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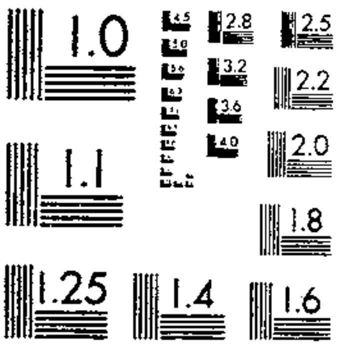

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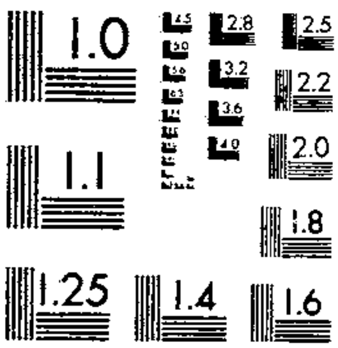

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Interrelations of Methods of WEED CONTROL and PASTURE MANAGEMENT at Lincoln, Nebr.

1949-55

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CONTENTS

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Interrelations of Methods of Weed Control and Pasture Management at Lincoln, Nebr., 1949-55[1]

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INTRODUCTION

Weeds in pastures use moisture, nutrients, and light that might produce forage species of higher value. Although weeds when eaten may contribute to the diet of livestock, nevertheless plants classified as weeds are usually undesirable for numerous reasons. Many are low in productivity and palatability and are not readily eaten by livestock. Some weeds cause undesirable flavors in dairy products; and others are poisonous or cause mechanical injury to the grazing animals. In addition, many of the weeds are annual plants greatly affected by seasonal adversities that result in wide fluctuation in production from season to season.

Available estimates of the losses due to weeds indicate that the losses are great. Almost all pastures have some weeds, and a high percentage have serious weed and brush infestations. The magnitude of this problem is apparent when it is considered that over a billion acres, or more than 50 percent of the land area in the United States, is grazed by livestock, and about three-fourths of this is classified as open pasture. The United States Department of Agriculture has estimated that 240 million acres of these range and pasture lands are seriously infested with weeds and brush. About 15 percent of the open pastureland is plowable and suitable for conversion to improved pasture. Improvement of vegetative composition on the other 85 percent is more difficult.

Information is available to the farmer about methods for maintaining grasslands in a productive and relatively weedfree condition. Nevertheless, many pastures are weedy and produce considerably less than their potential amount in palatable forage. These weedy pastures need attention so that they can be returned to a more productive state.

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[1] Cooperative investigations of the Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the Nebraska Agricultural Experiment Station.

[2] Acknowledgments are due to Arthur Hornung, who furnished the land, and to graduate assistants Merle R. Teel, Dale W. Bohmont, and Milo L. Cox, who helped with the experiment.

Many pastures are weedy largely because of mismanagement. Proper management often would rectify the degradation that has taken place. It is also generally recognized that such improvement would be slow unless accompanied by efficient weed control treatments. Mowing for weed control has been widely recommended for weedy pastures and has proved effective on many weed species.

That good stands of forage plants, well managed, would largely take care of the weed problem has long been accepted. In degenerate pastures, reseeding to adapted species will give rapid recovery of productive capacity. The rapid return to high productivity associated with introduced species and with control of weeds will usually justify the cost.

Spraying with 2,4-dichlorophenoxyacetic acid (2,4-D) has not been practiced widely in pastures and seldom has been compared directly with mowing. Because 2,4-D has revolutionized weed control practices in many other crops, it was thought important that control by 2,4-D should be evaluated in comparison with the methods normally recommended, i. e., mowing and reseeding. The experiment reported herein was planned to give information about the effects of weed control treatments and grazing management practices upon vegetative composition and forage production in a weedy pasture.

REVIEW OF LITERATURE

The Pasture Weed Problem

According to Frolik and Frolik (*12*)[3] in 1941, continuous close grazing severely weakened the tall grasses in pastures in Nebraska. Such introduced species as Kentucky bluegrass and white clover[4] gradually replaced the tall grasses. Also, drought in the 1930's killed out much grass, which in turn gave the weeds an opportunity to increase rapidly. As a result, there were thousands of weedy, unsightly acres of pasturelands in Nebraska (*11, 12*). In the neighboring State of Kansas the weed problem was also present. Pasture surveys were made in 92 Kansas counties in which 97 pastures were examined in 1928. From these surveys Grandfield (*14*) found that 93 pastures were below normal in density of grasses and 26.4 percent of the vegetation present consisted of weeds. According to Elder (*10*), most grasslands in Oklahoma, especially in the central section, were infested by perennial ragweed. In the heavily infested pastures the weed reduced grass yields 50 percent or more.

During the years 1929 to 1934 Weaver and Hansen (*22*) made a survey of pasture weeds in 41 large pastures in the True Prairie region of eastern Nebraska, western Iowa, and parts of four adjoining States. The total number of weed species occurring in the several types of pasture increased with deterioration of the pasture. Annual ragweed, ironweed, and gumweed surpassed all other species in the number of pastures in which they occurred as weeds of primary importance. Ironweed occurred in 37 of the 41 pastures and was first or second in importance in 18. Hoary vervain was of primary or secondary importance in 13 of 41 pastures, and annual ragweed occurred in 20 pastures. Perennial ragweed was recorded in 21 pas-

[3] Italic numbers in parentheses refer to Literature Cited, p. 45.

[4] Common names will be used throughout the bulletin. Scientific names with authorities are shown in the appendix, p. 47.

tures. Certain of the annual grasses that regularly occurred only in the lower grade pastures were threeawn, downy brome, crabgrass, little wild barley, squirreltail, sand dropseed, and povertygrass. Forbs that increased under heavy grazing were yarrow, prairie sage, whorled milkweed, many-flowered aster, daisy fleabane, ground-cherry, smooth goldenrod (*22*), marestail, hemp, snow-on-the-mountain, bull thistle (*12*), and wavyleaf thistle (*4, 22*).

Causes of Degeneration

Grasslands deteriorate as a result of mismanagement (*1, 4*). When excessive removal of top growth is continued year after year, the desirable pasture plants are gradually eliminated by starvation and are subsequently replaced by weeds (*5, 11, 12*). In certain studies conducted by Aldous (*2*), stands of desirable vegetation on plots clipped each 2 weeks at a height of 1½ inches were almost eliminated by 3 years of such treatment. Weaver and Hansen (*22*) found that when the desirable plants were closely grazed, a considerable number of forbs were either entirely uneaten by stock or grazed so sparingly that they were little affected. The weeds profited by the reduced competition and increased in number and stature. When the native bluestems were present, they often almost excluded the invasion of weeds; when the bluestems were weakened and largely replaced by bluegrass, the entrance of invading weeds was rather easily accomplished. It was then that the ragweeds, ironweed, and a host of other species thrived (*24*).

In addition to injury of desirable species by overgrazing, much grass was killed by drought, which in turn gave the weeds opportunity to increase rapidly (*22, 23*).

In Iowa, Peterson (*18*) found that two annual weedy grasses, crabgrass and threeawn, increased considerably in the second year on pastures grazed only in the spring and fall. These and other weed species increased in abundance as the experiment continued. No important changes were observed in the botanical composition of pastures under moderate continuous grazing during this same period.

The reduced cover due to close grazing combined with exposing of the sod by the death of certain species allowed light at the soil surface to be greatly increased (*17, 22*). Levy (*17*) recognized light as a major factor in controlling competition. Light and shade affected seed germination as well as growing plants, and some seeds did not germinate unless there was adequate light intensity. Moreover, the denser the pasture the lower the survival of seedlings. Light at the ground surface also encouraged the spread of stoloniferous species and those with shallow rootstalks.

Means of Improvement

Pasture Management

Grass is favored and weeds are curbed by such practices as water conservation, proper grazing intensity, rotational grazing, timely mowing, and the addition of lime and fertilizer where needed (*1, 19*).

Plant succession following reduced cover, when encouraged by carefully controlled grazing, advances rapidly toward more desirable species in pastures where weeds have not increased too greatly. In

Kansas, Anderson (*6*) reported that the prairie dominants recovered rapidly under protection, and these species spread by vegetative means as well as by natural reseeding to reoccupy the ground lost by depletion of vegetation. Studies by Aldous (*4*) indicated that food reserves of protected or lightly grazed bluestem grasses were restored about the middle of June. From this time until the close of the grazing season the cropping of foliage was less harmful than earlier.

Weaver and Clements (*21, p. 165*) state: "In bringing about natural recovery on the range, especially in the mixed prairie, the first need is complete rest for a year or so, or at least a sharp reduction in the numbe of cattle, in order to restore the competitive balance. This permits the grasses again to reduce the forbs to their proper position of subordination and then to adjust the competition between themselves in such a way as to reestablish the mixed cover of mid and short grasses." In Nebraska, Weaver (*23*) found that the desirable grass species made phenomenal recovery in 4 years of protection of a pasture that had never been greatly overgrazed but which had been seriously injured by drought. The basal density of little bluestem increased 375 percent, big bluestem 362 percent, side-oats grama 413 percent, sand dropseed 137 percent, while bluegrass decreased 91 percent. Rough pennyroyal, Pursh's plantain, and daisy fleabane were the chief forbs in 1937, but all decreased 90 percent or more by 1940. Conversely, many-flowered aster and smooth goldenrod increased 480 and 111 percent, respectively, by 1940.

