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Effects of Time and Method of Treatment On Tree Kill and Bluegrass Recovery[1]

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Abstract. Box elder trees in replicated plots within four seasonal blocks mostly ranged in age from 17 to 24 years, in breast-high diameter from 2 to 8 inches, and in height from 18 to 24 feet. Tree cutting at 3 inches and at 1 foot was done with a chain saw; and a brush killer—fuel oil mixture, at the rate of one quart of concentrate to 5 gallons of fuel oil and one quart to 10 gallons, was applied to the stumps. Resprouting from stumps cut at both heights and in four different seasons was controlled by both concentrations of the mixture to the extent of 99.8 per cent. Untreated stumps sprouted almost 100 per cent. Basal treatment of standing trees bordering the cleared blocks gave 100 per cent kill with the 1 to 5 mixture, but only imperfect kill with the 1 to 10 mixture.

Weed growth was greater in the two blocks cleared before growth started in the spring than in the two blocks cleared in July and October. Yield of bluegrass in October, 1958, was about 60 per cent greater in the first two clearings than in the last two and in the adjacent uncleared check. This early sampling seemed to test the effect of time elapsed since clearing, rather than season of clearing. Low-cut, treated stumps with tree removal gave excellent sprout control, and as a method was superior to (1) high cut stumps, (2) no tree removal, and (3) basal treatment of standing trees in the control of weeds, improvement of bluegrass growth, and utilization, sanitation, and general husbandry.

A tract of upland grassland, about 60 acres in extent, was purchased by the Iowa Lakeside Laboratory in 1930 and retired from grazing. The area lies just north of the laboratory grounds and is bordered on the southeast by Little Miller's Bay. There is no evidence that the original prairie sod was ever broken by plow, but prior to 1930, it had been grazed for many years. The southern portion of the tract, adjoining the laboratory grounds, was used as a horse corral. Here, the destruction of the prairie and its replacement by bluegrass was almost complete (Anderson, 1936). The relict prairie plants, sparsely scattered throughout the less disturbed northern part of the 60-acre tract in 1930, have not recovered to the degree originally anticipated (Anderson, 1936, 1946; Rudman and Pohl, 1951). The vegetation of this part of the tract at present has more the general appearance of an ungrazed bluegrass pasture, than of the prairie generally considered to be the climax vegetation on the upland areas of the region (Aikman and Thorne, 1956).

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An area of approximately 8 acres at the southern end of the tract has been covered for several years with a relatively close, pure stand of boxelder (*Acer negundo* L.). It has been determined on the basis of ring-counts that the invasion of the area by the boxelder began about 1930 when grazing was discontinued. Ring-count evidence also indicates that invasion was generally from the south, northward. The most likely causes of boxelder invading only this portion of the tract would seem to be: (1) the presence of an adequate number of seed trees in contiguous gullies on the laboratory grounds, (2) the amelioration of the climatic factors along the southern border of the new tract because of its proximity to the tree-shaded laboratory grounds, (3) the presence of a gully immediately inside the new tract, and (4) the complete destruction of the prairie by grazing and, later, overgrazing injury to the bluegrass which had replaced the prairie.

The director of the Lakeside Laboratory became interested chiefly in clearing the area of trees. A project was set up in 1957 to accomplish this purpose and, at the same time, to obtain as much information as possible. It was decided to investigate the structure of the boxelder community originating under such conditions and the effects of (1) two different concentrations of spray, (2) two heights of cutting, and (3) four seasonal applications of treatment, on the percentage kill of the trees and on the degree of recovery of the bluegrass ground cover. The four seasonal treatments were applied from April, 1957, to March, 1958. Previous to and during this period the studies were made on the structure of the boxelder community.

The Boxelder Stand

The wooded portion of the tract was made up in April, 1957, of a pure stand of boxelder trees which varied in size from 2 inches to 8 inches D.B.H. and from 18 to 24 feet in height. Trees smaller or larger than these limits were few in number. For the entire wooded area the average number of trees per acre was 1,250. The average basal area per tree trunk was 10 square inches and per acre was about 12,500 square inches. In general, the basal areas varied little; in places where the trees were more sparse, they were larger.

The average spacing interval for the wooded area was 6 feet. The crowns of the trees throughout the area were touching or overlapping, with very few exceptions. This constituted very nearly a 100 per cent crown cover. Actually, on a light measurement basis, the percentage of light reaching the spare bluegrass cover on the ground was 25 per cent of full sunlight. This is extremely low for boxelder which is very intolerant to shade. This degree of shade is almost as great as that cast by a good stand of oak-hickory and is not found under any except the most dense boxelder stands.

