Deer Browsing and Browse Production of Fertilized American Elm Sprouts

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Highlight: Small blocks of land producing dense stands of American elm trees along streamcourses in north-central Oklahoma were fertilized after clearcutting in late summer, late winter, and spring. Twig tips of first-year elm sprouts were readily browsed by deer after succulent cool season, herbaceous plants had matured in May. Browsing and browse production were greater on fertilized sprouts if trees were cut and fertilized in the previous late summer or current late spring seasons. Fertilization and lateral branching after browsing increased total twigs per sprout which, in turn, increased browse production and use as the season progressed. These results indicate browse production from unproductive stands of elm trees can be increased greatly by different habitat management practices.

Much of the white-tailed deer (*Odocoileus virginianus*) habitat in the tallgrass prairie occurs as relatively narrow bands of woodlands along streamcourses. Throughout central Oklahoma, American elm (*Ulmus americana*) is an important member of the streamcourse woodland and is commonly found on upland plains adjacent to floodplains (Fowells 1965). The extent of woodlands is increasing in many of these areas because of the invasion of elm into grasslands adjacent to streamcourses (Rice and Penfound 1959).

Although these elm stands provide woody cover for deer, shading, tree height, and lack of understory shrubs or herbs result in relatively low amounts of forage for deer and livestock. American elm was given relatively low preference ratings for both deer and cattle by Hosley (1956) and Petrides (1941), but elm sprouts were readily browsed in Pennsylvania (Pogge 1967). Moore and Johnson (1967) also found elm sprouts to be readily browsed and much more than adjacent elm seedlings. Apparently, the greater succulence of sprouts increases the palatability of woody species compared to less succulent tree and seedling twig tips (Dalrymple et al. 1965).

Fertilization also produces greater utilization of woody plants by deer. Fertilized plants of such species as dogwood (*Cornus* spp.) (Mitchell and Hosley 1936), oaks (*Quercus* spp.) (Ward and Bowersox 1970), and even the relatively unpalatable Mariposa manzanita (*Arctostaphylos mariposa*) (Gibbens and Pieper 1962), and Douglasfir (*Pseudotsuga menziesii*) (Longhurst et al. 1968) were browsed to a greater extent than unfertilized plants.

Based on the information concerning increased utilization of woody plants as sprouts and from fertilization, we combined the two practices in a habitat management study. The specific objectives were to determine the first-year effects of top removal and fertilization of elm trees at different elm phenological stages upon (1) the degree of browsing of elm sprouts by deer and (2) browse production of elm sprouts during the growing season.

Study Area

Our study area is about 18 km west of Stillwater in the Lake Carl Blackwell watershed. The general area has a continental climate with the average absolute maximum temperature exceeding 40°C from June through September and the average absolute minimum temperature below −20°C from December through March. The annual precipitation averages 820 ± 250 mm. The average precipitation distribution during the 210 day growing season is 21% during April and May, 28% during the June–August period, and 17% during September and October.

Fig. 1. *Aerial view of study area in floodplain adjacent to upland prairie.*

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The study area lies within a transition zone between the floodplain of a perennial stream and the adjacent upland, tallgrass prairie (Fig. 1). The alluvial floodplain soil is a Port silt loam (*Cumulic Haplustoll*) with the following chemical characteristics in the A horizon: 6.3 pH; 1.7% organic matter; and extractable nutrients, 7 ppm PO_4, 170 ppm K_2O, 1,300 ppm Ca, 290 ppm Mg, and 60 ppm Na (George 1974).

The overstory vegetation consisted of a dense stand of uniform-sized trees, 97% of which were American elm. Associated species were green ash (*Fraxinus pennsylvanica*), black locust (*Robinia pseudoacacia*), hackberry (*Celtis occidentalis*), postoak (*Quercus stellata*), and blackjack oak (*Q. marilandica*). The stand contained 2,500 trees per hectare, with an average basal diameter of 10.0 ± 2.2 cm.

The most common understory species included little bluestem (*Schizachyrium scoparium*), broomsedge (*Andropogon virginicus*), purpletop (*Tridens flavus*), Scribner's panicum (*Panicum scribnerarianum*), Japanese brome (*Bromus japonicus*), Virginia wildrye (*Elymus virginicus*), sedges (*Carex* spp.), western ironweed (*Vernonia baldwinii*), tick clover (*Desmodium sessilifolium*), and goldenrod (*Solidago* spp.).

