
A Simple Competition Assessment System Associated with Intensive Competition Control in Natural Loblolly–Shortleaf Pine Seedling Stands¹

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ABSTRACT. A simple competition assessment system was evaluated as part of an intensive competition control study in a natural, even-aged stand of loblolly–shortleaf pine (*Pinus taeda* L.–*P. echinata* Mill.) seedlings in southern Arkansas. Four levels of competition control were

maintained annually for 3 years as follows: (1) no competition control, (2) woody competition control, (3) herbaceous competition control, and (4) total control of nonpine vegetation. The competition assessment system is based on a correlation of total height to groundline diameter (gld) for loblolly pine seedlings that are less than 6 ft tall. The correlation indicated that if seedling gld's are not within +10 mm of total seedling height (in feet) multiplied by 10, then the seedlings would most likely show a positive growth response to competition control.

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In loblolly pine management, considerable emphasis is placed on site preparation to facilitate natural or artificial regeneration of cutover lands. Traditionally, oper-

ational site-preparation treatments are considered to be successful if they result in well-stocked stands of loblolly pine seedlings that grow in height at a rate equal to or exceeding that of reinvading competition, at least until the time of crown closure when the pines dominate the site. However, there has been increasing evidence in the last 10 years that supplemental control of competing vegetation during the time between pine establishment and crown closure can produce substantial pine growth gains in both height and diameter (Haywood and Tiarks 1981, Nelson et al. 1981, Knowe et al. 1985, Tiarks and Haywood 1986, Zutter et al. 1986, Bacon and Zedaker 1987, Miller et al. 1987).

In studies where the effects of various components of competition (woody and herbaceous) have been examined, competition from herbaceous species rather than woody species has been found to contribute to significant loss in pine growth through the first 5 years following pine establishment. Results from these intensive competition control studies represent unique standards of pine growth response to which operational treatments can be compared.

The problem faced by forest landowners in light of these research findings is how to assess a potential response from competition control in stands of pine re-

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generation. Some elaborate systems for assessing competing vegetation are being used or proposed for use in young southern pine plantations (Zedaker 1983, Zutter et al. 1985, Weise and Glover 1987). Such assessment systems can be rather labor-intensive and often subjective. The purpose of this paper is to present a competition assessment system that should help forest managers determine whether or not pines will respond to competition control in naturally regenerated stands of loblolly pine seedlings.

METHODS

Study Area and Treatment

The competition assessment system was evaluated in a study located on two 5-ac clearcuts within the Crossett Experimental Forest in southern Arkansas. The study was initiated 3 years after a seed tree regeneration harvest in an uneven-aged stand of loblolly and shortleaf pines. Site preparation prior to harvest included prescribed burning and stem injection of hardwoods with groundline diameters (gld's) larger than 1 in. Just before study installation, the 3-year-old rough was mowed with a Hydro-ax® to a height of 2.5 ft so that established pine seedlings would not be cut. After mowing, pine seed trees were removed to create a uniform treatment area. The study consisted of 16 plots (4 competition control treatments replicated 4 times) that were established in the fall of 1983 using a randomized, complete block design. Plots were 104 by 104 ft (0.25 ac) in size, having an interior measurement plot of 66 by 66 ft (0.1 ac) with 10 systematically established, permanent quadrats (circular milacres) for data collection.

The four competition control treatments initiated during the 1984 growing season and maintained annually were as follows:

Check. A mixture of woody and herbaceous competition that invaded the study areas following removal of the midstory and overstory pines and hardwoods was

left untreated. The 3-year-old rough was mowed to a height of 2.5 ft in August 1983 with no additional treatment.

Woody control. All standing and sprouting hardwoods, shrubs, and woody vines were controlled by single-stem treatments with herbicides.

Herbaceous control. Forbs, grasses, semiwoody plants, and vines were controlled using pre-emergent and post-emergent herbicides.

Total control. A combination of herbicides was used to control all nonpine vegetation.