Most of the trees varied in age from 17 years to 24 years. A few trees in the gully near the south border of the tract, outside the experimental area, are well over 28 years old, indicating that they were probably growing there as small trees before the tract was purchased in 1930. On the upland near the south side, the presence of trees 25 and 26 years old in 1957 indicates that invasion began at once after the retirement of the tract from grazing. About half of the 1-inch and 2-inch trees in the stand were young and about half of them were of sufficient age to indicate that they were stunted trees rather than later, fill-in invaders. Since invasion was apparently from the south, the average age of the trees became less toward the north side of the stand. The reduction in average age was not great, however, because practically no invasion of the new area has occurred since about 1948. In fact, ring-count data show that the general boundary of the northern extent of tree invasion was established about 1938 and since that date has changed but very little.

The Plan of the Experiment

There are literally thousands of acres of Iowa land, primarily used for pasture, which are overrun with unwanted trees of the type utilized for this experiment (Sylwester, 1954). To study the rate of bluegrass recovery after removal of these boxelder trees would throw at least some light on increases of palatable forage which could be expected to occur under similar circumstances elsewhere. Trees of this sort can be killed either by basal treatment, that is, spraying the basal 15-18 inches of the trunk to runoff with a "brush-killer"—fuel oil mixture; or by stump treatment wherein the trees are cut down and removed from the area and the stumps treated with the same type of brush-killer—fuel oil mixture used in the basal treatments. Stump treatment was decided upon as the chief treatment to investigate because it leaves few dead trees to mar the landscape and very little dead material to interfere with sunlight penetrating into the liberated area. In addition, such removal indicates better stewardship since it utilizes to a maximum the trees so removed as fuel, posts, or lumber, and eliminates the haven for bark beetles which is present in standing dead timber. This latter is important in its relation to Dutch elm, phloem necrosis, and oak wilt control programs.

In planning the experiment it was necessary to include in one block the cutting and spray treatments to be applied at each one of the four seasons. The variation in light alone among the several plots, arranged at random in the tree stand on each of the four treatment dates, would constitute a factor difference difficult to evaluate. The blocks, 0.1 acre in size (1 chain by 1 chain), were arranged in a square at random. The location of the 4-block

area was selected carefully on one soil type and as nearly uniform as possible as to degree and aspect of slope, and homogeneity of the tree stand among the blocks. Each of the four blocks was divided into four equal squares. In two of these, located at random, the trees were cut at a height of 1 foot from the ground and in the other two at a height of 3 inches. Each of the four plots was split, right and left, for spraying at the 1 to 5 rate and the 1 to 10 rate of application.

Figure 1. View of the wooded area from the south, showing the first seasonal clearing, April, 1957.

Tree Cutting and Spray Treatments

The trees were cut with a chain saw and removed from the area (Fig. 1). The diameter of stumps varied from 1 to approximately 8 inches. The stumps were cut at two different heights to determine if equally good kills could be expected on lower cut stumps. If so, lower cutting would make the area more sightly and enable owners of such areas to use a field mower should that become necessary for vegetation control. The seasonal cutting was used to determine if there was any difference in effectiveness of kill during the various seasons, so that owners of similar areas could more effectively utilize the labor supply to do the necessary cutting, removal, and spraying work.

Two concentrations of spray solution were used to determine if

a lower concentration might be employed, at least under some conditions of tree stand and variety. Brush killer[2] was used at the rate of 1 quart of concentrate to 5 gallons of fuel oil or at the rate of 1 quart to 10 gallons of fuel oil. The same type of fuel oil (distillate No. 1) was used throughout the tests. In all treatments relatively optimum weather conditions prevailed for the work. Good drying conditions prevailed, enabling the applied spray to penetrate the bark in an optimum manner. Snow covered the ground to a depth of about 3 inches on one treatment date, March 1, 1958. All spray mixing and spraying of stumps was done by one individual so as to keep treatment technique, mixing, and applications as similar as possible.

