CROWN SIZE RELATIONSHIPS FOR BLACK WILLOW IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

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Abstract--Growing space requirements derived from maximum and minimum crown sizes have been identified for many southern hardwood species. These requirements help managers assess stocking levels, schedule intermediate treatments, and even assist in determining planting densities. Throughout the Mississippi Alluvial Valley, black willow (*Salix nigra* Marsh.) stands are common along major rivers as single-species stands. Management of these stands is limited in part by the lack of information regarding crown size-stem density relationships. We developed equations to predict maximum crown sizes from open-grown black willow trees and minimum crown sizes from natural, even-aged black willow stands. This information is being utilized to construct stocking guides for thinning treatments and provide preliminary planting density guidelines for plantations based on a target diameter size. Our initial results show that a polynomial tree area equation predicted the maximum density data well; however, the data associated with the development of the maximum crown area equation (leading to the average minimum density line) were much more variable.

INTRODUCTION

Black willow (*Salix nigra* Marsh.) is a common species occupying alluvial sites throughout major river bottoms in the Lower Mississippi Alluvial Valley. Flooding along these river systems lays down new sediments, which are often colonized by black willow. As a result, new stands typically occur as "bands" ranging from tens to hundreds of feet wide. Under these conditions, black willow stands are often single-species, but depending on the amount of soil deposition, they may co-occur with eastern cottonwood (*Populus deltoides* Bartram ex. Marsh.) and/or sandbar willow (*Salix interior* Rowlee). Following initial colonization, stand development proceeds rapidly. Newly established stands may have 10,000 or more stems per acre. Stem density declines rapidly, as willow is very shade intolerant. On the best sites, black willow may grow 5 feet per year in height and 1 inch in diameter at breast height (d.b.h.) (Lamb 1915), although these growth rates decrease as stands age.

The scant evidence available suggests black willow responds positively to thinning (Johnson and McKnight 1969). However, information related to stocking is absent in the literature. No guidelines are available for predicting relative density or stocking percent in order to objectively manage black willow stands.

The goal of this study was to quantify the maximum and minimum areas that black willow occupies for a given d.b.h. (i.e. tree areas). This information can then be used to develop density management diagrams to predict upper and lower bounds for maximum and minimum stocking levels.

METHODS

Tree area ratios were used to predict growing space requirements for stands growing at their maximum density for a given d.b.h. (Chisman and Schumacher 1940). Plots were established in stands where black willow was the dominant species, canopy gaps were absent, and mortality present to indicate the area contained its maximum density. Data were collected from 23 stands located near the confluence of the Arkansas, White, and Mississippi rivers. The number (1 to 7) and size (0.01 to 0.2 acre) of measurement plots per stand varied depending on stand conditions and tree size, with small plots used in stands with small average diameters.

At each plot, d.b.h. and species for all trees > 1 inch d.b.h. were recorded. To facilitate stand development studies and additional research objectives, the location of all plot centers was recorded using GPS, and each tree was permanently tagged with a unique number for future monitoring. A tree area (TA) equation, originally developed by Chisman and Schumacher (1940) to estimate the area occupied by trees growing at their maximum density, was fit to the data in the following form:

$$TA = b_0N + b_1\Sigma D + b_2\Sigma D^2 \qquad (1)$$

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where b_0, b_1, and b_2 are regression coefficients, N is trees per unit area, and D is tree d.b.h.

To determine the average minimum density (minimum number of trees for a given diameter that can fully occupy a unit area), we measured willows that were open-grown without competition. Crown width (CW) was estimated as the average of the north-south and east-west crown extents and recorded along with d.b.h. Crown width was then predicted as a linear function of d.b.h.:

$$CW = b_0 + b_1 D \quad (2)$$

where CW is in feet and all other parameters are as previously defined.

Maximum crown area or TA_{max} was estimated using the following equation outlined by Krajicekand others (1961):

$$TA_{max} = \pi(CW/2)^2 \div 43.56 \quad (3)$$

where TA_{max} is in milacres.

Once expanded the equation takes on the form:

$$TA_{max} = b_0 + b_1 D + b_2 D^2 \quad (4)$$

RESULTS AND DISCUSSION

A tree area ratio equation was used to predict area required for a tree of a given size in fully stocked stands (TA_{min}). The equation for stands with quadratic mean diameter (QMD) $\geq$ 4 inches was highly significant ($P < 0.0001$):

$$TA_{min} = -1.66 + 0.52375D + 0.00005480788D^2 \quad (5)$$

where TA_{min} is tree area in milacres and D is d.b.h. in inches.

