Response of Planted South Florida Slash Pine to Simulated Cattle Damage

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Highlight: *Seedling outplants injured to resemble damage by cattle the 6th, 18th, or 30th month after planting were observed until trees attained sapling size. Simulated browsing alone killed few trees, but combinations of damage increased losses and aggravated the stunting of trees. With factorial combinations which included varying degrees of defoliation, shoot removal, and stem breakage, plots with unclipped trees contained 1½ to 4 times more basal area at the end of the study than trees that were totally defoliated. Without the other treatments, less than a full girdle of the stem was not detrimental.*

Cattle rarely graze pine foliage when other green forage is available, but some trampling and browsing damage can always be expected if grazing is permitted the first few years after an area has been planted or seeded (Cassady et al., 1955). Cattle damage seedlings in a variety of ways (Hughes, 1965). They may actually eat the needles, new shoots, or buds, and their hoofs may girdle, bruise, or break the stem.

The findings reported here evolved from attempts to isolate and measure response to several commonly observed kinds of cattle damage. Results are based on survival and growth following the hand application of simulated cattle injury to individual trees.

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Methods

Plantations were established at the Caloosa Experimental Range near Fort Myers, in southwest Florida, on a site typical of the cutover pine flatwoods. Soils were predominately Myakka fine sand, heavy substratum, a common flatwoods soil with strongly acid fine sand underlain by an organic stained pan and clayey substratum. South Florida slash pine (*Pinus elliottii* var. *densa* Little & Dorman) seedlings were planted at a spacing of 5 X 10 ft on disked ridges constructed with a tractor and fireplow unit.

Five trees in a row comprised a treatment plot. Treatments consisted of various degrees and combinations of foliage removal, shoot removal, stem bending, and girdling, and were applied as soon as needles were fully developed, in May or June. Measurements on growth and survival were taken annually during the dormant winter period, usually in November or December.

The study consisted of 513 plots involving 19 damage treatments, 3 years of planting (1963, 1964, and 1965) and 3 ages of trees (6, 18, and 30 months). For data collection and analysis, the three seedling ages were treated as separate tests. Treatments were applied only once, in a randomized block design, and measurements were continued until trees were 5 to 8 ft tall.

Defoliation was accomplished by clipping the ends of the needles with shears to remove an ocularly estimated average needle length in percentages as follows: D_o = no needles clipped; D_1 = 25%; D_2 = 50%; D_3 = 75%; and D_4 = 100%.

Shoots, referring to an elongating bud or the current internode formed when elongation is complete, were removed by pinching off the current growth. Treatments were S_o = no shoots removed and S_1 = all shoots removed.

Bending the stem over at a right angle to simulate stem damage by the hoof of a cow was compared with an undisturbed stem, as follows: B_o = stem not bent and B_1 = stem bent 90°.

Girdling was accomplished by removing the bark and cambium from the stem in a 1-inch band near the groundline. A sharp knife was used to cut radially to wood and slip off the specified portion. Care was taken to avoid leaving strips of inner bark or cambium and to avoid cutting the wood. Girdling was applied as a percentage of stem circumference removed (G_o = no girdle; G_1 = 25%; G_2 = 50%; G_3 = 75%; and G_4 = 100%).

There were 19 treatments and combinations, as follows:

1. $D_oS_oB_o$	8. $D_2S_oB_1$	15. G_o
2. $D_oS_1B_o$	9. $D_2S_1B_1$	16. G_1
3. $D_oS_oB_1$	10. $D_3S_oB_o$	17. G_2
4. $D_oS_1B_1$	11. $D_4S_oB_o$	18. G_3
5. $D_1S_oB_o$	12. $D_4S_1B_o$	19. G_4
6. $D_2S_oB_o$	13. $D_4S_oB_1$	
7. $D_2S_1B_o$	14. $D_4S_1B_1$	

Results were analyzed as three separate experiments: treatments 1, 2, 3, . . . 14 having to do with *mechanical injury* combinations; treatments 1, 5, 6, 10, and 11 on *defoliation* alone; and treatments 15, 16, . . . 19 on *girdling.* Results are presented in separate sections which follow under *Results and Conclusions.*

Seedling mortality hindered establishment and progress of the study. Enough trees survived to complete the observations on two replications of trees treated at 6 months after planting and all three replications for trees treated at 18 or 30 months. Unless otherwise indicated, the summaries that follow refer to status of trees 6 years after planting.