Methods

The experiment consisted of three replications of two fertilizer treatments on each of three different cutting dates. The 18 total plots, each 15 m × 30 m, were arranged in a randomized block design. On each of the three cutting dates, all trees on plots randomly chosen to be cleared on that date were cut with chain saws at a height of 5–10 cm above ground level. The wood from tree trunks was removed from the plots as firewood, and tops were piled around the plot perimeter for small game cover and to facilitate sampling of the plot. The three cutting dates were selected to coincide with the following stages of elm phenology: mature leaf in late summer (8/15/72); bud stage in late winter (3/1/73); and half-leaf, rapid growth stage in late spring (5/15/73).

After cutting and clearing on each cutting date, one plot per replication was broadcast fertilized with the equivalent of 210 kg of ammonium nitrate (33.5-0-0) and 160 kg of superphosphate (0-46-0) per hectare. A similarly cleared plot was left unfertilized in each replication.

The degree of browsing on elm sprouts by deer, rabbits, and other browsing wildlife was determined monthly from May through September, 1973. Nine different elm stumps with sprouts were randomly chosen from each plot each month for determination of degree of browsing. The total number of twig tips present and the number of twigs browsed during the preceding 30 days were counted for each of the selected stumps. The degree of browsing reported was calculated as the number of recently browsed twigs divided by the total number of twigs available (Aldous 1944). No attempt was made to distinguish deer browsing from browsing by rabbits or other small mammals since most twig tips were out of reach of small mammals within 30 days after sprout growth was initiated. Insects can have a significant effect on twig tips of sprouts (Powell et al. 1972), hence any insect damage on elm twig tips was noted, but was distinguished from deer browsing. Although the determination of how recently each twig tip had been browsed was an arbitrary decision, the decision was made only after careful consideration of the observable factors on the remaining portion of the browsed twig tip.

All sprouts from three stumps selected in each plot were clipped at the base, weighed, and dried at 45°C to a constant weight to determine dry matter content. One soil sample was collected from the 0–30 cm soil depth zone in each plot on each sampling date. Percent soil water was determined gravimetrically (N.R.C. 1962).

The analysis of variance and least significant difference methods were used to determine statistically significant differences. Unless otherwise noted, all differences discussed are significant at the 95% or higher level of probability.

Results and Discussion

Browsing Response

Temporal Effects

The average degree of browsing in April (7%) was much lower than that in May (56%), June (54%), July (44%), or August (48%) (Fig. 2). In April all sprouts were relatively short and not easily seen because of the dense stand of taller, cool-season grasses. The cool-season grasses and forbs provided a variety of succulent, herbaceous plants and deer probably selected these plants rather than elm twigs.

