daily minimum soil temperature (open circle), soil respiration in the control (open square) and in the trench plots (filled circle). (c) Shoot, stem and needle elongation as a percentage of maximum size, and root demography (sum of 18 minirhizotron tubes). The horizontal line shows the 85% levels. Vertical dotted lines show the beginning and the end of the vegetation season, and the two rain pulses during summer (days 212 and 233).