According to Anderson (*5*), once a native pasture was allowed to deteriorate, its restoration was a long and costly process, often involving years of protection from grazing and a great deal of tedious labor in weed control. The abundance of weeds in many rundown pastures made the eradication of the worthless vegetation the first step in the improvement of this land. The desirable forage plants were restored in a minimum length of time by removing the weeds or brush. Aldous (*4*) stated that grazing practices on improved pasture should permit forage plants to make sufficient top growth to occupy the ground after the weeds are eradicated.

Mowing

Annual and biennial weeds are controlled most easily by keeping them from seeding. According to Frolik and Frolik (*11, 12*), control was most effective when mowing was done at the time weeds were beginning to blossom. Some of the more vigorous pasture weeds and brush—especially buckbrush and ironweed—were able to compete with bluestem and other palatable pasture plants even where conservative or light grazing was practiced. Mowing of perennial weed species was most effective when it was done at the low point in their organic food reserves, as reported by Aldous (*4*).

In 1928 Grandfield (*14*) and Aldous (*3*), working independently in Kansas, determined the effects of dates of mowing on root reserves of ironweed, hoary vervain, and stiff-leaved goldenrod. Grandfield (*14*) found that hoary vervain roots contained the least amount of total carbohydrates when cut June 8 (early bud stage); i. e., 2 weeks earlier than the date at which cutting resulted in greatest reduction of stand, June 23. For stiff-leaved goldenrod, July 7 (late vegetative) was the low point for total carbohydrates, which was also 2 weeks earlier than the date of greatest reduction of stand. However, the differences between the effectiveness of cutting in reducing stand on these dates were very small. The low point for ironweed was July 7 (early bud). Similarly, Aldous (*3*) found that carbohydrates of vervain roots decreased until the plants were in flower; afterward, the depleted supply was gradually restored until the end of the season. He also found that the lowest food reserves of ironweed occurred on July 16 (bud stage) and that this was the date which gave the greatest reduction in number of stems the following year from mowing. In 1935, Aldous (*4*) states further that all the experimental work with herbaceous broad-leaved pasture plants indicated that the low point of their food reserves was just before the first flowers appeared.

In Oklahoma, mowing during June for two successive years effectively controlled sand sagebrush,[5] but mowing to control perennial ragweeds was not very effective (*10*). In Mississippi, mowing at regular intervals controlled 44 percent of the weeds.[6]

Use of Herbicides

In Great Britain, Templeman (*20*) wrote that perennial weeds could be controlled by phenoxyacetic acids, especially in areas where permanent grass could not be plowed. Perennial weeds were very troublesome; the most important were species of buttercup, docks, perennial nettle, ragwort, rush, and creeping thistle.

Studies conducted by Cornelius and Graham (*9*), on a mountain meadow in northeastern California, showed that plaintainleaf buttercup is susceptible to 2,4-D. Production of meadow vegetation was increased threefold in the second year after the use of 2,4-D. Native grasses increased in density and yield concurrently with decreases of weeds susceptible to 2,4-D.

In a 3-year cooperative study in Mississippi, Harris[7] reported that the use of 2,4-D amine at the rate of three-fourths pound per acre reduced weeds and, by removing competition, permitted greatly increased forage yields. By September of the second year, weeds had been reduced from 650 to 1 per square yard. Grass plants had increased from 35 to 100 and legumes had increased from 10 to 90 per square yard. The 2,4-D controlled tarweed, boneset, cassia, primrose, and sneezeweed. The herbicide did not injure the grasses or cause significant damage to legumes (lespedeza, white clover, and black medic). Late-spring applications gave the best results.

In North Carolina, spraying with 2,4-D at rates ranging from 0 to 2 pounds per acre in April, June, and August, 1950, had no significant effects on the final yield or botanical composition of a Ladino clover-orchardgrass sward in April 1951 (*15*). However, 30 days following treatment, the growth and vigor of Ladino clover was reduced where 2,4-D was applied at rates higher than ⅛ pound in April, 1 pound in June, ½ pound in August, and ¼ pound in October.

Elder (*10*) reported that treatment of perennial ragweed with 2,4-D at the Coalgate Pasture Fertility Research Station in Oklahoma increased grass and lespedeza production threefold on an overgrazed

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[5] McIlvain, E. H., and Savage, D. A. EIGHT-YEAR SUMMARY OF RESULTS OF GRAZING, FEEDING, AND OTHER RANGE IMPROVEMENT STUDIES ON THE SOUTHERN PLAINS EXPERIMENTAL RANGE. U. S. South. Great Plains Field Sta. Semiann. Rpt. [20] pp. 1949. [Processed.]

[6] Harris, V. C. CHEMICALS CONTROL WEEDS IN PASTURE. U. S. Dept. Agr. Mimeo. News Release 978-52. May 5, 1952. [Processed.]

[7] See footnote 6.

pasture. Treatment of ragweed with one-half to three-fourths pound 2,4–D per acre, when ragweed was 4 to 6 inches high, gave a good kill, as well as control of many other troublesome broad-leaved weeds. It was possible to kill the weeds where lespedeza was growing without causing severe injury to the lespedeza. Also, in Oklahoma, McIlvain and Savage [8] found one application of 2,4–D to sagebrush in May resulted in 50 to 60 percent increased carrying capacity of rangeland and 70 to 75 percent increased cattle gains per acre.

Reseeding

According to Fuelleman and Graber (*13*), seeding of legumes in thin, weedy pastures in Wisconsin was undertaken without plowing up existing grasses. This method was designated as renovation. In 30 pastures renovated in 1934 and 1935 where ragweeds prevailed at an average rate of 423,200 per acre, the renovations reduced them 85.7 percent by 1937. In 30 pastures where horesweeds prevailed at the average rate of 336,267 per acre, renovation reduced them 92.1 percent.

The first 2 or 3 years after renovation, such treatment was very effective in controlling weeds, but further duration of such benefits was dependent on managerial treatment (*7*).

At the United States Southern Great Plains Field Station, Woodward, Okla., McIlvain and Savage [8] found that every one of the station's 10 reseeded pastures on abandoned cropland has supported more cattle and produced 2 to 4 times as much beef per acre as well-managed range.

MATERIALS AND METHODS

A weedy native pasture was selected for this investigation. The pasture, which is approximately 60 acres in size, is located 8 miles south of Lincoln, Nebr., on a Pawnee silty clay loam soil of moderately rolling topography. The pasture had no cultural treatment of any kind prior to the study, and grazing use had been moderate to heavy.

The main weed species in the pasture were ironweed, false boneset, hoary vervain, many-flowered aster, annual ragweed, hairy chess, and threeawn. The principal desirable grass species present in the pasture were Kentucky bluegrass, with scattered stands of side-oats grama, sand dropseed, and big bluestem.

Included in the major experiment were eight weed control treatments, which could be classified into four groups as follows: (1) No treatment; (2) mowing; (3) spraying with 2,4–D; and (4) plowing and reseeding to grasses, supplemented with 2,4–D treatment. The details of each treatment were as follows:

Treatment No.	*Treatment*
1.	Check, no treatments were applied.
2.	Mowed in June (mowing height during the first season was about $1\frac{1}{2}$ inches, thereafter mowing height was approximately $3\frac{1}{2}$ inches). The June date of mowing generally occurred on June 15, plus or minus 1 or 2 days, and the mowed vegetation was allowed to lie where it fell.
3.	Mowed in early July, within 1 or 2 days of July 1. The techniques in mowing were the same as for the June dates.

[8] See footnote 5.

Treatment No.	Treatment
4.	The isopropyl and butyl ester of 2,4–D at 1 pound acid equivalent per acre was applied in June. The dates of application each year coincided with the dates of mowing. The 2,4–D was applied in water diluent at 10 gallons of spray per acre with a tractor-mounted sprayer. The spray boom was set at about 20 inches above the tallest vegetation.
5.	One pound of 2,4–D isopropyl and butyl ester per acre was applied in early July. The application techniques were similar to those described for June. The dates of application coincided with the early July dates of mowing.
6.	Seeded to intermediate wheatgrass.
7.	Seeded to bromegrass.
8.	Seeded to a warm-season grass mixture. The mixture consisted of 7 pounds of big bluestem, 2 pounds of sand lovegrass, 4 pounds of switchgrass, and 4 pounds of blue grama seed per acre.

The seedbed preparation for the above-seeded grasses (treatments 6, 7, and 8) was initiated in October 1949, when the land was plowed to a depth of 4 inches. The soil was allowed to lie rough through the winter and on March 30, 1950, the soil was thoroughly disked and treaded (a Dunham treader, which is similar to a heavy rotary hoe pulled backward, was used) to give a firm seedbed. On March 31 bromegrass and intermediate wheatgrass were drilled at the rate of 15 pounds per acre into their respective plots and again treaded to insure thorough coverage of the seed and to make the seedbed firmer.

