# PREDICTING SAPLING GROWTH AND RECRUITMENT IN DIFFERENT SIZE CANOPY GAPS

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**Abstract—**Accurate simulation of the effects of uneven-aged management on future stand structure and species composition requires good empirical data on sapling growth, survival, and canopy recruitment, particularly as these dynamics are influenced by the number and size of canopy openings created at each harvest. In order to examine the response of various species to different levels of understory light and woody competition, we measured annual growth increments (1993-97) on tree saplings in 30 northern hardwood stands in north-central Wisconsin and adjacent western Upper Michigan. Understory conditions in the 100 "gap" plots sampled ranged from closed canopy to group selection openings (>400 $m^2$). Average daily radiation received by individual saplings was estimated from computer analysis of hemispherical canopy photographs taken directly above the 510 subject saplings (size 25 cm tall to 10 cm dbh). In addition, data on woody competition experienced by subject trees were collected for all sapling and overstory trees in the plot.

Shade-tolerant sugar maple reached close to its maximum height growth rate (30-40 cm/yr) at surprisingly low light intensities typical of small single tree gaps (2-15 percent full sunlight). Increasing gap size had little further effect on growth rate for maple. In contrast, height growth rates of midtolerant species continued to increase with increasing light intensity, consistent with the normal expectation that midtolerant species will have a substantial competitive advantage in larger openings. At moderately high gap light intensities (40-60 percent full sunlight, typical of gaps 100-300 $m^2$), growth rate increased substantially for both red oak and white ash (~60 cm/yr). For all species, height growth rate clearly increased with sapling size (fig. 1). For example, at a given light intensity of 25 percent full sunlight, the height growth rate of a large white ash sapling (>2.5 cm dbh) was nearly three times greater than that of a smaller white ash sapling (<1.5 m tall) in the same light environment. Species specific regression equations for height growth as a function of sapling height and PPFD (photosynthetic photon flux density) had $R^2$ values in the range of 0.47 - 0.62.

Sapling growth rates can be expected to continually change over time as a result of increasing sapling size, changes in sapling height relative to competitors, and decreasing gap size due to lateral gap closure. To forecast interspecific competition over time in response to canopy gap formation and closure, we sought to develop predictive equations for sapling growth and mortality based on simple measures that could be easily updated within the context of an iterative model. While irradiance levels increased with gap size, light reaching individual saplings was also strongly influenced by its horizontal position within the gap and its relative height. Almost half of the variation in PPFD could be explained by four variables (i.e., subject tree height, square-root of gap area, distance of the sapling north of the gap's southern border, and a competition index based on the aggregate crown projection area of all taller saplings; $R^2$=0.48). These four variables were also found to be among the most significant in regression equations predicting sapling height growth. Coefficients of determination ($R^2$) for height growth equations ranged from 0.54 for the sugar maple up to 0.85 for red oak. These equations are being incorporated into a spatially explicit, crown-based model of forest dynamics (CROWN) that keeps track of the size, growth, and mortality of individual trees within a stand.

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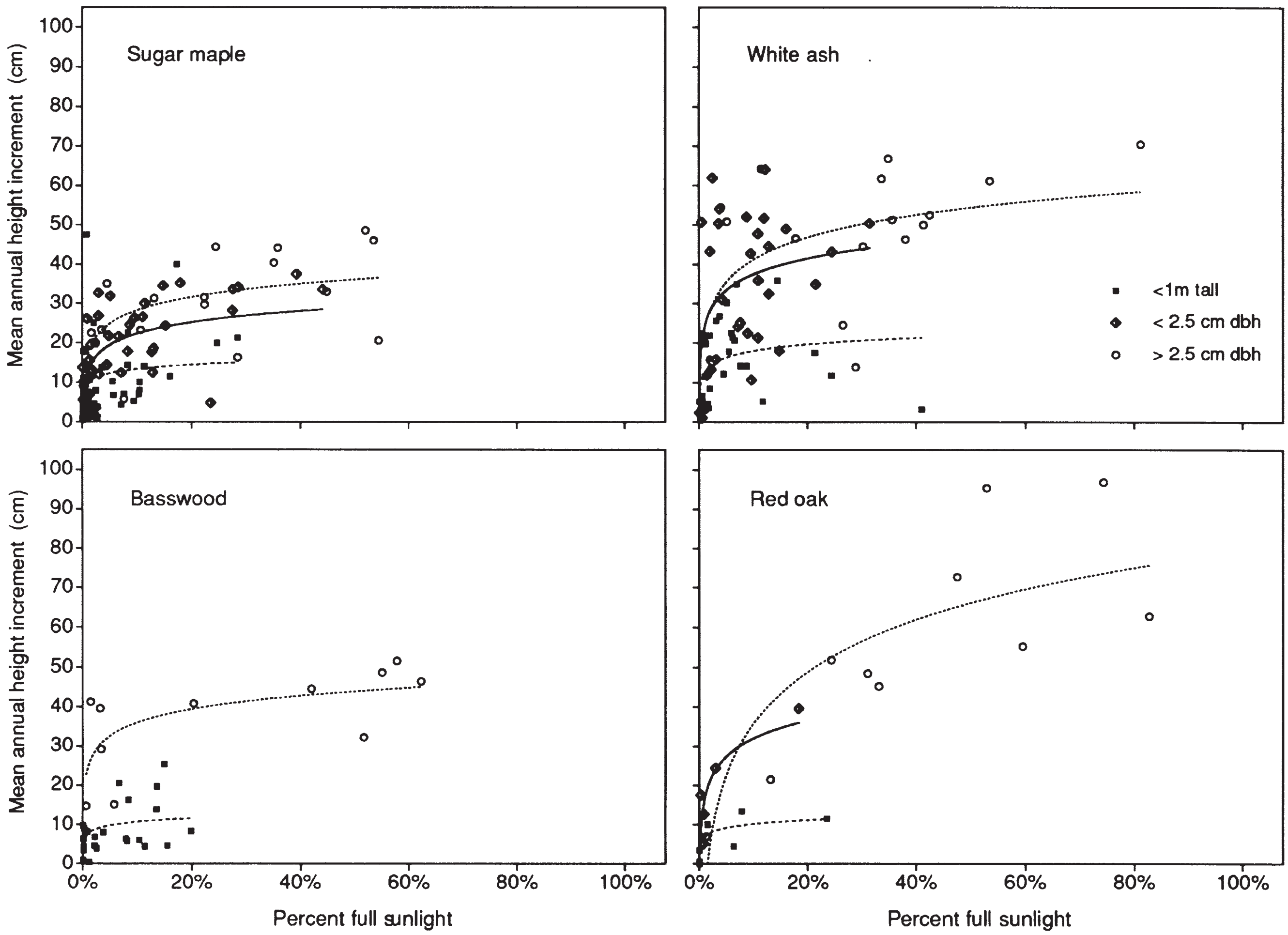


Figure 1—Mean annual height growth versus the amount of solar radiation reaching the sapling. For each species, separate response curve are displayed for three different sapling size classes (< 1.5 m tall, >1 m tall but <2.5 cm dbh, >2.5 cm dbh).