Measurements and Data Analysis

Competition levels of woody and herbaceous species were assessed annually in late summer to document the degree of treatment success. Woody rootstocks were counted and percent ground cover of herbaceous vegetation was determined by ocular estimation to the nearest 10% on each milacre quadrat.

Prior to treatment and annually at the end of each growing season, pine seedlings were counted on the 10 milacre-quadrats per plot for calculation of density and percent stocking. In addition, 50 pine seedlings—principally loblolly—were randomly selected on each plot, tagged for identification, and measured at the end of each growing season for total height (to the nearest 0.1 ft) and gld (to the nearest mm).²

Based on annual remeasurement of total height and gld on some 800 pine seedlings, there was a recurring trend on the total control treatment for gld (in mm) to be equal to total height (in feet) multiplied by 10. If actual gld of pines on total control plots could be accurately estimated by multiplying total height times a constant, that would provide forest managers with a standard against which they could gauge whether

or not a response to competition control in seedling pine stands would occur.

To determine if these field observations could be verified statistically for use as a competition assessment system, data for each treatment were analyzed by the standard chi-square (χ^2) test (Freese 1960). For verification of this assessment system, it was necessary to state the accuracy required if the estimator (height in feet multiplied by 10) of actual gld in mm was to be considered acceptable. The degree of accuracy chosen was ± 10 mm since data analyses indicated that the standard deviation for mean gld in each of 3 years was that amount. Accuracy was specified in the form of a hypothesized variance at the 0.10 level of significance. Simple correlation coefficients were also computed to determine the degree of linear association between total height and gld for measurement pines within treatments by year.

RESULTS AND DISCUSSION

Evaluation of the Competition Assessment System

The procedure for this evaluation was to determine if the height-gld correlation on total control plots would be accurate enough for use as a competition assessment system even though correlation coefficients indicated a high degree of linear association between total height and gld for pine seedlings on all four treatments and in each of 3 years (Table 1). Based on the χ^2 test (Table 1), total height in feet multiplied by 10 proved to be an accurate estimator of actual gld in mm within the defined limits of the hypothesized variance at the 0.10 level of significance only for the total control plots for each of 3 years. The gld estimator also proved accurate after the first year of treatment on herbaceous control plots, but after the second and third years on that treatment, the assessment system predicted a potential response to competition control. Herbaceous control plots

² Mixed units of measure were used because neither English nor metric alone provided the most practical assessment system in field use.

averaged about 6,000 more pine seedlings per acre than did the other three treatments, and such excessive intraspecies competition can eventually have a negative impact on pine growth. On check and woody control plots, where herbaceous vegetation was left untreated, the computed χ^2 values exceeded the tabular values in all 3 years (Table 1) and indicated that total height in feet multiplied by 10 was not accurate enough to estimate actual gld (in mm) for pines on plots without herbaceous competition control.

The linear association of gld to total height is illustrated in Figure 1 for pines that were less than 5.6 ft tall on total control plots and on check plots after 3 years. For pines on the other two treatments, the linear association of gld to total height fell between the regression lines in Figure 1 with woody control close to the check and herbaceous control close to total control. These data suggest that if actual gld's for loblolly pine seedlings less than 6 ft tall are not within +10 mm of the total height in feet multiplied by 10, then these seedlings would most likely show a positive growth response to competition control.

If English units of measure are preferred, the constant (10), that was used for mm, is changed to

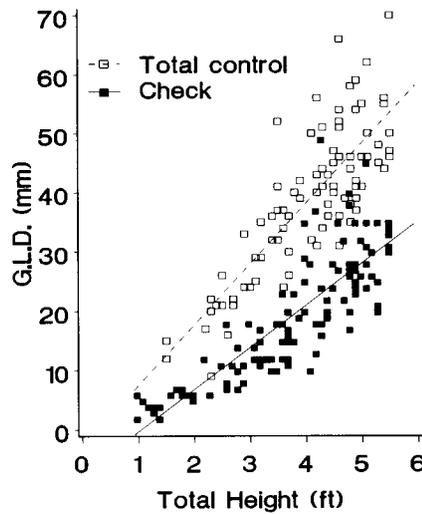


Figure 1. Relationship of groundline diameter (gld) to total height for natural loblolly pine seedlings less than 5.6 ft tall with 3 years of total competition control and without competition control (check).