On May 17, 1950, the plots on which the warm-season grass mixture was to be seeded were again double-disked and treaded just before the seeding. The warm-season grasses were broadcast by hand and treaded. All the seeded grasses were protected from grazing for the full 1950 season. The cool-season grass plots were sprayed with one-fourth pound of 2,4–D ester per acre June 8, 1950, for control of broad-leaved weeds in the seedling grasses. The warm-season grass plots were mowed on July 21, 1950, instead of being sprayed. Thereafter, all the seeded plots were given 2,4–D ester weed control treatments of one-half pound per acre in 1951 and 1 pound per acre annually thereafter.

The plots for the weed control treatments were 30 feet wide and 230 feet long. The experiment consisted of four replications of each treatment arranged in a randomized block design.

There were three levels of management that crossed the weed control treatments. They were as follows: (1) Grazed as usual, as the farmer used his pasture (continuous grazing); (2) deferred and rotationally grazed; and (3) protected from grazing. These grazing management treatments were superimposed on the weed control treatments in such manner as to give a split-plot design with subunit treatments in strips (*8*). With the two grazing intensities above, the management strips were 100 feet wide, whereas the strip protected from grazing was 30 feet wide.

Grazing in the farmer's pasture of 60 acres usually started early in May and was continued through the summer with 18 to 20 cattle ranging in age from 1 year old to mature cows. The calves were not counted. During 1950 and 1951, 2 horses were also grazed in this pasture. The fence was removed from the deferred-and-rotationally-grazed portion of the pasture, June 15 each year, and this portion was managed through the season to favor the warm-season grasses. Rotational grazing was necessary to protect the seeded plots from abuse. When it was determined that the plots of warm-season grass mixture had been sufficiently utilized for a given grazing period, the area was again refenced to exclude the stock. Again at the end of the season, between September 1 and 15, stock were excluded from the deferred-and-rotationally-grazed portion of the pasture. The livestock were removed from the pasture at dates varying from October 1 to November 15, depending on the grazing conditions for the year.

The stand of weed forbs was determined by counting the number of stems of each species in five permanent 2- × 4-foot sample areas per plot each season. Clones of ironweed and false boneset were counted in 1950 and 1951; thereafter, stems were counted. Since there were three management treatments and four replications, a total of sixty samples, 2 × 4 feet in area, were counted for each weed control treatment.

The density of grass species was determined by a modified line-interception method.[9] The basal occurrence of species was noted in each square centimeter along 12 randomly located 1-meter lines per plot, a total of 48 lines per management-treatment, and 144 lines for a weed control treatment (12 lines per plot × 4 replications × 3 grazing managements).

Consumption and production of plant material was determined by cages as described by Klingman, Miles, and Mott (*16*). One cage 5 × 5 feet in area, was located at random in each grazed plot. However, the size of the sample clipped was 4 × 4 feet. The clipped vegetation was hand-separated into 3 components: Desirable grasses, weed grasses, and weed forbs. Each was individually bagged, labeled, oven-dried, and weighed in grams. The amount of plant material was calculated to pounds of dry matter per acre. Since the caged and uncaged sample areas were selected as similar at the beginning of each grazing period, the difference in the weight of the plant material in the two areas was assumed to be the amount of vegetation consumed. Total production was determined by adding the amounts consumed in each grazing period with the amount of aftermath remaining at the last date of clipping.

A study, supplemental to that described above, comparing eight dates of mowing with eight dates of spraying 2,4-D, was initiated in 1950. This experiment, a split-plot design in three replications, had dates of treatment as main plots and treatments as subplots. The *treatments* in 10- × 50-foot plots, were as follows:

1. Mowed.
2. Sprayed with 1 pound 2,4-D isopropyl and butyl esters per acre.
3. Sprayed with 1 pound 2,4-D amine per acre.
4. Check.

The treatment dates were June 5, June 12, June 19, June 26, July 3, July 17, July 31, and August 14. Treatments were applied on or near the specified dates in each of the years 1950–54. The above experiment was repeated in an adjoining area and treatments were applied each of the years 1951–54. Notes on stands of ironweed were taken each spring before that year's weed control treatments were applied.

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[9] CONARD, E. C. THE EFFECT OF TIME OF CUTTING ON YIELD AND BOTANICAL COMPOSITION OF PRAIRIE HAY IN SOUTHEASTERN NEBRASKA. 1953. [Unpublished doctor's thesis. Copy on file in Texas A. & M. College, College Station.]

RESULTS

Weed Populations as Affected by Treatments

The data on the effects of treatments upon weed populations were collected in June 1953 before the 1953 weed control treatments were made. Therefore, they represent the residual effects of treatments applied in 1950, 1951, and 1952.

The best control of perennial weeds resulted in the plots that were plowed, seeded to grasses, and given supplemental 2,4-D treatments (fig. 1). The control of perennials ranged from 89 to 94 percent in the

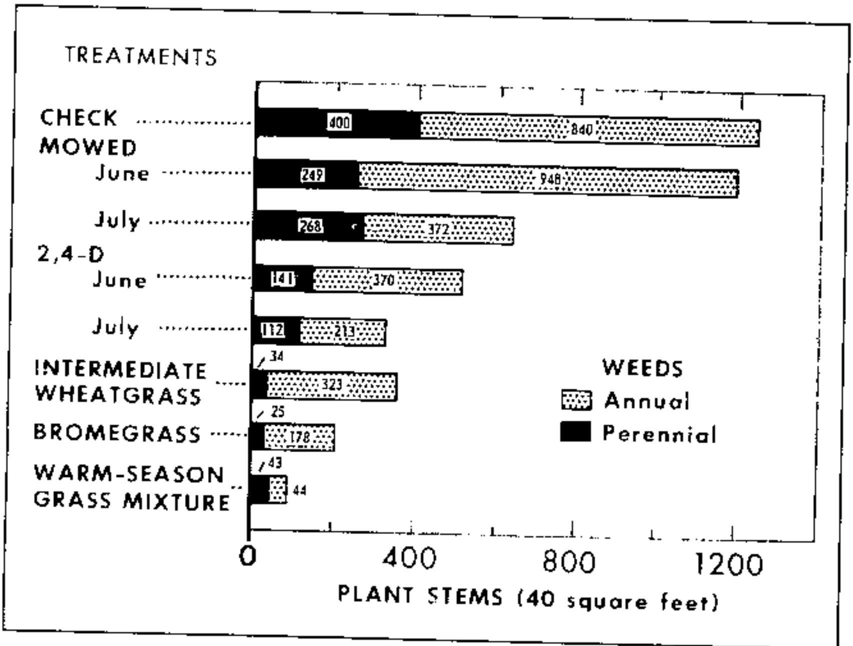

FIGURE 1.—Effect of weed control treatments upon average number of the annual and perennial broad-leaved weeds in 40 square feet in June 1953 following treatments in 1950, 1951, and 1952.

plots made up of intermediate wheatgrass, bromegrass, and a warm-season grass mixture. The 2,4-D treatments were next in effectiveness in reducing stands of perennials. The June and July 2,4-D treatments reduced stands 65 and 72 percent, respectively. These percentages are considerably higher than the 38 and 33 percent reductions that resulted from mowing.

Annual weed populations were affected by treatments in much the same way as the perennial weeds. The main difference was that mowing in July also gave satisfactory control of annual broad-leaved weeds.

Photographs of untreated checks of this experiment are shown in figure 2; effects of treatments upon weed populations in August 1953 are shown in figures 3 to 7.

Mowing, while giving only slight to moderate reductions in stands of weeds, always gave immediate improvement in appearance of the plots (figs. 3 and 4). This apparent improvement was largely tempo-

FIGURE 2. *A*, Untreated check in center portion contains ironweed, ragweed and false boneset. Adjoining plot to the right had 2,4-D treatments in June for 4 years, and the plot to the left was mowed in July. *B*, Another untreated check plot with ironweed, with some plants as tall as 42 inches, and other smaller weeds. Density of ironweed is greater than the average of the check plots. Photographed August 8, 1953.

rary, as evidenced by appearance of the plots the next year prior to treatment. In seasons of normal rainfall, regrowth of weeds was more profuse after mowing. The 2,4-D treatments gave less rapid improve-

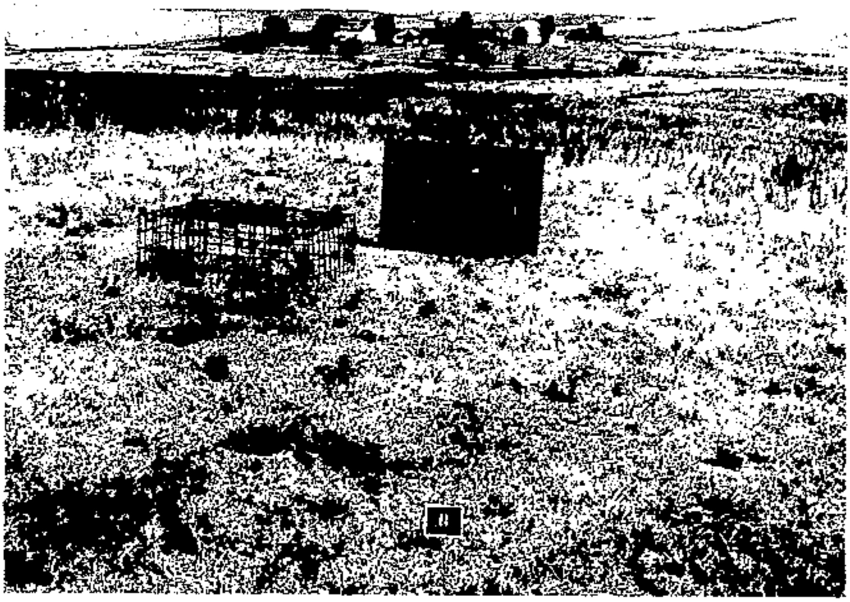

FIGURE 3. A plot mowed in June for 4 years. Although the plot looked relatively clean of weeds, there was only a moderate reduction in stand of perennial weeds. Regrowth of weeds was more profuse in seasons of normal rainfall. Photographed August 8, 1953.

ment in appearance, because many of the plants remained standing, though in a stunted condition. However, by 1953, after 4 years' treatment these plots had improved much in appearance (figs. 5 and 6) and more grass cover remained than in the plots that were mowed. The plots plowed and seeded to adapted grasses and given supplemental 2,4-D treatments had a good cover of desirable grasses in addition to good weed control (fig. 7).

