MODELING HARDWOOD CROWN RADII USING CIRCULAR DATA ANALYSIS

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Cylindrical data are bivariate data composed of a linear and an angular component. One can use uniform, first-order (one maximum and one minimum) or second-order (two maxima and two minima) models to relate the linear component to the angular component. Crown radii can be treated as cylindrical data when the azimuths at which the radii are measured are also recorded. The radius is the linear component, while the azimuth is the angular component. Crown radii were measured as part of a hardwood forest research project at Arkansas Post National Memorial near Gillett, AR. The forest is composed of various stands of upland and bottomland hardwoods. Basic descriptive statistics, and uniform, first-order and second-order models were used to examine the circular patterns of crown radii by species.

A total of 167 trees of various sizes were used in this analysis: 48 sweetgum (*Liquidambar styraciflua* L.), 42 southern red oak (*Quercus falcata* Michx.), 41 American elm (*Ulmus americana* L.), 26 willow oak (*Quercus phellos* L.), and 10 water oak (*Quercus nigra* L.). The crown radii (meters) were measured in the north, northeast, east, southeast, south, southwest, west, and northwest directions and were made relative by dividing each by the respective total tree height in meters prior to use in the analysis. American elm, on average, possessed the largest relative crown radii (23 percent of tree height) whereas sweetgum possessed the smallest (10 percent of tree height). Tree to tree variation in relative crown radii was largest, on average, in willow oak and lowest in sweetgum as determined by standard deviations (13 percent of tree height and 5 percent of tree height, respectively). Within tree variation in relative crown radii was largest in willow oak, on average, and smallest in American elm as determined by the within tree coefficient of variation (64 percent and 41 percent, on average, respectively).

The first-order cylindrical model was significant (at $\alpha = 0.10$) for 30 percent of the willow oak; about 20 percent of the southern red oak, water oak, and American elm; and 10 percent of the sweetgum trees measured. A significant first-order model implies that the crown radii were largest in one particular direction (azimuth) and then decreased to a minimum at another direction (azimuth). The second-order cylindrical model was significant (at $\alpha = 0.10$) for three willow oak (about 12 percent of those measured), two sweetgum, and one southern red oak. A significant second-order model implies that the crown radii were largest in two particular directions (azimuths) and then decreased to minimums at two other directions (azimuths). A uniform model (approximately the same crown radii in all directions) was assumed appropriate for the remaining trees. Of the species examined, willow oak appears to be quite opportunistic with respect to radial crown expansion whereas sweetgum appears to be the least opportunistic.

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