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SOIL RESPIRATION IN A PACIFIC NORTHWEST CONIFEROUS FOREST

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ABSTRACT

A seasonal study of forest floor respiration is being conducted at the H. J. Andrews Experimental Forest. The main objective of the study is to determine how seasonal shifts in temperature and moisture altered both field and laboratory respiration rates and to determine how respiration rates are related to dissolved organic carbon (DOC) concentrations. Field respiration rates show a significant positive correlation with soil temperatures but seasonal patterns observed thus far show that moisture extremes also have a profound effect on respiration rates. When moisture limited respiration by being either too high or too low, DOC concentrations increase as respiration rates decrease.

INTRODUCTION

Soil respiration rates have long been studied as an indicator of total metabolic activity in soils. In general, these studies have shown that, within the time scale of most studies (i.e. under one year), the major controlling factors are temperature and moisture. As a result, most soil respiration models use relatively simple temperature-moisture equations to predict soil respiration. By studying field respiration rates at a monthly time-step at 20 permanent study sites on the H. J. Andrews Experimental Forest (HJA), we wanted to determine to what degree moisture interacts with temperature to control forest floor respiration over a broad range of microclimates and vegetation types. We also wanted to determine if laboratory respiration rates measured at 15C showed the same patterns as those observed in the field and to what degree DOC correlated with either measurement of soil respiration.

METHODS

Field respiration measurements were made in 10 plots at 5 m intervals along a 50 m transect at 20 permanent sites at the HJA (Fig. 1). We use the soda-lime method for measuring soil respiration as outlined by Edwards (1982. Pedobiologia 23:321-330). The amount of CO_2 absorbed was calculated from the weight gain in the soda-lime over 24 hr. Soil moisture and laboratory respiration rates were conducted as previously reported (Griffiths et al., 1991. Biol. Fert. Soils 11:196-202). DOC was measured by adding ten g of wet weight soil to 30 ml of water. The soil slurry was shaken for one hour at 15C and allowed to set for one hour at 15C. One and one half ml of the slurry was removed and centrifuged for 5 minutes. After centrifuging, 0.5ml of the supernatant was removed and put into 0.5ml centrifuging tubes. The supernatant was analyzed for dissolved organic carbon using a Dohrman carbon analyzer.

RESULTS

The reported values are the mean values for measurements made in five soils per site with up to 20 sites sampled per month. During the study, the mean soil temperature decreased from 13.8C in August to 1.7C in December (Fig. 2) and the laboratory respiration rates increased from 0.24 to 0.43 uM x gdw^{-1} x h^{-1} (Fig. 3). In SEPT, the soils were much drier than in AUG; the percent moisture decreased from 47% to 27% (Fig. 4). As a result of this drying, the respiration rates were lower and the DOC concentrations were higher in SEPT (Figs. 5 & 6). In OCT, the soil moisture increased to 40% resulting in elevated respiration rates and decreased DOC concentrations. Even though the moisture levels were equal to those in AUG, the field respiration rates were lower because the soil temperature had decreased from 13.8 to 10.3C. In NOV, the respiration rates were drastically reduced even though there was only a 3.5C drop in temperature since OCT. It appears that the extremely high moisture levels may have inhibited respiration by limiting gas exchange. As the result of decreased respiration, there was once again an increase in DOC. In DEC, the soils dried out again resulting in an increase in respiration and a decrease in DOC even though the soil temperature had dropped to 1.7C.

DISCUSSION

Broadscale modeling of climatic effects on CO_2 efflux and soil carbon dynamics in forest ecosystems requires accurate determination of the relationships between respiration, temperature and moisture.

While the general downward trend of field respiration from AUG thru DEC reflects the decline in soil temperature, the obvious departures from a smooth curve in SEPT and NOV suggest a secondary influence. Using data from those periods with fairly uniform soil moisture -- AUG (47%), OCT (48%) and DEC (60%) -- we estimated a Q10 of 1.76. When we used this to predict respiration response to soil temperature, two major decreases in soil respiration were found at the two moisture extremes, SEPT (27%) and NOV (108%), where observed respiration rates were only 69 and 47% of the respective temperature-predicted rates.

Our results show that respiration in soils between 47 and 60% moisture is primarily under temperature control, while soils below 27% or above 108% moisture are subject to moisture control. Future studies are planned to more clearly define how moisture controls respiration, and indirectly DOC, at the high and low extremes.