Perennial Weeds

Ironweed

Stands of ironweed were significantly reduced by all weed control treatments with the exception of mowing in July (table 1). The 2,4-D treatments gave considerably greater stand reductions than the mowing treatments; that is, 2,4-D applied in June and July gave 93 and 76 percent reduction, respectively, from no treatment, while the mowing resulted in 53 and 7 percent reductions for the same dates. The plots that were plowed, seeded to grasses, and given supplemental 2,4-D treatments had from 98 to 99 percent control of ironweed. In this experiment it has been observed that plowing alone has almost eliminated ironweed.

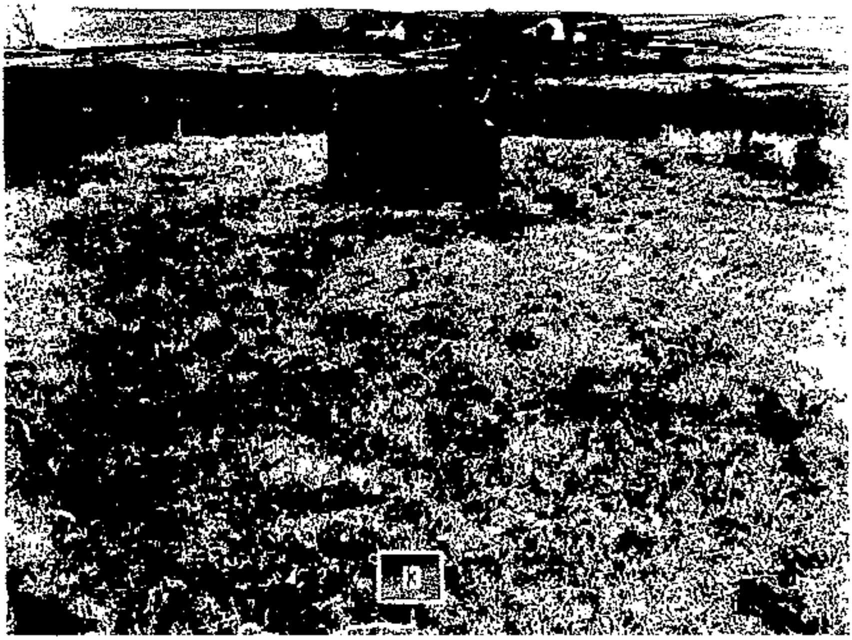

FIGURE 4.—A plot mowed in early July for 4 years. Mowing gave immediate improvement in appearance of the plot, but actually only moderately reduced the stand of perennial weeds. Photographed August 8, 1953.

TABLE 4.—*Ironweed stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatments	Stems in 30 square feet for grazing management: Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	197	191	142	177
Mowed, June	130*	75**	43*	83**
Mowed, July	199	18**	113	103
2,4-D, June	20**	4**	12**	13**
2,4-D, July	62**	18**	16**	13**
Intermediate wheatgrass[2]	6**	2**	1*	1**
Bromegrass[2]	0**	2**	0**	1**
Warm-season grasses[2]	1**	4**	1**	2**
Average for management[3]	76	47	41	
Standard error of the treatment mean	21	21	29	11

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: * = significant at the 5-percent level; ** = significant at the 1-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ½, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 except that mowing was substituted for spray in warm-season grasses in 1950.

[3] Standard error of the means for management = 8.

FIGURE 5. A plot sprayed with 2,4-D in June for 4 years. The scattered stand of weeds remaining was mostly false boneset. Photographed August 8, 1953.

FIGURE 6. A plot given 2,4-D treatment in early July for 4 years. Perennial weeds persisting were mostly false boneset, yarrow, a few ironweed, and a small patch of pasture sage. Photographed August 8, 1953.

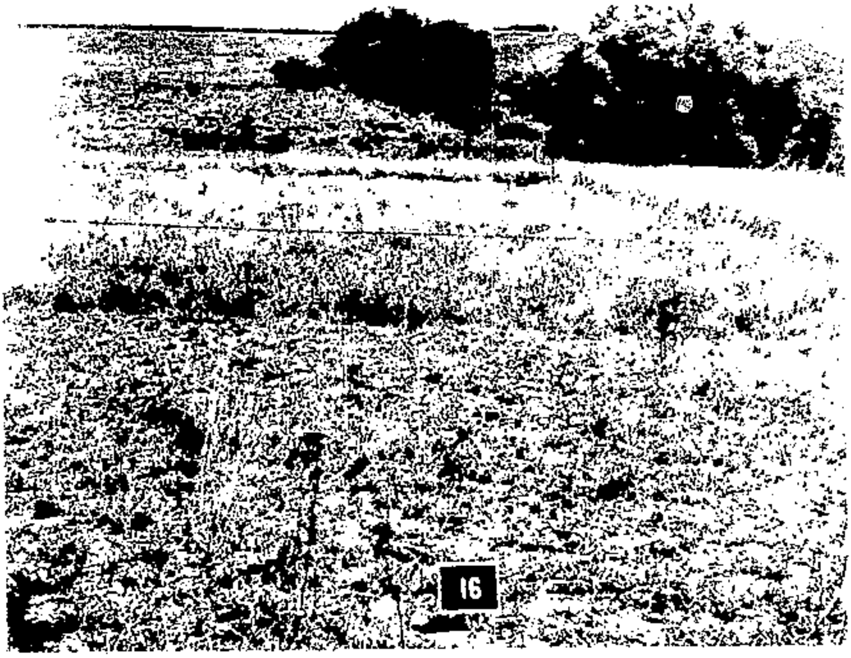

FIGURE 7.—Warm-season grass mixture, showing the 3 levels of grazing management used in these experiments: In the foreground, grazed as usual; in the center, deferred and rotationally grazed; and in the background, protected from grazing. Note the relative freedom from weeds. Photographed August 8, 1955.

Grazing management resulted in a lower population of ironweed in the protected plots than in the plots grazed as usual. However, this difference was not statistically significant. Interaction of weed control treatments × grazing managements also was not significant (appendix, table 24).

The relative stands of ironweed in plots given different treatments are shown for each of the 6 years of this experiment (table 2). Initial stands in 1950 were taken before any weed control treatments were applied and at that time stands of ironweed did not differ significantly (appendix, table 25). In 1951, following 1 year of treatment, the mowing treatments had given no stand reduction and 2,4-D treatments only slight reduction (table 2). The plowing, as preparation for seeding grasses, eliminated 90 percent or more of the ironweed. In 1952, after 2 years of treatment, mowing still had little effect on ironweed stand, but the 2,4-D treatments had given 77 and 52 percent control for the June and July dates, respectively. The values calculated for 1953, 1954, and 1955 show the progressive control obtained by the successive applications of 2,4-D.

The poor results obtained with mowing to control ironweed were somewhat unexpected in light of earlier research (4, 7). The reasons for differential results between the experiment reported herein and those reported earlier are not known, but differences in results herein were not caused by a poor choice of dates of mowing.

TABLE 2.—*Ironweed: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Ironweed populations as percentages of check [1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	76	87	73	47	60	68
Mowed, July	92	97	104	93	89	114
2,4-D, June	80	53	23	7	5	2
2,4-D, July	88	67	48	24	15	7
Intermediate wheatgrass		0	1	0	0	0
Bromegrass		3	1	0	0	0
Warm-season grasses		10	4	1	0	0

[1] Percentages calculated from an actual count in June each year of plant stems in 60 permanently located areas. Average numbers of stems in 40 square feet for the check were 227, 177, 146, and 106, respectively, in 1952, 1953, 1954, and 1955.