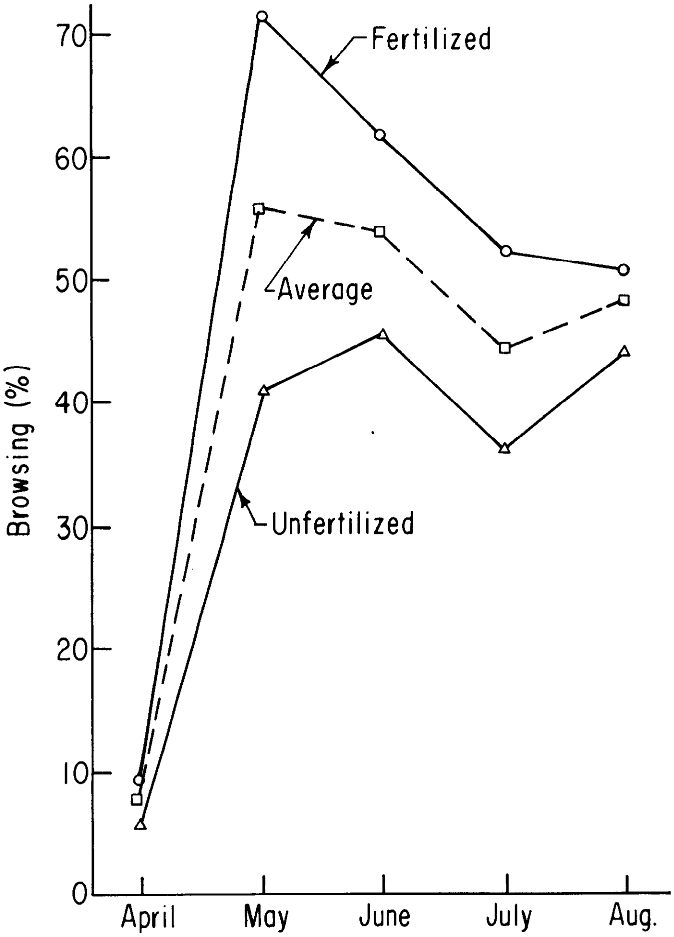

Fig. 2. *Browsing (%) on fertilized and unfertilized sprouts. For sampling date means,* $LSD_{.05}$ = 7; *for fertilizer × sampling date means,* $LSD_{.05}$ = 10.

Browsing increased greatly on all cleared plots in May and remained high in June. Sprouts were taller and twig tips were probably more succulent than the rapidly maturing cool-season grasses and forbs. During July the degree of browsing averaged for all cleared plots was lower than earlier in June or later in August.

Soil water content was 20%, 20%, 6%, 8%, and 18% on May 4, June 6, July 9, August 8, and September 8, respectively. Elm sprout water content was 74%, 66%, 61%, 56%, and 58% on those dates. When plants undergo soil water stress, there is an accumulation of photosynthesis by-products (Black 1957). In certain shrubs the greatest increase in unpalatable (Nagy et al. 1964) by-products occurs in the most rapidly growing plants (Powell 1970). The relatively lower degree of browsing of elm twigs in July may have resulted from a temporary decline in palatability.

Fertilizer Effects

Degree of browsing was greater on fertilized plots than on unfertilized plots (Fig. 2). The increased utilization of fertilized elm sprouts was apparently a response to increased palatability of the sprouts. However, there also appeared to be a preference for the fertilized plots, at least for bed sites. Although no data were collected, there appeared to be more deer beds on fertilized plots where the herbaceous plants were taller, more abundant, and provided more low-level cover. Anderson et al. (1974), using pellet group counts only, determined deer used fertilized oak range in New Mexico in the summer, fall, and winter more than unfertilized oak range.

The average number of twigs per sprouting stump was slightly greater ($P < .11$) on fertilized plots (106 twigs/stump) than on unfertilized plots (90 twigs/stump), but there was no difference in sprout dry matter content due to fertilization. We believe that data on twig tips alone would be more useful for predicting deer utilization and response to fertilization than that of the entire sprout. We observed that deer use, after April, was restricted almost entirely to twig tips.

Interaction of Fertilizer and Temporal Effects

Although browsing on fertilized elm twigs was consistently greater than on unfertilized twigs, the difference was greatest in May and minimal by the end of August (Fig. 2). The influence of fertilizer on preference was rather short-lived and dissipated with increasing sprout age. If deer are attracted to sprouting stumps because of the actual number of twig tips available, the influence of fertilizer on sprout morphology may be as important as its effect on palatability after the initial flush of growth.

Interaction of Fertilizer and Date of Cutting

Differences in browsing response to fertilization were not consistent nor of the same magnitude on plots cleared on different dates. Browsing on fertilized, summer-cut sprouts (56%) averaged for all five sampling dates was about 20% greater than on unfertilized sprouts from stumps cut on the same date; however, browsing on fertilized (44%) and unfertilized (40%) sprouts from stumps cut during late winter was about the same. Since spring-cut plots were sampled only on the last three sampling dates, differences due to interaction of fertilizer and cutting date were also tested using data collected from all plots on the last three sampling dates.

Browsing differences due to fertilizer on the last three sampling dates were significant on summer-cut plots (64% vs 48%) and on spring-cut plots (51% vs 31%), but not on winter-cut plots (49% vs 48%) (Fig. 3). The lowest average utilization was on unfertilized, spring-cut sprouts (31%), the highest on fertilized summer-cut sprouts (64%) and about the same (48–51%) for all other sprouts.

