Growth of a 45-Year-Old Ponderosa Pine Plantation: An Arizona Case Study

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Abstract—*Information on the growth of forest plantations is necessary for planning of ecosystem-based management of the plantations. This information is also useful in validating or refining computer simulators that estimate plantation growth into the future. Such growth information has been obtained from a 45-year-old ponderosa pine (*Pinus ponderosa*) plantation in the Hart Prairie area north of the Fort Valley Experimental Forest headquarters. Average annual growth in terms of number of trees, basal area, and volume was obtained. Growth information such as that obtained on this plantation is crucial to planning of long-term forest management activities.*

Introduction

Information on the growth of forest plantations is necessary for planning of ecosystem-based management of the plantations. This information is also useful in validating or refining computer simulators that estimate plantation growth into the future. Such growth information has been obtained from a ponderosa pine plantation located 3.2 km (2 miles) north of the Fort Valley Experimental Forest headquarters and about 24 km (15 miles) north of Flagstaff, Arizona. It was estimated from early planting histories in the area that this plantation is approximately 45 years of age.

Study Protocol

The 1.1-ha (2.7-acre) plantation, located in the Hart Prairie area, is similar in structure to other ponderosa pine plantations established by the U.S. Forest Service in the early 1960s to reforest sites where the forest overstory had been destroyed by wildfire. The plantation is 2,077 m (6,800 ft) in elevation, located on basaltic soils, with slopes less than 5 percent. Annual temperature at the nearby Fort Valley headquarters averages 6º C (43º F), ranging from -4º C (25º F) in January to 17º C (63º F) in July (Ronco and others 1985). Average annual precipitation is about 635 mm (25 inches), with one-third of the precipitation occurring in the summer monsoons. The estimated site index of 20 m (65 ft) at 100 years (Minor 1964) is equivalent to the Southwestern Region's Site Class 2 designation (Schubert 1974). More than two-thirds of the ponderosa pine forests in the Hart Prairie vicinity are found within this site class.

Age and quality of the seedlings planted by the Forest Service in establishing the plantation, the site preparation techniques applied, the planting methods used, and initial survival of the seedlings are unknown. However, surviving trees when the plantation was measured in 2007 were spaced 1.2 m (4 ft) apart in parallel rows with 2.4 m (8 ft) intervals between the rows. Diameter breast height (dbh) of these trees was measured by standard procedures. Total height measurements taken on a sub-sample of 30 trees indicated that the dbh-height relationship established in a nearby 30-year-old plantation (Heidmann and others 1997) also applied in the plantation in the current study. The dbh measurements and dbh-height relationship were used to calculate basal area and volume of the measured trees. A formula for young-growth (blackjack) southwestern ponderosa pine trees (Myers 1963) was applied in the volume calculation.

Results

A total of 1,050 trees (equivalent to 960 stems/ha [388.8 stems/acre]) were measured in the plantation. Average dbh of these trees was 19.8 cm (7.8 inches), with a range of values

In: Olberding, Susan D., and Moore, Margaret M., tech coords. 2008. Fort Valley Experimental Forest—A Century of Research 1908-2008. Proceedings RMRS-P-55. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 282 p.

from 1.3 to 36.3 cm (0.5 to 14.3 inches). Average basal area was 32.7 m^2/ha (142.5 ft^2/acre) and average volume was 93.9 m^3/ha (1,324.5 ft^3/acre). Respective frequencies of 2.5-cm (1-inch) dbh values approximated slightly skewed bell-shaped distributions for these parameters (Figure 1). Heidmann and others (1997) reported similar distributions for dbh and volume in their study of the nearby plantation; a frequency distribution for basal area values was not included in the latter study.

Assuming that the estimated age is correct and that tree mortality has been insignificant, average annual growth rates since establishment of the plantation studied were 0.73 m^2/ha (3.18 ft^2/acre) of basal area and 2.08 m^3/ha (29.4 ft^3/acre) of volume, respectively. Both of these values were larger than those reported for the 30-year-old ponderosa pine plantation (Heidmann and others 1997). The average annual basal area and volume growth rates for this latter plantation were 0.45 m^2/ha (1.95 ft^2/acre) and 1.25 m^3/ha (17.6 ft^3/acre), respectively. However, inferences on comparative growth rates for the two plantations must be made in relation to the differing histories of the plantations.

The plantation measured in this current study was 15 years older when it was measured in 2007 than the plantation measured by Heidmann and others. It was not surprising, therefore, that larger trees (up to 37.0 cm [14.6 inches] dbh) were tallied in the former than in the latter (28.6 cm [11.3 inches] dbh). Furthermore, a precommercial thinning was conducted in the plantation measured by Heidmann and others (1997) in 1984—about 20 years following its establishment—removed an estimated 840 stems/ha (340 stems/acre). If tree mortality from the time of the precommercial thinning to when the plantation was measured by Heidmann and his colleagues was also insignificant, about 60 percent of the trees were removed from the plantation by the thinning operation. There had been no thinning or other silvicultural treatments imposed in the 45-year-old plantation studied since its establishment.