Mowing and spraying with 2 formulations (ester and amine salts) of 2,4-D at 1 pound per acre are compared for 8 dates, starting the first week in June (fig. 8). Curves are an average of 2 experiments—one initiated in 1950, the other in 1951—and treated each year thereafter. Mowing on June 19 has given reductions of 36 percent in stands;

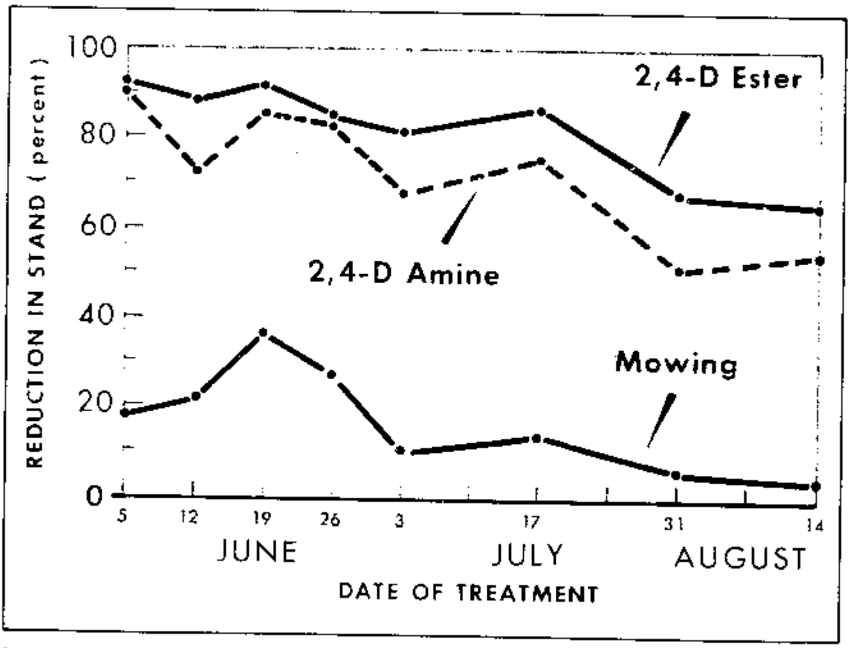

FIGURE 8.—Percentage reduction in stands of ironweed as affected by dates of mowing or spraying with 2,4-D. (Curves represent an average of data from 2 experiments (one treated annually, 1950–54; the other annually, 1951–54) at Lincoln, Nebr. Data taken in July 1955 before 1955 treatment.

mowings on the week before or after June 19 being only slightly less effective. The June 5 date gave only 18 percent reduction, and all the later dates gave 14 percent or less reduction of stand.

Annual applications of 2,4-D ester gave 81 to 92 percent reduction of stand for the first 7 dates, and was 65 percent in plots given mid-

August treatments (fig. 8). A few of the individual plots showed no ironweed left. The amine salt formulation gave slightly less reduction of stand at all dates.

The 2,4–D treatments were distinctly superior to mowing in reducing stands of ironweed. Nevertheless, the optimum dates of spraying tended to coincide with the optimum dates for mowing.

As indicated, 2,4–D was effective in controlling ironweed, but it did not quickly eliminate the plants from the pasture. The spraying arrested the terminal growth of the plants, but the plants normally remained alive for a long time. Often the plants retained their leaves for the rest of the season and ranged in coloration from dark green to purplish. Some leaves turned brown and dropped from the plants. In figure 9 is shown a normal plant; in figure 10, a survivor of four annual sprayings in early July; and in figure 11, a survivor of four sprayings made annually in June.

Figure 9.—Ironweed plant of about normal size with 34 stems and 32 inches tall in 1953, although in seasons of normal rainfall these plants often exceed 48 inches in height. Photographed August 8, 1955.

False Boneset

False boneset was almost eliminated by plowing and seeding grasses when supplemented with treatments of 2,4–D (table 3). All other treatments, excepting 2,4–D applied in July, gave unsatisfactory control. The 2,4–D applied in July gave 57 percent reduction in stand. Grazing management had slight effect upon stands of false boneset. There were less plants in the protected plots than in the

FIGURE 10.—An ironweed plant that has survived 4 years' treatment with 2,4-D applied early in July each year. Terminal growth has ceased on the two stems remaining, but the plant has remained green. Photographed August 8, 1953.

plots of the other two grazing intensities. However, the differences were less than the 5-percent level of probability. Neither was the interaction of grazing managements × weed control treatments significant (appendix, table 24).

By chance, at the beginning of the experiment in 1950, the stands of false boneset in the check were lower than in all the other plots (table 4). These differences among treatments were statistically significant at the 1-percent level of probability (appendix, table 25). In 1951 the stands of false boneset in the intermediate wheatgrass, bromegrass, and warm-season grass mixture plots were reduced more than 90 percent, again mostly by the plowing operation. By 1953 spraying with 2,4-D in early July was the only other treatment that approached satisfactory control, although spraying in June had also resulted in reductions of stand as compared to those of 1950. By 1955 both dates of spraying had given about 70 percent reduction in stand of this species.

Hoary Vervain

Hoary vervain, a common pasture weed, had less than one-half the stand density of false boneset and less than one-fourth that of ironweed in this pasture. It averaged approximately one stem per square foot in the plots of the check (table 5). Since the stands of hoary vervain were moderately dense and with relatively high variability, most of

FIGURE 11.—A [illegible] plant that has survived [illegible] treatment with 2,4-D [illegible]. Photographed [illegible] 8, 1953.

TABLE [illegible]

[illegible]

TABLE 4.—*False boneset: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	False boneset populations as percentage of check [1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	173	127	106	87	98	141
Mowed, July	100	82	120	86	80	111
2,4-D, June	104	100	95	103	102	33
2,4-D, July	109	64	64	43	54	26
Intermediate wheatgrass		9	8	10	16	5
Bromegrass		0	6	4	8	3
Warm-season grasses		0	3	1	11	5

[1] Percentages calculated from an actual count in June each year of plant stems in 60 permanently located areas. Average number of stems in 40 square feet for the check were 51, 77, 163, and 64, respectively, in 1952, 1953, 1954, and 1955.

TABLE 5.—*Hoary vervain: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Stems in 40 square feet for grazing management [1]—			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	86	13	12	37
Mowed, June	61	11	8	26
Mowed, July	14*	6	2	7
2,4-D, June	27*	1	1	10
2,4-D, July	17*	2	0	6
Intermediate wheatgrass [2]	25*	4	0	10
Bromegrass [2]	9*	0	1	3
Warm-season grasses [2]	30*	7	1	12
Average for management [3]	34	6	3	---
Standard error of the treatment mean	18	18	18	11

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: *=significant at the 5-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

[3] Standard error of the means for management=8.

the treatments were not significantly different from the check; however, there were some apparent trends. All treatments, except mowing in June, reduced the stand 68 percent or more.

In 1950 the initial stands of hoary vervain were equal to or greater than those of the check (table 6). Good reductions of stand were obtained by 1951 in the plots that were mowed in July and in the plots receiving 2,4-D treatments. However, in the plots plowed and seeded to grasses, stands of hoary vervain were far in excess of the check. Most of these plants were seedlings that had germinated following the plowing and seeding. Although all seeded plots had more hoary vervain than the check in 1951, the number in the warm-season grass mixture was three times that found in the cool-season grasses. It will be recalled that in 1950, seedlings of intermediate wheatgrass and bromegrass were sprayed with one-fourth pound 2,4-D ester, while the warm-season grass mixture was mowed instead of being sprayed. Although detailed data are not available, it is assumed that the hoary vervain seedlings in 1950 were killed by the spray in the cool-season grasses, but the mowing treatment did not eliminate these seedlings in the warm-season grass mixture. The 1951 spray treatments with 2,4-D had eliminated this differential by 1952, when great reductions in stands of hoary vervain were evident in all of the seeded plots.

Many-flowered Aster

Many-flowered aster plants in the untreated pasture plots averaged about two stems per square foot. All the weed control treatments gave significant reduction of stands (table 7). After a single year's treatment all treatments except mowing (table 8) gave better than 80 percent control. After 2 years, the 2,4-D treatments eliminated more than 94 percent of the aster plants, and after 4 years complete control resulted. Also, complete control resulted in the plots plowed

TABLE 6.—*Hoary vervain: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Hoary vervain populations as percentages of check [1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	100	127	111	70	75	43
Mowed, July	150	50	79	19	58	14
2,4-D, June	100	25	36	27	117	0
2,4-D, July	150	50	21	16	67	14
Intermediate wheatgrass		150	25	27	8	0
Bromegrass		150	20	6	8	0
Warm-season grasses		450	28	32	25	0

[1] Percentages calculated from an actual count of plant stems in 60 permanently located areas. Average number of stems in 40 square feet for the check were 6, 20, 20, 37, 12, and 7, respectively, in 1950, 1951, 1952, 1953, 1954, and 1955

TABLE 7.—*Many-flowered aster: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Stems in 40 square feet for grazing management [1]—			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	50	130	80	87
Mowed, June	17	40**	37*	31**
Mowed, July	11	29**	39*	26**
2,4-D, June	1*	0**	6**	2**
2,4-D, July	0*	15**	0**	5**
Intermediate wheatgrass [2]	0*	0**	0**	0**
Bromegrass [2]	0*	0**	0**	0**
Warm-season grasses [2]	0	0**	0**	0**
Average for management	10	27	20	
Standard error of the treatment mean [3]	14	14	14	11

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: *=significant at the 5-percent level; **=significant at the 1-percent level.
[2] Plots reseeded in the spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).
[3] Standard error of the means for management=8.