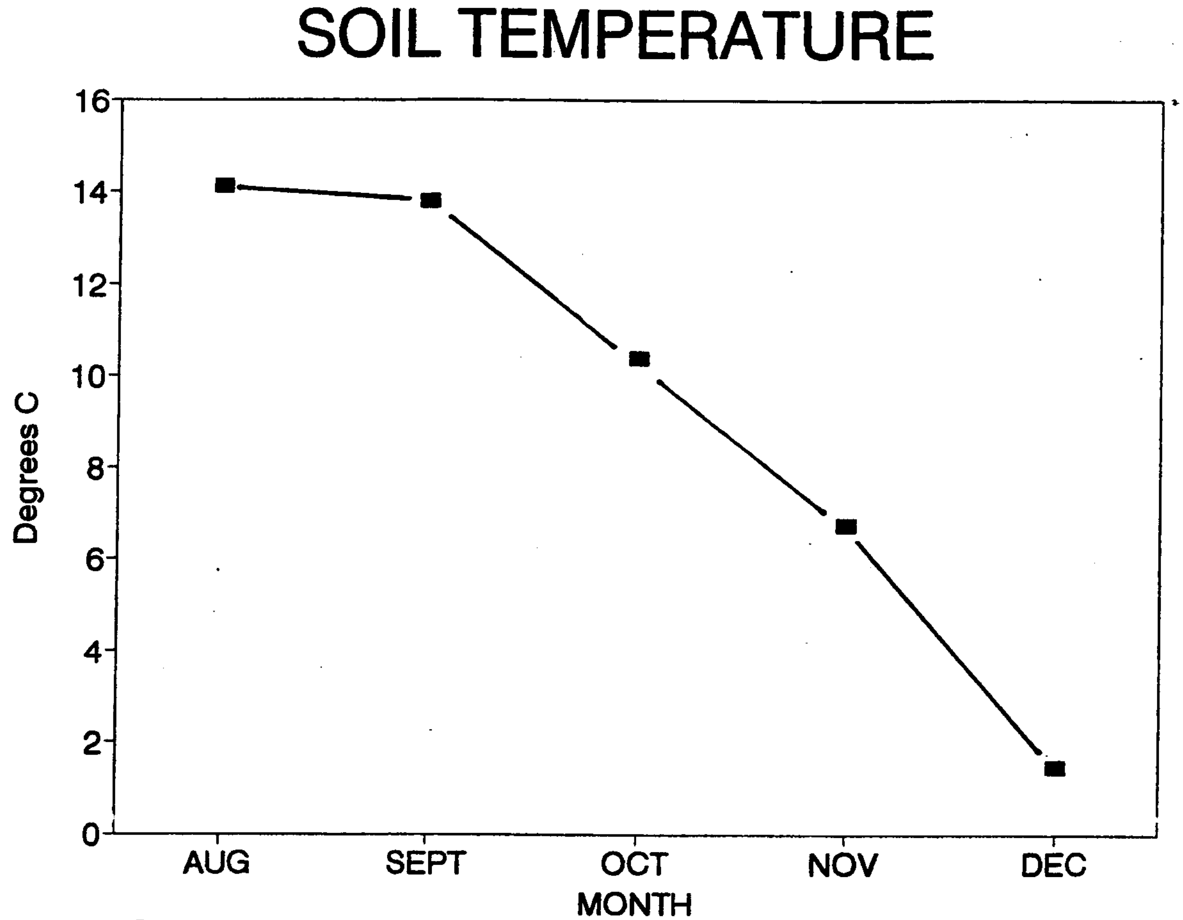


Figure. 2