Differences in total twig tips per stump due to interaction of fertilizer and date of cutting ($P < .10$) during June, July, and August were very similar to those differences in degree of browsing (Fig. 3). Fertilization increased twig tip numbers on summer-cut and spring-cut plots but not on winter-cut plots.

Gibbens and Pieper (1962) found the response of herbaceous plants fertilized in fall and winter had a detrimental effect on the survival of brush seedlings. We also found a much greater amount of cool-season herbage on fertilized, winter-cut plots than on any other plots. Apparently the shallow-rooted, cool-season annual grasses (primarily Japanese brome) pre-empted the fertilizer before the warm season elm plants were able to respond.

If browsing is as closely related to total twig tips per stump as indicated in this study, the degree of browsing early in the

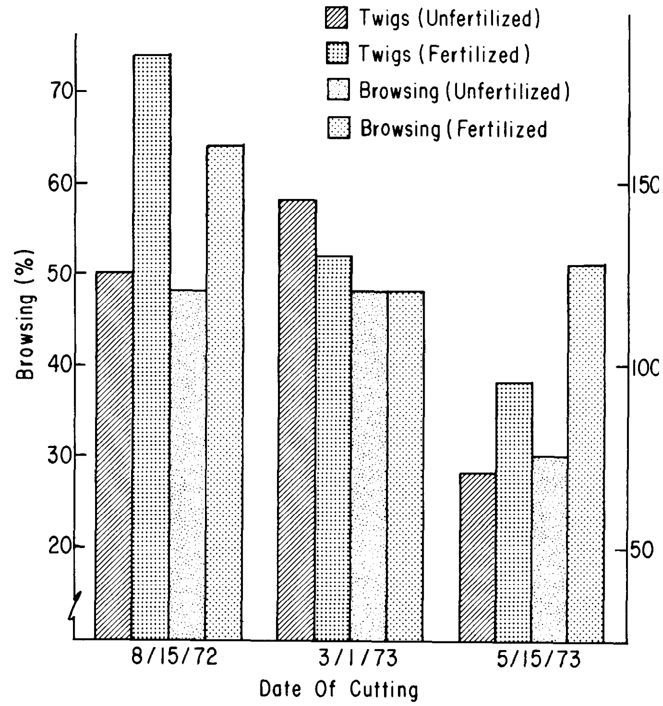

Fig. 3. *Total twig tips per stump and browsing (%) for different fertilizer date of cutting treatments. For total twig means,* $P < .09$; *for brow means,* $LSD_{.05} = 10$.

growing season may have a significant influence on brows later in the year. Browsing or any other type of removal of api dominance induces lateral branching and the production of m twig tips with continued plant growth. Therefore, those tre ments, such as fertilization, which increase browsing early the growing season, may produce a desirable effect for seve months thereafter.

Elm Browse Production

The degree of browsing on twig tips per stump indicates effects of various habitat management practices on deer pref ence, but it does not express the effects of the practices on supply of the preferred (browsed) twigs. Since treatments h no significant effect on percent sprouting elms or sprouts stump ($\bar{x} = 36 \pm 11$ at the end of the growing season), number of browsed twig tips per stump was used as a measure elm browse production.

Although the degree of browsing was similar between M and August, Figure 4 clearly shows deer were utilizing m total twig tips as the season progressed. Growing fawns co account for some of the increase in number of twig tips brows but it still appears that elm sprout browse became increasin more important as the season progressed. The average numl of twig tips browsed almost doubled during August comparec July.

Fertilized sprouts produced about 50% more browse than u fertilized sprouts, but this was not consistent for all dates cutting (Fig. 5). The average number of browsed twigs was greater on fertilized, winter-cut plots than on unfertiliz winter-cut plots.