0.4; gld's would then be measured to the nearest 0.1 in., and total height would still be measured in feet. The advantage of measuring gld's in mm is the simplicity of mentally tracking the competition assessment system as field measurements proceed.

Use of the Competition Assessment System in Other Seedling Stands

Is the proposed competition assessment system applicable to stand conditions other than nat-

ural loblolly pine seedlings? To find out, the system was tested using mean plot data, from as many as 196 observations per treatment, from planted, nursery-grown loblolly pines at 12 locations throughout the South where competition was controlled in a manner similar to that at Crossett, AR (Miller et al. 1987). These means included pines taller than 5.5 ft at age 2, which may have reduced the accuracy of the gld estimators. Mean deviations between estimated and actual gld are given in Table 2.

The assessment system did not predict a potential for response to competition control on any of the four treatments after one growing season because the estimated gld's were within 10 mm of the actual gld's at all 10 locations where gld measurements were taken. That is plausible because nursery-grown pine seedlings would have a distinct size advantage over natural pine seedlings during the first year of field establishment. When the natural pine seedlings were selected for measurement in the present study, some were as small as 1 mm in gld and 0.2 ft tall.

After two growing seasons, when the competition assessment system was reevaluated, the calculated values indicated a potential pine growth response from competition control at 11 of the 12 check plot locations. The only location where the estimated gld on check plots was below the proposed 10 mm limit of the actual gld after 2 years was at Counce, TN, where preplant site preparation was a more intensive shear-windrow treatment that normally would not require followup competition control efforts through the second year after planting. At most of the other 11 locations, less-intensive chop-burn site preparation had been used.

In contrast to check plots, when the competition assessment system was evaluated on the total control plots, it effectively predicted actual gld within 10 mm at all 12 locations through the second year (Table 2). The practicality of the proposed assessment system is

Table 1. Correlation coefficients¹ and a comparison of calculated to tabulated chi-square values for determining the accuracy of a gld estimator.²

Treatment and year	n ³	r	Chi-square values	
			Calculated	Tabulated ⁴
Check				
1st	199	0.89	316	225
2nd	185	0.90	707	210
3rd	113	0.84	700	133
Woody control				
1st	198	0.95	232	224
2nd	176	0.93	504	200
3rd	113	0.93	537	133
Herbaceous control				
1st	199	0.91	102	225
2nd	179	0.89	272	204
3rd	52	0.74	220	65
Total control				
1st	199	0.90	78	225
2nd	178	0.90	83	202
3rd	88	0.82	78	105

¹ Linear relationship of gld to total height.

² Gld estimator = (total height) (a constant).

³ Number of loblolly pine seedlings that were used in these analyses. They were up to 5.5 ft tall and did not have boles infected with fusiform rust (*Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusi-forme*).

⁴ Derived from published tables for 0.10 level of significance.

Table 2. Mean deviations between estimated¹ and actual gld for planted loblolly pines at 12 locations in the Southern United States.

Location	Check		Woody control		Herbaceous control		Total control	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
Atmore, AL	no data	+11	no data	+9	no data	+7	no data	+3
Camp Hill, AL	+6	+13	+6	+8	+4	+13	+1	+2
Tallassee, AL	+5	+10	+4	+7	+3	+11	0	-3
Warren, AR	+6	+10	+6	+11	+1	0	+2	-1
Bainbridge, GA	no data	+15	no data	+19	no data	+23	no data	+4
Monticello, GA	+7	+11	+7	+9	+6	+8	+5	+6
Pembroke, GA	+8	+14	+8	+15	+8	+8	+6	+1
Jena, LA	+4	+12	+4	+6	+2	-2	+2	-8
Liverpool, LA	+6	+12	+7	+12	+5	+8	+5	+4
Liberty, MS	+6	+18	+7	+17	+4	+17	0	+4
Counce, TN	+2	+6	+2	+6	0	-2	0	-5
Appomattox, VA	+3	+12	+3	+7	+4	+13	+3	+3

¹ Total height in feet multiplied by 10. The gld estimator was determined to provide the required accuracy at the 10% level when the estimated gld's of natural loblolly pine seedlings were within 10 mm of actual gld's.