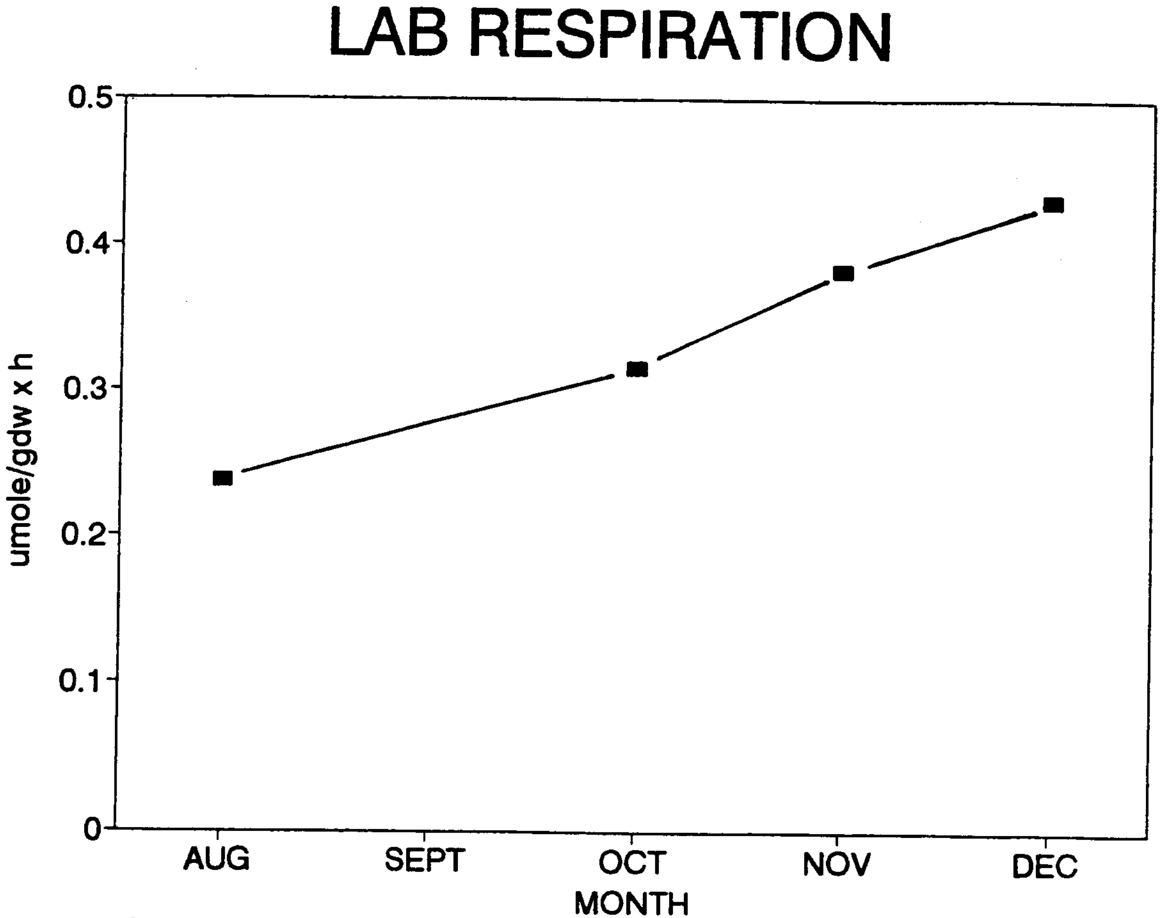
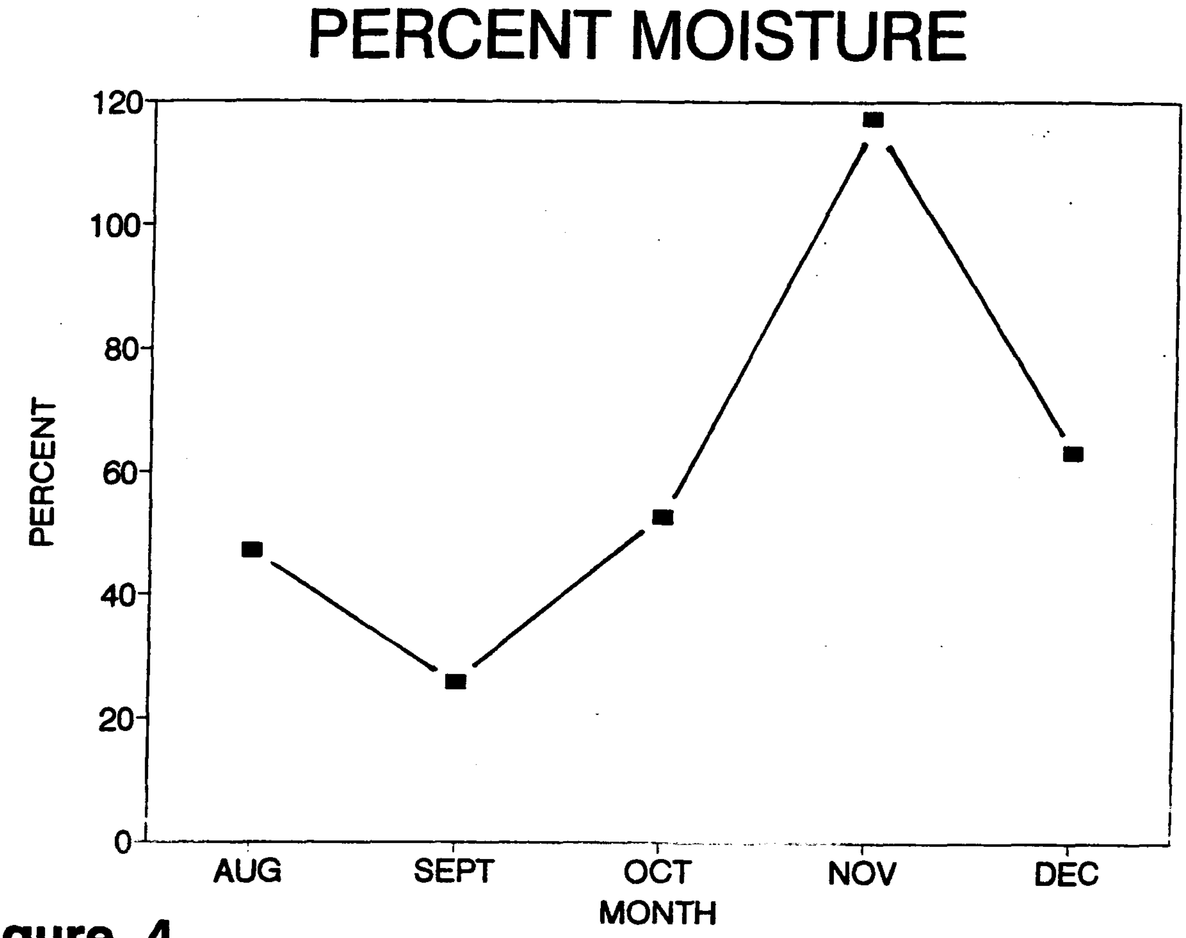