Only healthy and fully established seedlings were treated, yet survival in final tallies averaged less than 75%. Of 378 plots in the study of defoliation, shoot removal, and stem breakage, all five trees had died in 19 plots by time of final measurement.

In preparing the data for analysis, measurements on five or fewer living trees per plot were averaged for determining annual height growth. Total tree basal area per plot based on diameter at breast height (dbh) was used as an index for comparative productivity. Missing plots were represented by zeros, admittedly an introduction of bias favoring plots with living trees. More often than not, however, year of planting was not a significant variable, and the average measurement of the total 15 or fewer living trees representing trees planted in 1963, 1964, and 1965 was used as the observation for analysis of variance. Because of the small number of trees in each treatment, mortality of seedlings was analyzed by Chi-square. Response to the five defoliation treatments alone was analyzed separately by regression.

Records of annual rainfall helped to explain some of the variation in survival and growth from year to year. Amounts recorded by the Fort Myers Weather Station for the years of planting were 42.90 inches in 1963, 32.83 in 1964, and 50.83 inches in 1965.

Results and Conclusions

Defoliation Alone

Survival

When not combined with shoot removal or stem breakage, total defoliation when applied 6 months after planting appeared detrimental, and 50% defoliation applied at 12 months seemed to improve survival. Average survival for trees treated at 6, 18, or 30 months after planting was 67, 66, and 85%, respectively.

Annual Height Growth

Losses in growth tended to be recovered as trees grew older. By the end of the study, only the trees treated at 6 months after planting showed a significant response to defoliation (Fig. 1). Growth of these trees declined consistently with increasing intensity of defoliation. Precision, however, was not nearly as good as desired.

Coefficients of determination indicated that only one-fourth of the variation in growth was associated with

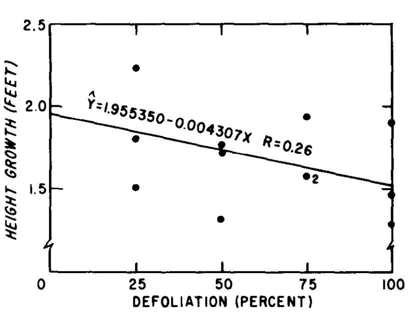

Fig. 1. *Relationship between annual height growth of trees and percent defoliation 6 months after planting. (Trees were measured at age 6 years after planting.) • = data points.*

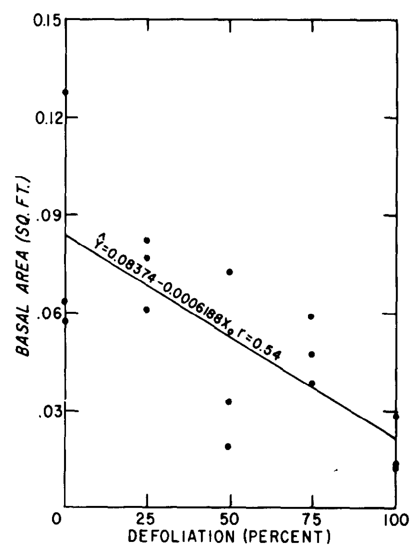

Fig. 2. *Relationship between basal area of trees per plot and percent defoliation at age 6 months after planting. (Trees were measured at age 6 years after planting.) • = data points.*

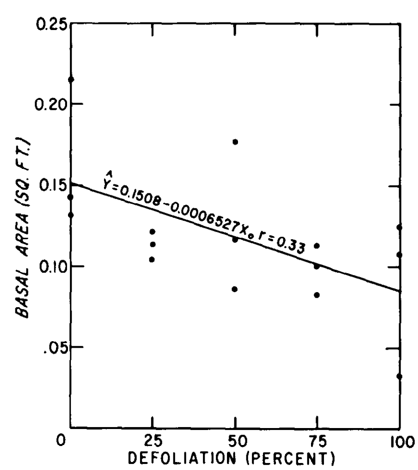

Fig. 3. *Relationship between basal area of trees per plot and percent defoliation at age 18 months after planting. (Trees were measured at age 6 years after planting.) • = data points.*

defoliation. Sensitivity to defoliation usually declined with age at time of treatment.

