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ORIGINAL PAPER

# Growing season temperatures limit growth of loblolly pine (*Pinus taeda* L.) seedlings across a wide geographic transect

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**Abstract** We grew potted loblolly pine (*Pinus taeda* L.) seedlings from a single provenance under well watered and fertilized conditions at four locations along a 610 km north–south transect that spanned most of the species range to examine how differences in the above-ground environment would affect growth rate, biomass partitioning and gas exchange characteristics. Across the transect there was an 8.7°C difference in average growing season temperature, and temperature proved to be the key environmental factor controlling growth rate. Biomass growth was strongly correlated with differences in mean growing season temperature ($R^2 = 0.97$) and temperature sum ($R^2 = 0.92$), but not with differences in mean daily photosynthetic photon flux density or mean daily vapor pressure deficit. Biomass partitioning between root and shoot was unchanged across sites. There was substantial thermal acclimation of leaf respiration, but not photosynthesis. In mid-summer, leaf respiration rates measured at 25°C ranged from 0.2 μmol $m^{-2}$ $s^{-1}$ in seedlings from the warmest location to 1.1 μmol $m^{-2}$ $s^{-1}$ in seedlings from the coolest site. The greatest biomass growth occurred near the middle of the range, indicating that temperatures were sub- and supra-optimal at the northern and southern ends on the range, respectively. However, in the middle of the range, there was an 18% decrease in biomass increment between two sites, corresponding to 1.4°C increase in mean growing season temperature. This suggests that thermal acclimation was insufficient to compensate for this relatively small increase in temperature.

**Keywords** Loblolly pine · Thermal acclimation · Net photosynthesis · Dark respiration

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## Introduction

Climate simulations predict that temperatures in this century will increase by approximately 2°C in the southeastern United States (Meehl et al. 2007). Most biological processes determining net biomass accumulation are temperature dependent, including photosynthesis and respiration (Hellmers 1962). Yet factors such as the ability of a species to acclimate physiologically to different temperature regimes, changes in the length of the growing season and increased potential for high temperature stress complicate predictions of how warmer conditions will affect tree growth.

Many studies of the effect of temperature on tree growth have reported that higher temperatures increase tree growth. Height growth of a population of genotypes of *Pinus sylvestris* (L.) planted in genetic trials throughout Europe was greatest in sites in the southern (warmest) locations, and least in the colder northern sites (Reich and Oleksyn 2008). The annual biomass increment of mature moist tropical evergreen forests growing on different sites with mean annual temperatures ranging from 10 to 27°C