Figure. 3



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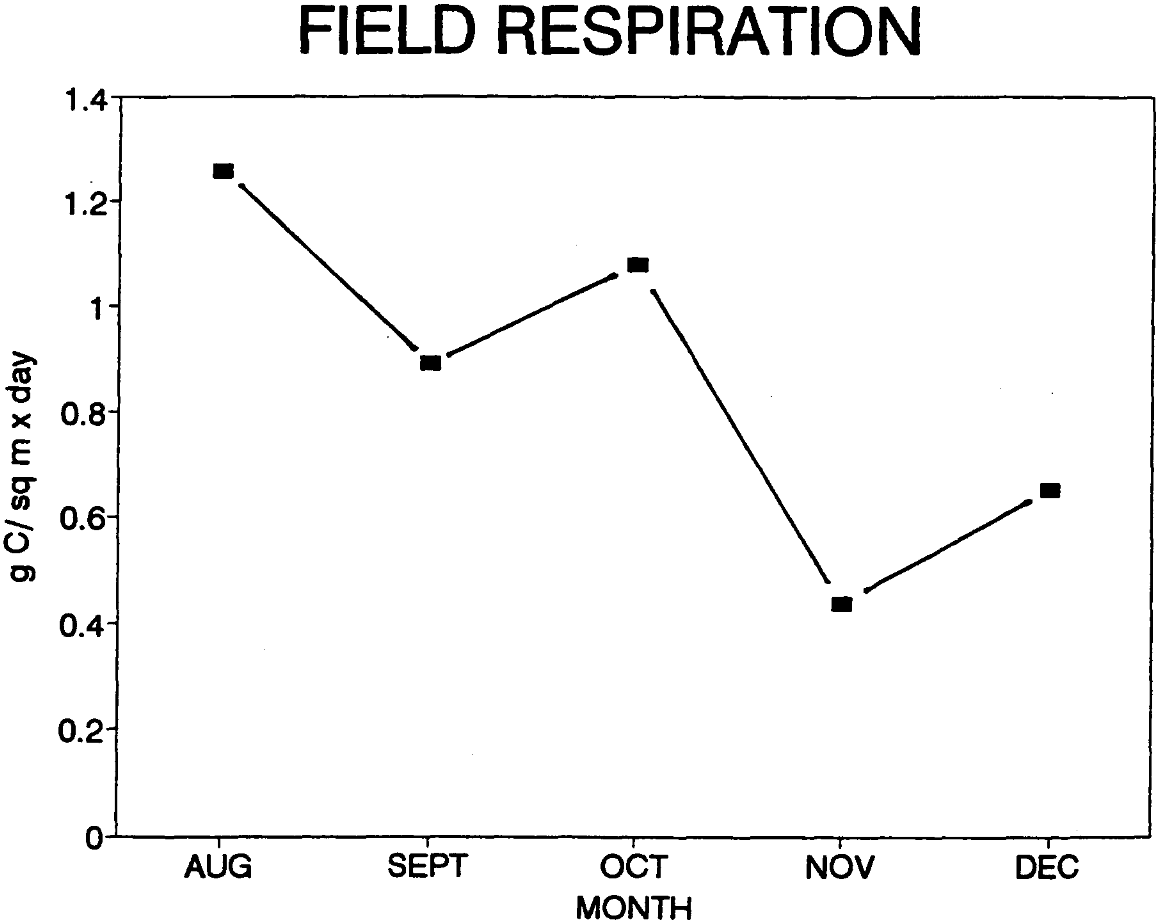