Table 1

Summary of Stump Treatments, Lakeside Laboratory, 1957-1958

Date of Cutting and Treating	Temperature at Noon	Number of Stumps Cut 12"	Cut 3"	Total 1/10/A	Condition of Stumps	Percentage Kill
April 12, 1957	50°F	97	108	205	Stumps dry but sap running, ground free of snow, humidity low	100.0
July 5, 1957	80°F	53	51	104	Stumps dry, humidity low	100.0
October 12, 1957	55°F	31	49	80	Stumps, dry, humidity low	100.0
March 1, 1958	50°F	31	49	80	Stumps dry, some snow on ground, humidity low	100.0
Totals		250	274	524	Percentage overall control	99.81

Response to Cutting and Spraying

It will be noted that, regardless of season of treatment, height of stumps, or brush killer—fuel oil mixture used, extremely effective results were obtained (Table 1). It could be that the extremely small percentage of stumps showing regrowth were inadvertently missed during the spraying operation. Only a small ring of dead grass appeared around each stump following treatment and this had generally disappeared within a year. Although this method is preferable for the severeal reasons stated above, there is, initially, more labor involved. The extra cost, based on the removal of trees of this boxelder stand by hand labor, would be about 30 dollars per acre. The amount of hand labor could be reduced by the use of

[2]Weedone 38 Brush Killer (mixture of 2,4-D and 2,4,5-T), made by Amchem, Inc., was used in all spraying work.

a tractor. In some cases utilization of the trees would lower the net cost.

Basal treatment of standing trees, using the same two concentrations as for stump treatment, proved equally effective at the higher concentration but some tree survival was evident at the lower concentration (Fig. 2). Basal treatment of standing trees resulted in many unsightly dead trees remaining in the area which would have to be dealt with at some future time.

Figure 2. Basal spray treatment of standing trees. Trees sprayed with the 1 to 5 concentration were completely killed (left). Trees sprayed with the 1 to 10 concentration were only partially killed (right).

The high percentage of control obtained, as presented in Table 1, indicates the effectiveness of the treatments used. Regrowth on untreated "check" stumps outside of the area indicated that if labor is expended in a clean-up program of this nature, stumps left in the area should be treated, otherwise regrowth will nullify the work in a few years time. Regrowth on untreated check stumps had attained a height of 2 to 3 feet by the middle of the second season. (Fig. 3.)

Many weeds invaded the newly cleared area, especially following the April, 1957, and March, 1958, treatments. Pigweed, lambsquarters, wild hemp, dandelion, burdock, figwort, mullein, and bull thistle were the predominant weeds. In 1958 these were controlled by timely application of 2,4-D "ester" at the rate of 1 pound of active ingredient per acre. Their control favored the recovery of the bluegrass sod. Cutting of stumps close to the ground permits either mowing or follow-up sprayings with negligible interference from stumps.

Figure 3. Sprout growth on unsprayed stumps of the April, 1957, clearing had attained heights of 2 to 3 feet. July, 1958.

The ground cover of Kentucky bluegrass, *Poa pratensis* L., under the trees was very sparse. Apparently the invasion of the trees had occurred so soon after the grazing stock was removed that the bluegrass had increased very little in vigor and abundance. The average number of leafy bluegrass stems at the time the trees were removed from each of the four blocks of plots was 3.5 on an area of 10 square inches. Bluegrass in a comparable area farther north in the tract, where trees were absent and grazing previous to 1930 was less severe, had an average number of stems per 10 square inches in excess of 15.

Removal of the trees and prevention of sprouting by spray treatments at different seasons provided four different sets of conditions which might well cause measurable differences in the growth response of the vegetative ground cover. Observational data were of little use in evaluating the differences in response of bluegrass at different dates. However, there was a marked difference in the development of weeds in the four seasonal blocks. The two blocks cleared in July and in October had very little weed development compared with the two that were cleared before growth started in the spring, April 12, 1957 and March 1, 1958. In spraying for weed control in late May, 1958, spot-spraying was adequate for the July and October blocks, but blanket-spraying was necessary for the other two.

Yield data were taken by means of replicated 1/8 mileacre quadrats of the bluegrass cover in the four treatment blocks. In the random sampling the only precaution taken was not to include in the quadrats the grass killed areas surrounding stumps because they showed different degrees of recovery in the four seasonal treat-

ments. These yields were taken on October 3 and 4, 1958, and must be explained on the basis of elapsed time since release by tree removal as well as of the season in which release occurred. The elapsed times in months for the four treatments were, respectively, 18, 15, 12 and 7.

Dry weight yield per acre and percentage dry weight for each of the seasonal blocks are presented (Table 2). The yield of bluegrass in each of the two blocks which had been cleared for the greatest length of time showed an increase of about 60 per cent over the check and also over each of the other two treatments. Later yield results may show a closer relationship between yield and season of clearing, but these data show a closer relationship between yield and elapsed time since clearing.