TABLE 8.—*Many-flowered aster: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Many-flowered aster populations as percentages of check [1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	177	61	81	36	46	37
Mowed, July	92	56	45	30	30	37
2,4-D, June	92	6	3	2	0	0
2,4-D, July	215	27	1	[illegible]	0	0
Intermediate wheatgrass		0	1	0	0	0
Bromegrass		0	[illegible]	0	0	0
Warm-season grasses		0	3	0	0	0

[1] Percentages calculated from an actual count of plant stems in [illegible] permanently located areas. Average number of stems in 40 square feet for the check were 46, 90, 30, 87, 89, and 89, respectively, in 1950, 1951, 1952, 1953, 1954, and 1955.

and seeded to grasses. It took 3 years of mowing to reduce the stands 64 and 70 percent, respectively, for the June and July dates of mowing. Grazing management treatments, however, did not appear to affect the stand of this weed, nor was the interaction of treatment × management significant (table 25).

Yarrow

The stand of yarrow was sparse, having an average of 1 plant per 2 square feet in the check (table 9). Some decrease in stand of yarrow resulted in plots treated with 2,4–D in June and in plots seeded to bromegrass. The 2,4–D in July was less effective. The mowing treatments and warm-season grass mixture gave no reduction in stands.

Grazing management significantly affected stands of yarrow, with the protected plots having the least number of plants. In the plots that were reseeded and grazed as usual, much of the soil surface was bare and provided an excellent site for germination of the yarrow seed. This big difference did not occur on the native plots where the sod was not opened by the heavy grazing. The differential response of yarrow to treatment and grazing management was not significant (appendix, table 24).

At the beginning of the experiment in 1950, all plots, except those mowed in July, had considerably more yarrow than did the check plots (table 10). Although these differences were appreciable, they were not statistically significant (appendix, table 25). Because of this difference in original stand, some treated plots gave greater reductions in stands of yarrow than was indicated in the comparisons to the check in 1953. For instance, the plots sprayed in June started with 166 percent of the stand of the check in 1950, and the figures have decreased in succeeding years. All the plots plowed and seeded to grasses (plus 2,4–D) had less yarrow than the check in 1951, although a gradual increase in yarrow stands had occurred in the reseeded plots from 1951 to 1955. As indicated above, much of that increase had come on the plots grazed as usual. These plots had been grazed to less than 1-inch height during 1951 and the years following. Stand counts represented seedling plants as well as established plants in this experiment.

TABLE 9.—*Yarrow: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Stems in 40 square feet for grazing management [1]—			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	21	24	17	21
Mowed, June	45*	50*	19	38*
Mowed, July	20	32	16	23
2,4-D, June	7*	12*	1*	7*
2,4-D, July	13	5*	11	10*
Intermediate wheatgrass [2]	32	8*	1*	14*
Bromegrass [2]	17	3*	2*	7*
Warm-season grasses [2]	30	47	1*	28*
Average for management [3]	24	23	8*	...
Standard error of the treatment mean	10	10	10	6

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Differences from check: * = significant at the 5-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

[3] Standard error of the means for management = 3.

TABLE 10.—*Yarrow: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Yarrow populations as percentages of check [1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	300	271	231	181	243	233
Mowed, July	100	200	213	110	71	100
2,4-D June	166	100	48	33	71	67
2,4-D, July	150	157	62	47	43	100
Intermediate wheatgrass		57	23	67	243	133
Bromegrass		14	21	33	57	67
Warm-season grasses		29	75	133	257	233

[1] Percentages calculated from an actual count of plant stems in 60 permanently located areas. Average number of stems in 40 square feet for the check were 17. 7, 21, 7, and 3, respectively, in 1950, 1951, 1952, 1953, 1954, and 1955.

Perennial Ragweed and Groundcherry

Stands of perennial ragweed were quite uneven and localized in this experiment. Because of the unevenness of stand, conclusions cannot be drawn, but certain observations were made. In this experiment perennial ragweed was not well controlled by spraying, although many workers [10] have observed that perennial ragweed is easily killed with 2,4-D. There was a slight downward trend in stands in all plots treated with 2,4-D, but changes in stand were not significant.

Only sparse stands of groundcherry were present in these experimental plots, but the weed was quite uniformly distributed. The three plots that were plowed and reseeded had stands significantly lower than the check. The mowed plots had less groundcherry than

[10] KLINGMAN, D. L. ANNUAL REPORT. NOXIOUS WEED CONTROL PROJECT, DIVISION OF CEREAL CROPS AND DISEASES, BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, IN COOPERATION WITH NEBRASKA AGRICULTURAL EXPERIMENT STATION, LINCOLN, NEBR. 143 pp. 1951. [Processed.]

McILVAIN, E. H., and SAVAGE, D. A. CONTROL OF RANGE BRUSH AND WEEDS. U. S. South. Great Plains Field Sta., Woodward, Okla. 9 pp. 1949. [Processed.]

the check, but not significantly so, whereas the 2,4–D treatments were ineffective in controlling groundcherry. Although groundcherry was resistant to 2,4–D treatment and although the stand intensities were low, it was thought important to follow the performance of this weed to see if it might possibly increase in stand with the decrease in stands of other weeds susceptible to 2,4–D. A trend of this kind was evident in 1953 and groundcherry increased in 1954 to a point where management and treatment mean squares were both highly significant. In 1955 the treatment × management mean square was also highly significant.

Dandelion

The stands of dandelion in 1950 were quite variable, but this was not of great concern with a species such as dandelion, which seeds prolifically and is widely disseminated by means of its well-developed pappus. The information concerning dandelion stands is of particular interest because of the erroneous conclusions that might be drawn from the data in table 11.

TABLE 11.—*Dandelion: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Plants in 48 square feet for grazing management [1]			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	112	58	15	61
Mowed, June	457**	395**	105	319**
Mowed, July	293*	166	76	178*
2,4–D, June	198	74	51	107
2,4–D, July	359**	37	11	130
Intermediate wheatgrass [2]	95	25	3	41
Bromegrass [2]	76	20	5	34
Warm-season grasses [2]	167	93	20	93
Average for management [3]	220	108	36	
Standard error of the treatment mean	58	58	58	42

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: *=significant at the 5-percent level. **=significant at the 1-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4–D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

[3] Standard error of the means for management = 51.

The trend toward increased stands of dandelion through the years on mowed plots in this experiment is probably reliable. Mowing reduced the amount of cover on these plots each year, and thus shading was less of a factor in eliminating new dandelion seedlings on mowed plots than on many of the other plots. However, stands of dandelion in sprayed plots are not a reliable indication of the effects of 2,4–D on this weed, since no seeds were produced on any of the sprayed plots from the time the experiment was initiated, and yet most of the plants counted on sprayed plots were seedling plants. Also, dandelion plants in plots at the time of spraying with 2,4–D were almost all eradicated by the spray treatment each year, but since a ready seed source was immediately adjacent to these 2,4–D treated plots of only 30-foot width, ample seed must have been disseminated into the plots from the borders. To conclude that 2,4–D treatment was not effective on dandelion would be subject to criticism. The 2,4–D has killed established plants and prevented seed production, and the treatment of a whole pasture would undoubtedly result in the major portion of it soon becoming essentially free of dandelion. The only possible source of seed under such conditions would be from the borders.

As the results were not typical of dandelion control that would be obtained in practical application, the data for stands of dandelion were not included in figure 1, but they are shown with other perennial weeds in table 12. The inclusion of data for dandelions has changed the picture of weed control by treatments considerably from that shown in figure 1. The reductions in stands of other perennial weeds by mowing had been replaced by about equal numbers of dandelion; however, the dandelions were a much less serious problem than were many of the weeds that were reduced in stand. In the first place dandelion was a palatable species and relished by livestock, and in the second place it did not grow as tall and furnish as much shade as some of the other weed species.

TABLE 12. *All perennial broad-leaved weeds: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Stems in 40 square feet for grazing management [1] [3]			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	599	526	286	470
Mowed, June	788	612	275	558
Mowed, July	668	508	291	489
2,4–D, June	414	161**	121	232**
2,4–D, July	497	199*	53*	250*
Intermediate wheatgrass [2]	160**	52**	14**	75**
Brome grass [2]	109**	38**	9**	52**
Warm-season grasses [2]	237**	162**	25**	141**
Average for management	430	286	135*	
Standard error of the treatment mean	67	67	67	57

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: * = significant at the 5-percent level; ** = significant at the 1-percent level.

[2] Plots reseeded in spring of 1951, supplementally sprayed with ¼, ½, and 1 pound of 2,4–D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

[3] Standard error of the means for management = 17.

All Species

The summarization in table 12 shows that when all species of perennial broad-leaved weeds were considered together, the grazing-management effects on stands were significant. The grazed-as-usual management averaged 430 stems per 40 square feet; deferred-and-rotationally grazed, 286 stems; and permanently protected, 135 stems. When individual perennial species were considered, only yarrow had stands that were significantly reduced by management (appendix, table 24). The interaction of treatment × management of all perennial species was not statistically significant.

Annual Weeds

Annual Ragweed

Annual ragweed was by far the most prevalent of the annual weed species found in this pasture. There were 800 annual ragweed plants in 40 square feet in the check, an average of 20 plants per square foot (table 13). The stand counts were taken early in June and seedling plants were all counted. No doubt, many of the seedlings in stands of this density did not survive to mature plants. Even so, great numbers of plants did grow to maturity. Stands of ragweed varied from plot to plot in 1953, and for this reason differences between treatments were not statistically significant.