Basal Area Per Plot

Defoliation had a significant effect on basal area when applied at 6 or 18 months after planting (Figs. 2 and 3) but not when applied at 30 months. Volume per plot declined as intensity of defoliation increased.

Coefficients of determination indicated that 1/3 or 1/2 of the variation in volume was associated with defoliation for trees treated at ages 6 or 18 months, but only 6% for trees treated at 30 months.

Mechanical Injury Combinations

Survival

When combined with shoot removal and stem bending, total defoliation was always detrimental (Table 1). When applied 6 months after planting, most of the other treatments tested which involved 50 or 100% defoliation also were harmful. Survival varied considerably among trees treated 18 or 30 months after planting, and there was no definite trend of treatment effects.

Table 1. Effects of mechanical injury combinations on survival (%).

Kind of injury			Age treated (months after planting)		
Defoliation (%)	Shoots removed	Stem bent	6	18	30
0	No	No	72	60	88
0	Yes	No	72	60	75*
0	No	Yes	65	69	65**
0	Yes	Yes	60	67	78
50	Yes	No	68	73	80
50	No	Yes	58*	60	75*
50	Yes	Yes	48**	51	75*
100	Yes	No	48**	53	80
100	No	Yes	32**	47	62**
100	Yes	Yes	30**	20**	60**

* $P = .05$.
**$P = .01$.

Annual Height Growth

Defoliation continued to limit growth from year to year, whereas those trees which survived the initial shock of shoot removal or stem breakage generally grew reasonably well without obvious stunting. Trees defoliated at 6 months of age were not as tall at the end of the first year as prior to defoliation midway the same year. By the fifth year after treatment, reductions in annual growth compared with no defoliation were about 20% for trees with needles clipped to half their length at 6 months after planting and 40% with total defoliation. Similar reductions were noted for trees treated 18 months after planting when measured the second, third, and fourth year after treatment. Growth data for trees treated 30 months after planting were inconclusive.

Basal Area Per Plot

Total defoliation was detrimental whether applied 6, 18, or 30 months after planting. Unclipped trees contained 1½ to 4 times more basal area per plot than trees totally defoliated (Table 2). With 50% defoliation, volumes averaged with shoot removal and stem breakage tended to be between these extremes.

Stem breakage was similarly detrimental to the three ages of trees tested. Plots occupied by trees without stem damage contained 1½ to twice more basal area than damaged trees, as indicated by the following tabulation:

Stem position	Age of trees at time of treatment: 6 months (ft^2)	18 months (ft^2)	30 months (ft^2)
Normal–not bent	0.0234	0.0617	0.0821
Horizontal–bent 90°	0.0117	0.0453	0.0659

In no case did shoot removal have a significant effect on basal area.

For trees treated at 30 months, basal area per plot appeared related to annual rainfall, with best volume occurring with near-normal rainfall in 1965 and least basal area with the least rainfall in 1964.

Table 2. Basal area (ft^2) per plot as influenced by foliage removal (%) (3 × 2 × 2 factorial).[1]

Defoliation	Age after planting when treated: 6 months	18 months	30 months
0	0.0267 a	0.0684 a	0.0837 a
50	0.0195 a	0.0600 a	0.0772 ab
100	0.0065 b	0.0321 b	0.0611 b

[1] Values within a column having the same letters do not differ significantly at the 5% level according to Duncan's multiple range test. All comparisons are made vertically.

Girdling

Survival

Full girdles were followed by losses of more than ½ of trees the first year and ¾ or more by the end of the study. Less than a full girdle killed very few trees, with survivals about the same for ¼, ½, or ¾ girdles.

Annual Height Growth

Full girdles were always detrimental, the sharp decrease in annual growth beginning immediately and continuing through subsequent annual remeasurements. Annual growth of trees with full girdles was usually less than half that of other trees. Responses varied little when less than a full girdle was inflicted. A ¾ girdle, for example, was generally no better or no worse than a ¼ girdle.