² A +10 mm or larger mean deviation would indicate that post-plant competition control could improve pine growth.

straightforward when comparing the extremes of competitive influence—check vs. total competition control—on pine growth.

When varying degrees of competition control are achieved, as in the woody control or the herbaceous control treatments, distinct trends are not as apparent with the assessment system. For example, at 7 of the 12 locations, the proposed assessment system predicted no potential for response to additional competition control through the second year when only woody or only herbaceous competition was controlled (Table 2). These somewhat erratic results are not easily explained, but in general, control of only woody species tended to result in positive growth gains for pine seedlings when woody species were effectively eradicated and when percent ground cover from herbaceous vegetation was not pervasive. Likewise, control of only herbaceous vegetation tended to favor a positive pine growth response when treatments drastically reduced herbaceous ground cover, and when percent ground coverage by woody species did not exceed that found on untreated plots. On some sites, the presence of specific herbaceous or woody plants may have less of a negative impact on pine seedling growth than would be indicated by arbitrarily assessing percent cover of competition components.

These overall trends suggest

that the usefulness of the proposed competition assessment system is not limited to seedling stands of loblolly pines established from natural seedfall. The probability of response from post-plant competition control might also be predicted, using the proposed assessment system, in planted loblolly pine stands on a variety of sites across the South, at least through the second growing season.

Another potential application of the proposed competition assessment system might be to predict a response to precommercial thinning in natural seedling stands. When seedbeds are well-prepared in advance of a bumper pine seed crop, there is a strong likelihood that overabundant natural pine regeneration will result. When pine density exceeds an arbitrary 5,000 stems per acre at ages 3 to 4 years, precommercial thinning is recommended (Mann and Lohrey 1974). Use of the proposed competition assessment system under these circumstances might help forest managers objectively plan for precommercial thinning on areas where intraspecific competition appears to be excessive.

Application and Limitation of the Competition Assessment System

To use the competition assessment system, a representative sample of 50 or more loblolly pine seedlings less than 5.6 ft tall are

measured to obtain gld's to the nearest mm or 0.1 in. and total height to the nearest 0.1 ft. A +10 mm (+0.4 in.) or larger difference between actual mean gld and mean total height times 10 for gld in mm, or times 0.4 for gld in inches, would indicate that competition control could improve pine growth. Subjective competition assessments by trained, experienced forest managers may be as reliable as quantitative measurements. Nevertheless, the competition assessment system presented in this paper may assist the inexperienced by giving some quantitative credence to their assessments.

There are limitations to these findings. The proposed assessment system should help predict which pine seedling stands might respond to competition control but will not predict a need for control; only an accurate assessment of predicted growth loss plus associated economic analysis can do that. The number of measurements that were used to verify the proposed competition assessment system ranged from 52 to 199 (Table 1). Therefore, application of the system might necessitate a similar data base. Also, inclusion of pines taller than 5.5 ft in the χ^2 analyses tended to negate the accuracy achieved with shorter pines. Once pine seedlings attain a height of over 5.5 ft, they are usually above the height of most herbaceous plants and begin to dominate the site and shade out

herbaceous vegetation as the pine crowns begin to merge. Even so, hardwood species that have developed along with the pines can become the most important source of competition within 5 or 6 years after establishment of pine regeneration (Cain and Mann 1980). The proposed assessment system must therefore be used in accordance with the limitations discussed here and is most applicable to stands of naturally regenerated loblolly pine seedlings. □

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