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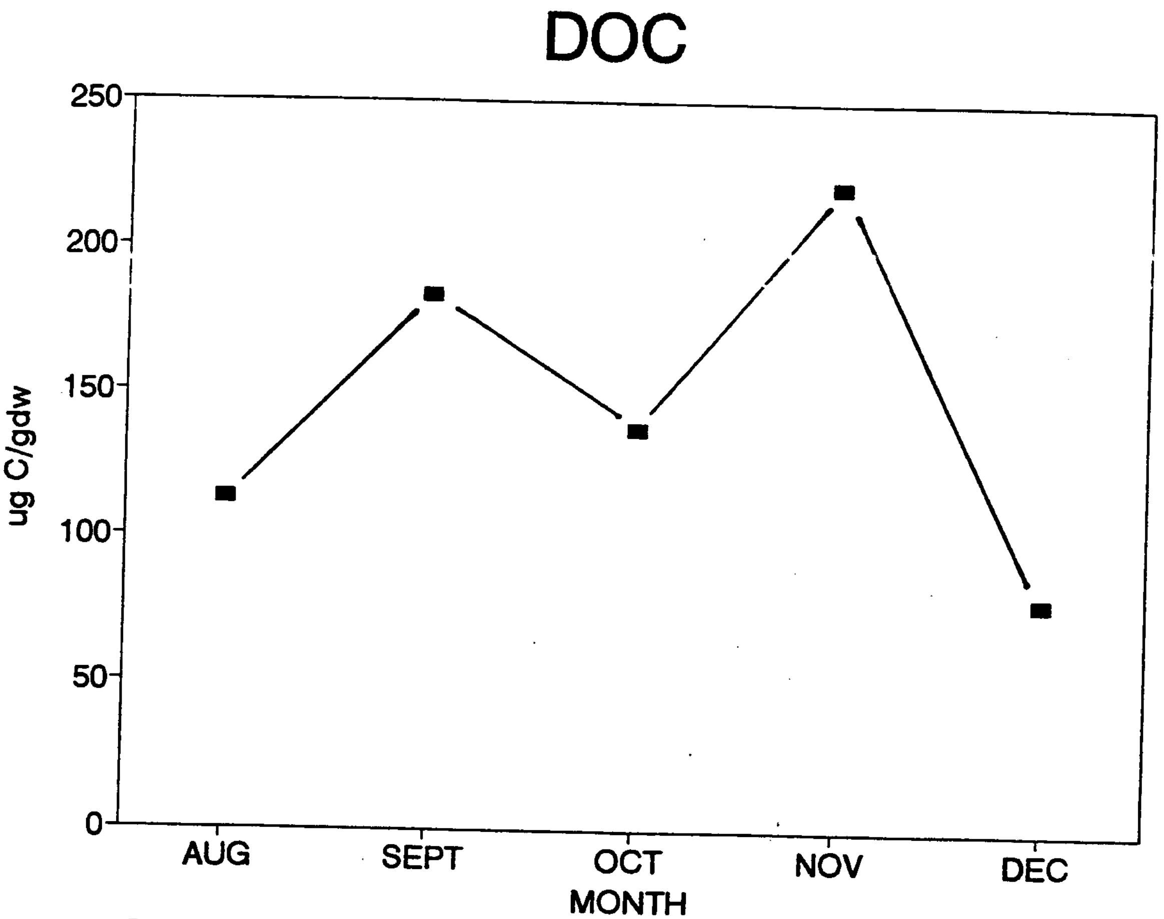

Figure. 6