Discussion

Average dbh and tree density information can be used with stand and growing stock tables that predict the conditions of fully stocked even-aged stands with average dbh values up to almost 60 cm (24 inches) (Myers 1967, Ronco and others 1985, Schubert 1974). Growing stock levels are numerical indices designating the basal area level in square meter per hectare (square feet per acre) that a residual stand has—or will have—when the average dbh of the stand is 25.4 cm (10 inches). The 45-year-old plantation in this study, with its average dbh of 19.8 cm (7.8 inches) and density of 960 stems/ha (388.8 stems/acre) has a growing stock level in excess of 27.5 m^2/ha (120 ft^2/acre) according to the tables. Managers could use this information to reduce the current stocking of the plantation to achieve a growing stock level of 13.8 m^2/ha (60 ft^2/acre) that is more consistent with optimizing the range of resources in southwestern ponderosa pine forests including (potential) timber production, forage production, and the augmentation of water yield (Brown and others 1974). The current basal area of the 45-year-old plantation should be reduced from 32.7 m^2/ha (142.5 ft^2/acre) to 14.3 m^2/ha (62.4 ft^2/acre) and the tree density to 412 stems/ha (167 stems/acre) to achieve this goal.

Summary

The 45-year-old plantation studied is representative of many of the reforestation efforts of the U.S. Forest Service in southwestern ponderosa pine forests. However, with only few exceptions, growth information for these plantations is limited. One exception is the information provided by Heidmann and others (1997). Growth information is crucial to planning of long-term forest management activities to attain ecosystem-based, multi-benefit goals in southwestern ponderosa pine forests.

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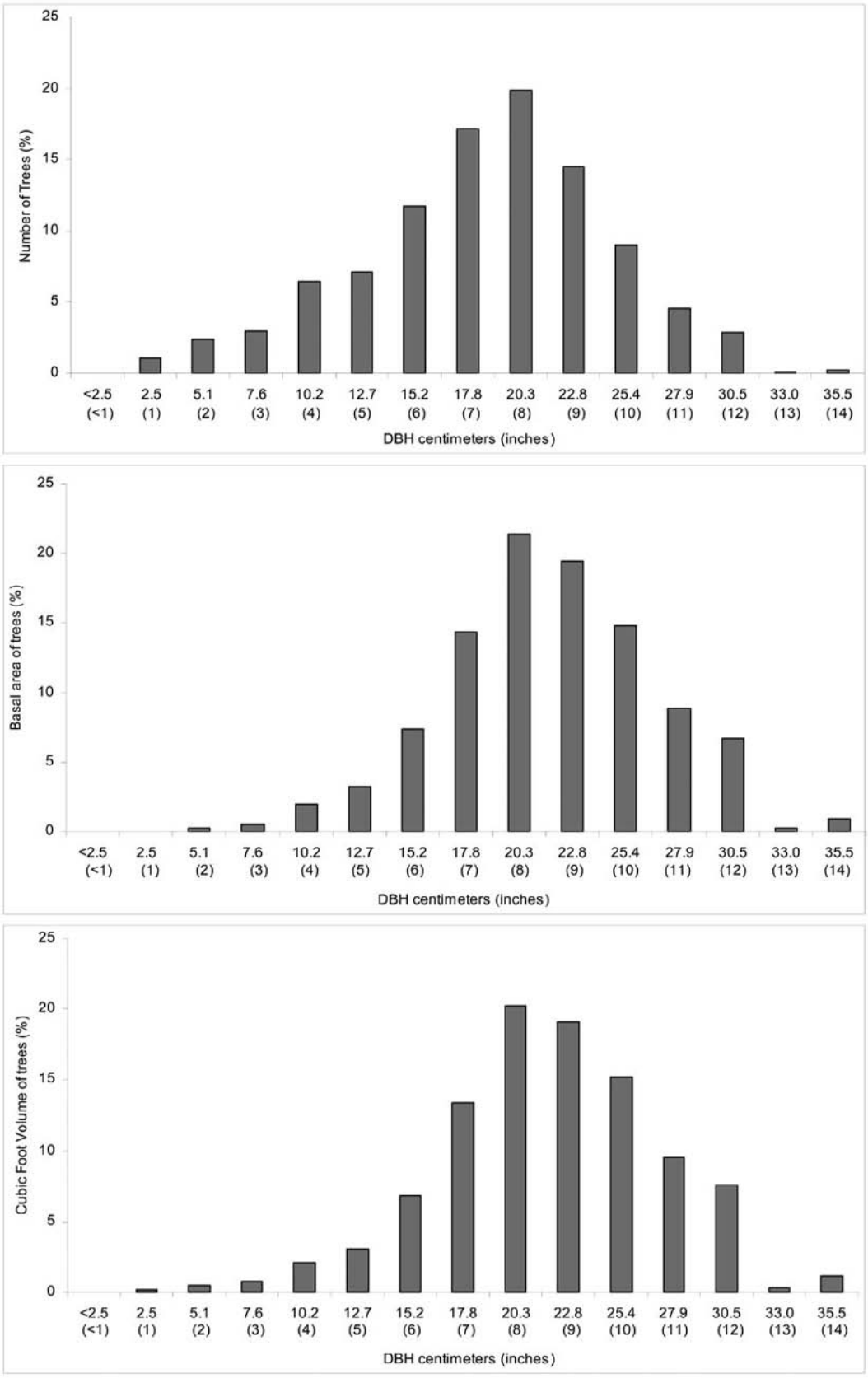

Figure 1. Frequency distributions of the number of trees (top), basal area (middle), and volume (bottom) of the Hart Prairie Ponderosa Pine Plantation by 2.5 cm (1 inch) dbh classes.