

# Notes For Forest Managers

Missouri Department of Conservation



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## Promoting shortleaf pine: Canopy openness and pine regeneration in closed canopy forests

Light is a limiting factor in the regeneration and recruitment of shortleaf pine. Light is transmitted to the understory as either direct radiation (light unimpeded in transmission) or diffuse radiation (light emanating from other parts of the sky as a result of scattering of light by the atmosphere). The amount of direct and diffuse radiation transmitted to the understory is directly related to the percent of overstory canopy openness. Therefore, knowing the percent of canopy openness is particularly useful for promoting shortleaf pine success.

In oak-pine forests of the Missouri Ozarks tree growth responses to changes in direct and diffuse radiation are not well understood. The intensity and quality of direct and diffuse light limits shortleaf pine seed germination, photosynthesis and growth. Understory shortleaf pines can have annual height increases ranging from 7 to 28 cm (2.8 to 11.0 in) per year immediately following canopy opening. In comparison, deciduous saplings can have average height growth rates of up to 1 meter (3.28 ft) per year. Although shortleaf pine seedlings are moderately shade tolerant (Shelton and Cain 1999), without adequate light they rarely grow to sapling size or main-

tain desirable growth form. Reukema (1959) reported that the degree of canopy opening influences crown development and increases the total number of branches per seedling during the first four years following canopy opening. Light is important for reasons other than attempting to increase shortleaf pine's competitive edge over hardwoods. Increases in the light environment can accelerate rates of litter decomposition, another important limiting factor of pine regeneration (Shelton and Cain 1999).



We measured canopy openings using several methods including ground and canopy opening dimensions and computer analysis of canopy images. Ground dimensions of canopy gaps were measured using the equation of an ellipse (Figure 1) and provided the best estimate of percent canopy openness. The equation for estimating percent canopy openness from ground measurements is:

$$PCO = 14.25 + 0.008 * CGA$$
$$(r^2 = 0.70, p < 0.01)$$

Where *PCO* is percent canopy openness and *CGA* is canopy gap area (m<sup>2</sup>). The equation

### ABSTRACT

Perpetuating shortleaf pine in closed canopy forests using uneven-aged management techniques is restricted by seed bed conditions, adequate seed source, and light. As a shade intolerant species, shortleaf pine's reproductive and recruitment success depends on open canopy conditions. Canopy openness is used to describe the potential for light to enter the understory of forests. We studied the light environment of canopy openings for the purpose of relating the percent canopy openness to ground measurements of canopy opening size. In this paper we present an equation for use in estimating the amount of canopy openness in closed canopy oak-pine forests and discuss the potential relationship between canopy openness and shortleaf pine regeneration abundance.

Figure 1. Measuring canopy gap area

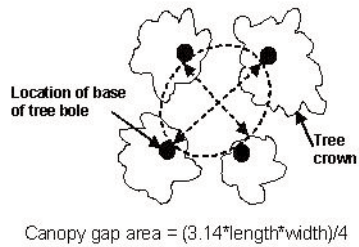


Figure 1. Estimating the percent canopy openness requires a measurement of the canopy opening size. An ellipse that extends to the boles of the trees surrounding the canopy opening is a straightforward method to measure canopy opening area and requires two measurements; ellipse length and width. Length and width must be measured in meters to be applied to the canopy openness equation.

was generated from data of 42 canopy openings in a mature closed canopy oak-pine forest. The opening sizes ranged from approximately 50 to 2000 m<sup>2</sup>.

We found that the maximum number of shortleaf pine seedlings regenerating increased with increasing canopy opening size (Figure 2). These data are limited in sample size and site replication; therefore the equation should be used with caution and evaluated through field trials. Other important limiting factors for shortleaf pine regeneration such as hardwood competition, litter depth and seed source will likely confound the relationship between canopy openness and pine regeneration success presented here. Our attempt to relate canopy openness to pine regeneration abundance represents preliminary work and further research is needed to improve our understanding of pine regeneration following canopy opening and the estimation of canopy openness for various stand densities.

*References:*

Reukema, D.L. 1959. Relation of pine forest overstory opening diameter to growth of pine reproduction. *Ecology*, 40:478-480.

Runkle, J. 1992. Guidelines and sample protocol for sampling forest gaps. *USDA Forest Service General Technical Report PNW-GTR-283*. 44 p.

Shelton, M.G. and M.D. Cain. 1999. Regenerating uneven-aged stands of loblolly and shortleaf pines: the current state of knowledge. *Forest Ecology and Management* 129:177-193.

Stambaugh, M.C. 2001. Canopy gap dynamics in shortleaf pine forests of the Ozark Highlands. M.S. Thesis. University of Missouri-Columbia, Forestry Dept. 186 p.

Stambaugh, M.C., R. Muzika and R.P. Guyette. 2002. Disturbance characteristics and overstory composition of an old-growth shortleaf pine (*Pinus echinata* Mill.) forest in the Ozark Highlands, Missouri, USA. *Natural Areas Journal* 22:108-119.

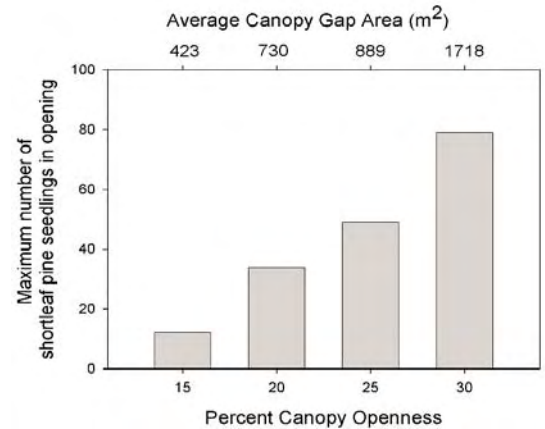


Figure 2. Bar plot depicting the maximum number of pine seedlings observed in canopy openings. Percent canopy openness is shown on the bottom horizontal axis and the respective canopy gap area is shown on the top horizontal axis.

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