Table 2

Percentage Dry Weight and Dry Weight Yields of Bluegrass Under a Boxelder Stand and in Seasonal Removal Blocks, Lakeside Laboratory, October 4, 1958

Treatments	Percentage Dry Weight	Dry Weight ⅜ Mileacre Grams	Dry Weight Tons per Acre
Trees present	70.1	235.0	0.69
Trees removed, no sprouts			
April 4, 1957	69.3	390.4	1.15
July 5, 1947	70.6	369.6	1.09
October 12, 1957	82.8	207.4	0.61
March 1, 1958	72.1	246.0	0.72

Table 3

Water Content of the Soil on a Dry Weight Basis in Cleared and Uncleared Blocks, Lakeside Laboratory, October 4, 1958

Treatments	Depths in Inches 0-6	6-12	12-24	24-30
Trees present	10.7	10.7	9.9	—
Trees removed July 5, 1957, no sprouts	13.1	12.0	12.3	12.3

The two factors which would seem to be the most probable causes of an increase in yield of bluegrass following complete clearing are increases in light intensity from 20 per cent to 100 per cent by clearing and a possible increase in the available water content of the soil in the cleared blocks. Under the conditions of this experiment, differences in water content of the soil of a magnitude to cause a difference in bluegrass yield would occur at critical periods of the growing season. Differences in water content of the soil in October in a cleared and in an adjacent uncleared block were not

significant (Table 3). They were taken, however, at the close of a period during which the dry weight yield of the bluegrass in the cleared block was about 60 per cent greater than that in the uncleared block. The average wilting per cent of the soil of the two blocks is approximately 11 per cent. These differences, though small, indicate that under the trees the soil had reached or fallen below the wilting percent, and where the trees had been removed for 15 months it had not.

Discussion

The ready invasion of the overgrazed bluegrass area by the boxelder trees as soon as the stock was removed was to be expected. Within the tree stand the dense crown cover and the relatively high degree of shade cast by so intolerant a tree can be explained on the basis of a highly fertile prairie soil and an adequate moisture supply, especially for the first 10 or 15 years. The barrier to invasion of the entire area was the well developed bluegrass cover of the moderately grazed pasture area north of the old horse corral. This well developed vegetative cover, in which scattered prairie plants have survived but have increased very little, has been an effective barrier to boxelder invasion. This is an indication that many grassland areas in the state can, with proper maintenance, be made resistant to tree invasion.

It was known at the beginning of the experiment that boxelder trees are more easily killed by spraying than are harder broad-leaf trees such as oaks and hickories, or even elms and ashes. It was not known, however, to what extent the spray material could be diluted. A dilution of 1 to 10 was effective for stump spraying. Unfortunately, no greater dilution was tested. For basal area spraying of standing trees the 1 to 10 dilution was not wholly effective. Reduced rate and depth of penetration of spray material through the bark in basal area spraying, as compared to the rate and depth of penetration into the cut ends of stumps, probably accounts for this difference. Since the 1 to 5 dilution is effective in both basal and stump spraying of boxelder, one has a choice of these methods, depending on the use to be made of the area.

The bluegrass cover of the experimental area, as sparse as it was, had better coverage and more recovery potential than might be expected on the basis of severe overgrazing and later shading. Its response to release from shading was not rapid, but the two treatments that had been in effect for 1½ growing seasons showed an increase in yield of 60 per cent. There was a slight but not significant increase in number of stems in these two treatments. Yield data and stem counts at later dates will be necessary to determine the degree of improvement of stand and if release at different seasons has any effect.

It seemed evident that at the time of tree removal the bluegrass stand did not occupy the area and utilize the water, nutrients, and light to a degree that would interfere with the establishment of weeds in all of the four seasonal blocks. However, only a few scattered weeds became established in the blocks cleared in July and in October, and these made little growth. The low moisture supply was probably the cause of the scattered, retarded weed growth in the July clearing, and the lateness of the season for weed establishment was the cause in the October clearing. The relative paucity of weeds in these seasonal clearings would seem to indicate the possibility of less interference from weed growth in pasture areas cleared in midsummer and fall compared to those cleared during the dormant period or in early spring.

Soil moisture samples were taken at the same time as the bluegrass yields to determine if the available moisture supply had become exhausted as seemed likely, especially in the uncleared area. The exhaustion of available water in the uncleared area indicated that growth of the bluegrass had ceased and for several weeks probably had been limited by the water supply of the soil. Although the difference in water content between the two blocks was small, the fact that the water supply of the cleared block was not entirely exhausted indicated that the growth of the bluegrass here was only beginning to be greatly hindered. The information obtained in this test shows the diagnostic value of soil water content determinations at critical periods in cleared and uncleared pasture areas.

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