The curve for black willow was more linear than curves for several other bottomland hardwood species (fig. 1). Black willow was most closely aligned with equations for cottonwood, silver maple (*Acer saccharinum* L.), and sycamore (*Platanus occidentalis* L.) (Larsen and others 2010). The application of the bottomland hardwood equations developed by Goelz (1995) would severely over-predict tree areas and substantially under-predict stocking for black willow (fig. 1).

Crown width of open-grown trees was a linear function of d.b.h. Data points were dispersed around the regression line that predicted tree area using d.b.h. ($r^2 = 0.68$, fig. 2). The fit for our equation was relatively poor compared to many published crown-width equations, where d.b.h. often accounts for more than 90 percent of the variation (e.g., Johnson and others 2009, Krajicek and others 1961). However, black willow branches are brittle and susceptible to breakage during storm events (e.g., Seischab and others 1993), which may partially account for the poor fit.

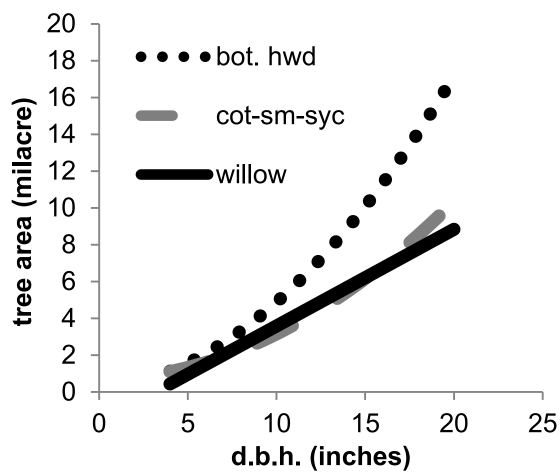

Figure 1--Minimum tree area curve for black willow compared to published equations for bottomland hardwoods (bot. hwd) (Goelz 1995) and cottonwood-silver maple-sycamore (cw-sm-syc) (Larsen and others 2010).

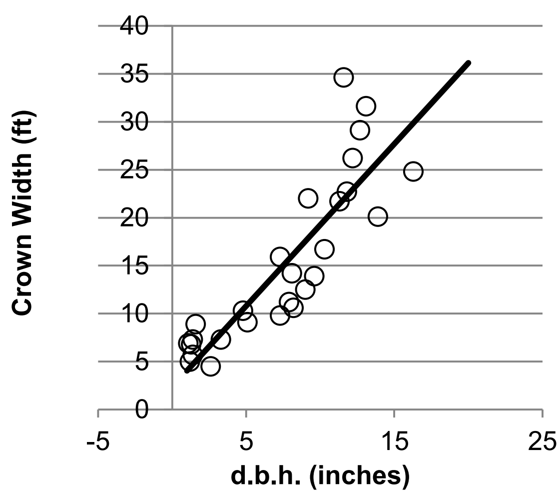

Figure 2--Predicted crown width for open grown black willow stems.

The TA_{max} was calculated as:

$$TA_{max} = 0.1002 + 0.1436D + 0.05143D^2 \quad (6)$$

Maximum tree areas were about 70 to 170 percent > the minimum tree areas for 6- to 20-inch d.b.h. trees, respectively (fig. 3). For black willow stands, this difference amounts to 355 and 673 tree per acre for 6-inch d.b.h. trees, 220 and 395 trees per acre for 8-inch d.b.h. trees, 150 and 279 trees per acre for 10-inch d.b.h. trees, 108 and 216 trees per acre for 12-inch d.b.h. trees, 82 and 176 trees per acre for 14-inch d.b.h. trees, and 64 and 148 trees per acre for 16-inch d.b.h. trees.

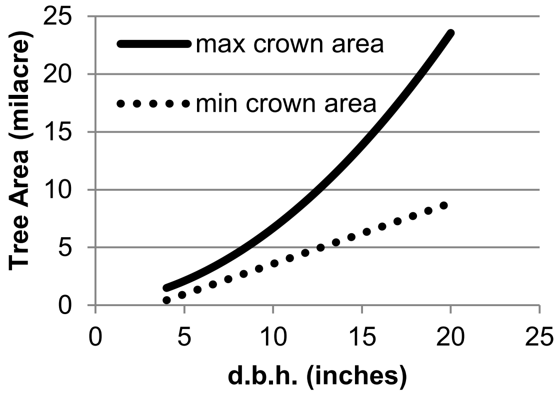

Figure 3--A comparison of minimum and maximum tree curves for black willow.

These data can be used by managers to assess bounds for managing stem density for thinning activities. Similarly, the maximum tree areas can be used to estimate planting density. For example, if a particular management objective was to grow 8-inch d.b.h. black willow trees, the maximum planting density assuming no thinning would be 395 trees per acre, or a plant spacing of 10- by 11-feet.

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