Sprouts from summer-cut plots produced more browse th either winter-cut or spring-cut plots, primarily because of much greater number of browsed twigs on fertilized, summ cut sprouts. Since the total number of twigs on fertiliz summer-cut sprouts was not greater than those on unfertiliz

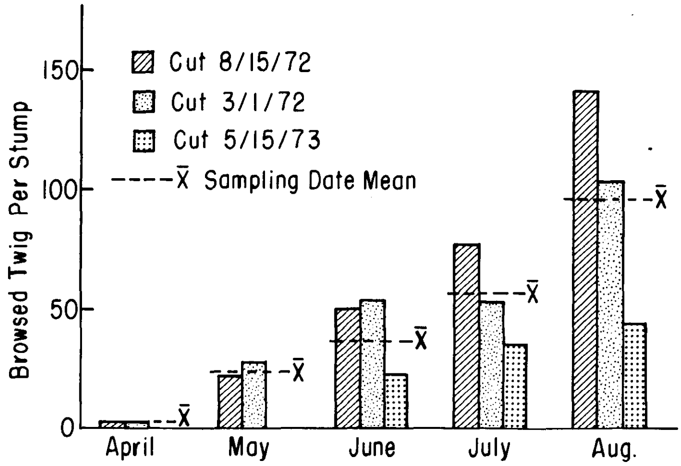

Fig. 4. *Number of browsed twigs per stump for different sampling dates and dates of cutting. For sampling date means,* LSD.05 = 18; *for sampling date × date of cutting means,* LSD.05 = 29.

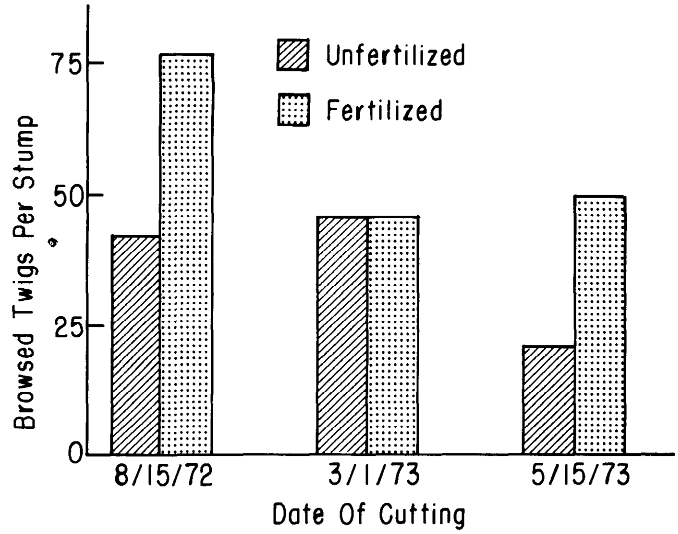

Fig. 5. *Number of browsed twigs per stump for fertilizer and date of cutting treatments. For fertilizer means,* LSD.05 = 14; *for date of cutting means,* LSD.05 = 17; *for fertilizer × date of cutting means,* $P < .08$.

summer-cut sprouts until after May, fertilization in late August of the previous growing season may have had a beneficial effect on the root system or carbohydrate reserves. The fertilized, summer-cut sprouts were apparently more vigorous, or had a more efficient root system than unfertilized, summer-cut sprouts. Twigs increased 166% of fertilized sprouts, but only 53% on unfertilized sprouts during the very dry June period. The effect of late summer or fall fertilization on shrub and sprout production efficiency deserves additional research.

Conclusions

Based on these results, we believe (1) first-year elm sprouts provide a valuable source of browse for deer, especially during late summer, (2) fertilization and the date of cutting influence elm browse production, (3) early browsing should be encouraged to induce lateral branching, and (4) more research on sprout morphology and physiology needs to be conducted if effective and economical deer habitat management practices are to be developed.

The total size of the area cleared and sprouts produced at any one time probably needs to be coordinated with the existing deer grazing pressure or the grazing pressure obtained from livestock. Early spring livestock grazing on cleared areas could benefit both livestock and deer by inducing lateral branching on elm sprouts and decreasing competition from fertilized cool-season annual grasses when they are palatable.

If deer and livestock grazing is not heavy enough to prevent elm sprouts from growing out of reach, the sprouts will need to be mowed, crushed or burned periodically. Additional research is needed to compare the forage value of first-year sprouts to that of older sprouts. The optimum frequency and degree of livestock grazing and mechanical sprout control should also be determined. Whatever the practice used, it is apparent elm stands can be manipulated to provide valuable browse for deer.

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