Contrasting activity and surface area for leaves and roots of intensively managed southeastern US forest species

Mark Coleman[1], Doug Aubrey[1], David Coyle[2], Lisa Samuelson[3], Rodney Will[4]

[1]USDA Forest Service, Southern Research Station, New Ellenton, SC
[2]Department of Entomology, University of Wisconsin, Madison, WI
[3]School of Forestry & Wildlife Sciences, Auburn University, Auburn, AL
[4]Department of Forestry/Environmental Institute, Oklahoma State Univ., Norman OK

Process-level understanding of forest growth, development and services is required to optimize production, predict growth response for variable sites and facilitate adaptation of forestry technology to new applications. Resource acquisition and allocation are considered to be major growth limiting factors. In particular, the surface area available for, and the activity of acquisition surfaces must be clearly defined to predict stand growth. There is a critical need to attain similar levels of detail for these factors for both leaves and roots. To address this need, the Short Rotation Woody Crops Cooperative Research Program – a consortium of federal, private, and academic scientists – installed a multi-species trial (*Populus deltoides, Platanus occidentalis, Liquidambar styraciflua* and *Pinus taeda*) and supplied stand-level treatments with drip irrigation consisting of control (C), irrigation (I), fertilizer (F) and irrigation + fertilization (IF) on a Carolina Sand Hill site low in nutrients and water holding capacity. Complete competition control was implemented and pest management options were employed. Biomass and production varied 1.5 to 4 fold between C and IF with the greatest response in *Populus* and *Platanus*. Hardwoods responded positively to both I and F and there was an additive response to IF. However, *Pinus* responded equally to F and IF, and not at all to I. Leaf area explained much of the growth response in all genotypes. Leaf gas exchange also showed significant differences among treatments, but not sufficient to explained growth differences. Radiation interception was greatest in the most productive plots due to higher leaf area, but radiation use efficiency – slope of production as a function of radiation interception – did not vary appreciably among treatments for any species. Transpiration rate at the stand level, as measured with sap flow, was proportional to biomass production; however, transpiration was not completely explained by leaf area, rather changes in hydraulic stem properties helped explain treatment effects. In total, this aboveground information demonstrates that the surface area for aboveground resource acquisition explains much, but not all of the growth response. Belowground, biomass for all root classes also responded in proportion to total biomass production. Such a proportional response is in contrast with commonly reported allocation shifts from above to belowground with resource limitations. Observed shifts in allocation were explained by development and resource availability simply accelerates development. The amount of nitrogen (N) uptake (i.e. total N content) increased with both age and fertilizer application. *Pinus* had the greatest specific uptake rates, which increased with age. In contrast, hardwood specific uptake rates remained constant because fine-root biomass increased in proportion to total N uptake. Therefore, resource acquisition both above and belowground is dependent upon the amount of acquisition surface but shifts in specific acquisition rate also help explain growth response to resource availability.