TABLE 13.—*Annual ragweed: Stands in June 1953 as affected by weed control treatments and grazing management, Lincoln, Nebr.*

Treatment	Plants in 40 square feet for grazing management [1]			
	Grazed as usual	Deferred and rotationally grazed	Protected from grazing	Average
	Number	*Number*	*Number*	*Number*
Check	1,011	709	678	800
Mowed, June	1,074	901	711	895
Mowed, July	305**	395	288*	330
2,4-D, June	109**	273*	659	347
2,4-D, July	130**	373	43**	181
Intermediate wheatgrass [2]	65**	651	178*	298
Brome grass [2]	171**	251*	51**	159
Warm-season grasses [2]	15**	51**	12**	26
Average for management [3]	340	450	325	
Standard error of the treatment mean	136	136	136	223

[1] Plants were counted before current year's treatments were applied. Treated in 1950, 1951, and 1952. Difference from check: * = significant at the 5-percent level; ** = significant at the 1-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

[3] Standard error of the means for management = 47.

In 1952 all the treatments, except the plots mowed in June and the plots of intermediate wheatgrass, had greatly reduced stands of annual ragweed (table 14). The same trend is observable in 1953, with the exception that intermediate wheatgrass also gave good reductions of ragweed. The reduction in stands of ragweed must have been caused by a reduction in seed supply, since weeds were counted before the current year's treatments were applied and all residual effects of chemicals applied in previous years would have been dissipated. The indication that early mowing increased stand of annual ragweed was confirmed by field observations. Mowing at that early date found the ragweed seedlings in the 2- to 4-leaf stage and short enough to be missed by the sickle bar. The mowing then served as a liberation cutting and promoted growth of the annual ragweed.

Spraying with 2,4-D at either date gave satisfactory control of annual ragweed for the growing season.

Snow-on-the-Mountain

Snow-on-the-mountain, another annual weed, was widely present in the pasture studied, with a 6-year average stand in the check plots of 18 plants in 40 square feet (footnote 1, table 15). Mowing treatments

TABLE 14.—*Annual ragweed: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Annual ragweed populations as percentages of check[1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	79	141	82	112	180	216
Mowed, July	101	51	24	41	67	58
2,4–D, June	109	38	42	43	68	16
2,4–D, July	94	57	37	23	43	32
Intermediate wheatgrass	----------	234	60	37	33	10
Bromegrass	----------	236	26	20	25	5
Warm-season grasses	----------	135	14	3	8	5

[1] Percentages calculated from an actual count of plant stems in 60 permanently located areas. Average number of stems in 40 square feet for the check were 89, 147, 1,039, 800, 159, and 19, respectively, in 1950, 1951, 1952, 1953, 1954, and 1955.

were ineffective with this weed. In fact, plots mowed in June gave an increase in stand in most years. The 2,4–D treatments gave good reductions in stand of snow-on-the-mountain with the exception of 1953 and 1954, when reductions were slight. No seed has been produced since 1950 in the plots treated with 2,4-D, because all snow-on-the-mountain plants were killed by each year's spraying treatments.

Marestail and Wild Hemp

Marestail (or horseweed) was sparsely present in this experiment. It is a weed that was relatively tolerant to 2,4–D. For this reason data for this minor species were maintained separately in order to detect whether a trend of increased stands might occur as other broadleaved weeds decreased as a result of 2,4–D spraying. These trends are not yet apparent.

Wild hemp stands were so sparse and variable that the data were not reliable. However, it was observed that 2,4–D was effective in controlling this weed.

TABLE 15.—*Snow-on-the-mountain: Trends in stands as affected by weed control treatments, Lincoln, Nebr., 1950–55*

Treatment	Snow-on-the-mountain as percentages of check[1] in—					
	1950	1951	1952	1953	1954	1955
Check	100	100	100	100	100	100
Mowed, June	120	120	86	168	222	43
Mowed, July	110	58	35	80	92	28
2,4–D, June	150	54	38	72	104	28
2,4–D, July	80	54	40	72	63	43
Intermediate wheatgrass	----------	17	5	4	7	14
Bromegrass	----------	42	3	4	4	14
Warm-season grasses	----------	22	11	4	4	28

[1] Percentages calculated from an actual count of plant stems in 60 permanently located areas. Average number of stems in 40 square feet for the check were 6, 24, 17, 25, 27, and 7, respectively, in 1950, 1951, 1952, 1953, 1954, and 1955.

Grasses as Affected by Treatments

Where weeds were controlled, increased basal density of stands of the desirable grasses resulted (fig. 12). The data shown in figure 12 were based upon 144 line transects designed to measure basal density of the different grasses in each of the weed control treatments. In the

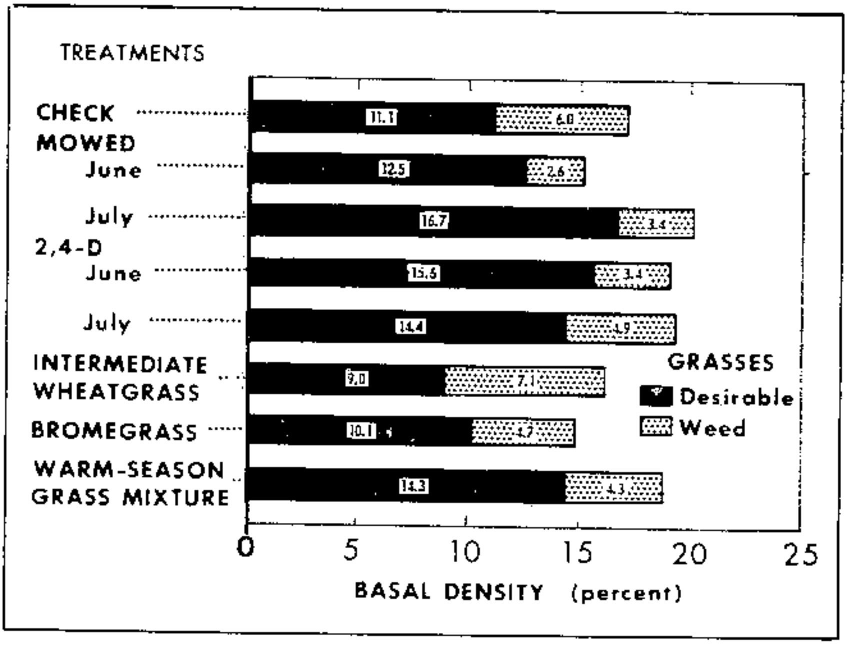

FIGURE 12.—Percentage of basal density of grasses in June 1953 as affected by weed control treatments.

first five treatments the desirable grasses were primarily bluegrass, with scattered stands of side-oats grama, big bluestem, and sand dropseed. In the last three treatments, plots were seeded to grasses on plowed areas. Here the basal-density percentages may be misleading, since most of the dominant grasses were of the larger, coarser types that naturally have relatively lower basal-density values for a satisfactory stand. Even so, the basal density of the desirable grasses in the warm-season grass mixture was greater than that of the check.

The basal density of the weed grasses decreased where the basal density of the desirable grasses increased (fig. 12). Apparently the increased stands of desirable grasses, associated with weed control, gave more competition to the weed grasses than did the broad-leaved weeds that were eliminated.

In table 16 is shown the basal density of grasses as affected both by grazing management treatments and by weed control treatments. With the desirable grasses there was a downward trend in basal density from the grazed-as-usual to the protected-management treatments. All the reasons for this trend are not known. It has been observed, however, that bluegrass has a more dense sod under moderate to close grazing than it does if not grazed at all. Since bluegrass was the dominant grass in these first five treatments, this might partially explain the trend found.

With intermediate wheatgrass the trend was in the opposite direction, with poor stands on the grazed-as-usual portion of the plots and better stands on the deferred-and-rotationally-grazed plots. The best stands of intermediate wheatgrass existed in the protected areas (table 16).

TABLE 16.—*Basal density of grasses in June 1953, as affected by weed control treatments*[1] *and grazing management practices,*[2] *Lincoln, Nebr.*

Treatment	Basal density of—											
	Desirable grasses				Weed grasses				Total grasses			
	A	B	C	Average	A	B	C	Average	A	B	C	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Check	11.8	9.7	11.8	11.1	6.9	4.7	6.5	6.0	18.7	14.4	18.3	17.1
Mowed, June	13.9	12.0	11.7	12.5	3.0	2.7	2.2	2.6	16.9	14.7	13.9	15.1
Mowed, July	20.3	16.8	13.0	16.7	4.0	4.7	1.6	3.4	24.3	21.5	14.6	20.1
2,4-D, June (1 pound)	17.2	15.3	14.2	15.6	4.8	2.9	2.5	3.4	22.0	18.2	16.7	19.0
2,4-D, July (1 pound)	15.0	13.7	14.5	14.4	5.4	5.5	3.7	4.9	20.4	19.2	18.2	19.3
Intermediate wheatgrass[3]	7.6	8.8	10.7	9.0	16.7	3.4	1.4	7.1	24.3	12.2	12.1	16.1
Bromegrass[3]	11.4	8.3	10.5	10.1	9.7	3.4	1.1	4.7	21.1	11.7	11.6	14.8
Warm-season grasses[3]	15.0	18.3	9.7	14.3	5.3	6.5	1.1	4.3	20.3	24.8	10.8	18.6
Average for management[4]	14.0	12.9	12.0		7.0	4.2	2.5		21.0	17.1	14.5	
Standard error of the treatment mean	1.8	1.8	1.8	1.3	1.8	1.8	1.8	1.6	2.0	2.0	2.0	1.1

[1] Treatments applied in 1950 and annually thereafter.