Basal Area Per Plot

Measurements required to determine basal area were not available for this phase of the study.

Discussion

Although several treatments were not representative of the damage that commonly occurs when cattle graze young plantations, response to a specific type and degree of injury in terms of survival and eventual growth may be reasonably concluded from these studies. The results agree fairly well with observations obtained from much field experience on specific types of cattle damage and special effort over a period of years to obtain evidence of the effects of cattle damage.

Enough kinds of injury were selected and ages of trees treated to provide a balanced experimental design that would bridge widely varying intensities of combinations of types of injury. Some of the treatments were assumed to be unusually severe, as for example, total defoliation and full girdling. Bending the stem over at right angles to simulate stem breakage by the hoof of a cow is a type of damage which occurs most frequently during the first year after planting;

hence, this treatment was not representative for trees that were treated the second or third year after planting.

Final measurements were taken the sixth year after planting when most trees were 5 to 7 ft tall, base of crown had progressed above 4.5 ft, and crown competition had begun. Age and size of trees within the plantation were similar to those observed by Barber (1964) for evaluation of juvenile-mature tree relationships. Other studies have shown that growth recovery following injury may extend over a period of several years from date of injury (Wickman, 1963).

It is not known that treatments were applied at the most critical time. Applications were completed during the first flush of growth in May or June, whereas browsing of needles, for example, may occur whenever green feed is scarce. In contrast to new growth, however, old needles apparently contribute little to overall survival and growth (Dochinger, 1963). Also, work preliminary to the planning of these studies had shown that the development of new growth coincides with maximum susceptibility of trees to damage by cattle (S.E. Forest Exp. Sta., 1959).

The problem of recurring damage awaits further study. Bruce (1956) observed that two-stage defoliation was generally worse than a single 90% clipping. Dimock (1970), on the other hand, concluded that with Douglasfir the effects of repeated browsing (shoot removal) were minimal, probably because fully established seedlings were able to recover quickly from damage to terminal shoots.

In the case of current growth, Bruce (1956) concluded that the degree to which seedlings were defoliated had a greater effect on growth than the dates when clipping was done. But since some trampling and browsing damage can always be expected if grazing is permitted, the only sure way to prevent damage is to keep cattle and other livestock out of young plantations until pines are 6 to 8 ft tall (Cassady et al., 1955).

In a management situation, recommendations specify one or a combination of ways to avoid cattle damage (Halls et al., 1964): graze the range lightly to moderately, exclude cattle from range during fall and winter or year round until trees are at least 3 ft tall. In the Caloosa Experimental Range, on range prescribed burned preparatory to planting, damage was excessive under continuous grazing but negligible on range burned 1 year prior to planting (Hilmon et al., 1963). Experience indicated that damage could be held to an acceptable level by planting on a 1-year rough, rather than on a fresh burn, and holding the cattle stocking down to 20 to 25 acres per head.

Summary

The findings reported here are based on survival and growth of South Florida slash pine seedling outplants following the hand application of simulated cattle injury to individual trees. Measurements were continued until trees attained sapling size following an injury schedule that was applied 6, 18, or 30 months after planting in three separate years and replicated three times.

Survivals at the close of the study varied from about 80% with 50% defoliation to only 20 to 30% for combinations of defoliation, shoot removal, and stem bending, and 25% for full girdling. Less than a full girdle killed very few trees.

Annual height growth generally decreased with increasing intensity of defoliation alone. Growth was depressed further when defoliation was combined with shoot removal and stem breakage. Only the full girdle was harmful; growth was about half that of trees with less than a full girdle.

Basal area per plot declined following defoliation 6 or 18 months after planting and after all treatment dates when defoliation was combined with shoot removal and stem breakage. Shoot removal did not influence basal area; stem breakage was a factor only when applied at 6 months.

The tendency was toward better subsequent survival and growth of trees treated in 1965 than those treated in 1963 or 1964. Rainfall was 43 inches in 1963, 33 inches in 1964, and 51 inches in 1965.

The older trees were generally more resistant to damage with age but are susceptible through at least 3 years after planting. Combinations of damage increase losses and aggravate the stunting of trees.

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