Model Description

LINKAGES v2.2 (Wullschleger et al. 2003) is a modification of the individual-based LINKAGES model developed originally by Pastor and Post (1986). The model was modified to reflect important results from the Throughfall Displacement Experiment (TDE; Hanson and Wullschleger 2003). These included the following:

1. The monthly description of evapotranspiration (ET) was replaced with a daily scheme in which evaporation from the soil surface and canopy transpiration were treated separately (Shuttleworth and Wallace 1985, Federer et al. 1996). A maximum stomatal conductance was specified for the stand, and transpiration was modeled on the basis of the response of stomatal conductance to radiation, temperature, vapor pressure deficit, and extractable soil water. Interception losses were determined for the canopy from leaf area and stem area index (Federer 1995).

2. The bucket model of soil water extraction in LINKAGES, which was predicted on the basis of a single soil layer, was replaced with an approach that used multiple soil layers and a scheme that extracted water for transpiration from each soil layer as modified by the relative distribution of roots within the soil profile. Eighty-one percent of the total root biomass was allocated to the upper 50 cm of soil, another 11% to the layers from 50 to 70 cm, and the remaining 8% to deeper soil profiles (70 to 100 cm).

In addition to these enhancements, several lessons learned from research specifically on the TDE were used to modify the LINKAGES model:

3. The calculation of drought days was weighted according to the time of year that soil water deficits occurred. This weighting factor reflected the fact that, although late-season droughts are frequently observed on the TDE, they are of little consequence to the growth increment of the species studied on the TDE in comparison to early season droughts. As characterized by Hanson and Weltzin (2000) and Hanson et al. (2001), there is a temporal mismatch between late-season drought and diameter growth. The weighting factor was an attempt to account for this temporal mismatch.

4. Rather than allow seedlings, saplings, and mature trees to have equal access to all soil layers and thus to all extractable soil water, roots were restricted to specific soil layers based on whether plants were designated seedlings, saplings, or mature trees. Seedlings occupied the soil layers from 0 to 50 cm, saplings occupied soil layers from 0 to 70 cm soil layers, and mature trees occupied the entire soil profile. The number of drought days for each size class was estimated separately, and as a result, the LINKAGES v2.2 model mimicked the differential susceptibility of seedlings, saplings, and mature trees to drought.

Other modifications to LINKAGES were also made. These changes included replacing the parabolic dependency of diameter growth on growing degree days with an asymptotic function for each species that mimicked the lower portion of the temperature-response function but did not impose a growth reduction under higher temperatures (Bugmann and Solomon 2000). Furthermore, canopy leaf area development was made a function of air temperature, thus allowing for year-to-year variation in stand phenology. Other than these changes, LINKAGES v2.2 retains all components of the original LINKAGES model.

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