[2] Differential management practices across which the weed control treatments extended were as follows: A=grazed as usual for the farmer's pasture; B=grazing deferred until June 15, rotationally grazed until September 1 to 15; and C=complete protection from grazing.

[3] Reseeded grasses planted in the spring of 1950 (protected for 1 season) and 2,4-D applied: ¼ pound 1950, ½ pound 1951, and 1 pound in 1952 and annually thereafter (mowing substituted for 2,4-D in 1950 on warm-season grasses).

[4] Standard errors of the means for managements: Desirable grasses=0.4; weed grasses=1.3; and total grasses=0.8.

Surprisingly good stands of bromegrass persisted even in the grazed-as-usual plots. During the time since the grazing was started in 1951, bromegrass has never reached a height greater than 3 inches and usually it was grazed to a height of less than 1 inch for each of the full seasons, 1951 and thereafter. Information as to how long this grass can be maintained under the severe overgrazing practiced is not yet available in this study.

The warm-season grass mixture also maintained relatively good stands under the grazed-as-usual management, although not so good as on the deferred-and-rotationally-grazed plots.

The basal density of the weed grasses tended to be highest on the grazed-as-usual plots, where the basal density for desirable grasses was also highest. Under the more intensive grazing practice the amount of ground covered was reduced, allowing the seedlings of annual weed grasses to become established more readily.

Total basal density of grasses in 1953 was relatively low (17.5 percent), as compared to the preceding years. In 1950 the average total basal density was 30.1 percent; in 1951, 29.1 percent; in 1952, 28.4 percent.

The basal density of the desirable grasses has fluctuated less with years than the weed grasses. The desirable grasses have tended to improve on the native sod, with 9.6 percent basal density of desirable grasses in 1950; 13.9 percent in 1951; 15.6 percent in 1952; and 13.0 percent in 1953. Thus, the basal density of the desirable grasses in 1953 was 135 percent of that found in 1950.

Stands of weed grasses were decidedly lower in 1953 than in any of the previous years. This was mostly because of the severe drought conditions through late August, September, October, and into early November of 1952, which killed off all the weed bromegrass seedlings that had germinated earlier in the fall; also, the severe drought conditions during the late spring and summer of 1953 reduced the number of threeawn seedlings that were able to become established.

Grasses in Undisturbed Plots

Desirable Grasses

In table 17 are shown the basal-density percentages of four desirable grasses in the undisturbed-sod plots of the experiment. Kentucky bluegrass made up the major portion of the desirable species. It tended to be favored by the increased grazing pressure of the grazed-as-usual practice. There was little difference in basal density between the other two grazing management practices

Side-oats grama tended to be favored by the deferred-and-rotationally-grazed and the protected-management practices. With sand dropseed no consistent trend associated with management was observed.

Big bluestem was sparsely present in the experimental plots. Since it is one of the dominant species of the area, the effect of favorable management upon its ability to replace Kentucky bluegrass in the years to follow will be watched closely. To date, big bluestem has increased slightly, but the differences shown are not statistically significant. The stands of big bluestem had degraded to such a low density level in this pasture before the experiment was started (0.2 percent) that a long period of time will undoubtedly be necessary before it can again become a dominant species even under protection.

The rate of recovery of big bluestem was accelerated by weed control treatments under protected conditions. It has been observed that big bluestem clumps were larger and the plants more vigorous in protected plots given weed control treatments. In August 1952, big bluestem clumps in protected plots sprayed with 2,4–D in June were estimated to be from 18 to 24 inches in basal diameter, while the basal diameter of the plants in the check ranged from 6 to 12 inches. In figure 13 is shown a big bluestem clump in a plot that had been protected and treated with 2,4-D in June for 4 years. Detailed measurements of individual plants were not made; only measurements of the plants' contribution to the vegetative composition of plots as a whole were made. With such measurements the increase of the desirable native grasses was slow and did not approach the figures given by Weaver and Hansen (*23*), who indicated that big bluestem increased 362 percent when protected from grazing and side-oats grama increased 413 percent. Data for individual plants might approach those of Weaver and Hansen. The sparsity of plants prevents even larger increases in individual plant size from having appreciable effect upon basal-density percentage in the plots as a whole (table 17).

Weed Grasses

The basal-density percentages of the most prevalent weed grasses and grasslike plants are shown in table 18. The stands of annual bromes, predominantly hairy chess, in the check plots were higher

TABLE 17.—*Basal density of 4 desirable grass species in June 1953 as affected by weed control treatments [1] and grazing management practices,[2] Lincoln, Nebr.*

Treatment	Basal density of—							
	Kentucky bluegrass				Big bluestem			
	A	B	C	Average	A	B	C	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Check	11.5	8.8	11.0	10.5	0.1	0.2	0.2	0.2
Mowed, June	13.2	10.5	10.9	11.6	.1	.4	0	.2
Mowed, July	19.7	14.4	11.7	15.3	.1	.9	.1	.4
2,4–D, June	16.0	11.1	12.2	13.2	.1	.4	.2	.2
2,4–D, July	12.8	13.0	12.6	12.8	1.2	2	.9	.8
Average for management [3]	14.6	11.6	11.7		.3	.4	.3	
Standard error of the treatment mean	1.7	1.7	1.7	1.3	.5	.5	.5	.2
	Side-oats grama				Sand dropseed			
Check	0.1	0.6	0.3	0.3	0.2	0.1	0.3	0.2
Mowed, June	.4	1.0	.6	.7	.2	.1	.2	.2
Mowed, July	.3	1.1	.8	.7	.2	.3	.4	.3
2,4–D, June	.5	3.0	1.2	1.2	.6	.5	.6	.6
2,4–D, July	.1	.4	.5	.3	.7	.1	.5	.4
Average for management [3]	.3	1.2	.7		.4	.2	.4	
Standard error of the treatment mean	.3	.3	.3	.1	.3	.1	.1	.1

[1] Treatments applied in 1950 and annually thereafter.
[2] Differential management practices across which the weed control practices extended were as follows: A=Grazed as usual for the farmer's pasture; B=grazing deferred until June 15, rotationally grazed until September 1 to 15; and C=complete protection from grazing.
[3] The standard errors for managements are: Bluegrass=1.4, big bluestem=0.2, side-oats grama=0.2, and sand dropseed=0.1.

FIGURE 13.—A big bluestem clump that has increased in size in a bluegrass sod in the plot given 2,4-D treatment in early July for 4 years and protected from grazing. Weedy forbs are false boneset. Photographed August 8, 1953.

than in plots with the weeds controlled. The lowest stands of hairy chess were found on the plots mowed in June. Mowing June 15 greatly reduced the production of viable seeds, although June 15 was a little late for optimum control.

The grasslike weeds, mainly slender cyperus with limited occurrence of other sedge species and rushes, were grouped with the grasses because of growth form. As they contributed little to the available forage and were of low palatability, they have been included with the weed grasses. Stands of these species were not greatly influenced by either weed control treatments or grazing management practices.

Threeawn tended to be present in greater density in the grazed-as-usual plots and in least density in the protected plots. There was also a slight increase in threeawn in plots of both dates of spraying and with early mowing.

The total of the weed species was found in greatest density on the check. There was a downward trend in weed grass stands from the grazed-as-usual management through the deferred-and-rotationally-grazed plots to the protected areas.

FENSTER, D. W. LIFE CYCLES AND CONTROL STUDIES OF SOME ANNUAL BROMEGRASSES. 68 pp., illus. 1953. (Unpublished doctor's thesis. Copy on file, Univ. of Nebraska, Lincoln.)

TABLE 18.—*Basal density of the less desirable grass species and grasslike weeds in June 1953 as affected by weed control treatments*[1] *and grazing management practices,*[2] *Lincoln, Nebr.*

Treatment	Basal density of—							
	Annual bromes[3]				Threeawn			
	A	B	C	Average	A	B	C	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Check	6.3	3.7	4.8	4.9	0.1	0	0.1	0.1
Mowed, June	.3	.4	.4	.4	1.0	.7	.1	.6
Mowed, July	2.4	3.5	1.0	2.3	.1	.2	.3	.2
2,4-D, June	2.8	1.5	2.0	2.1	1.3	.6	.4	.8
2,4-D, July	2.7	3.9	2.0	2.9	.9	.6	.2	.6
Average for management[4]	2.9	2.6	2.0	2.7	.7	.4	.2	.4
Standard error of the treatment mean	.8	.8	.8	1.0	.4	.4	.4	.1
	Grasslike weeds[5]				Total, grasslike weeds and weed grasses			
Check	0.1	0.3	0	0.1	6.5	4.0	4.9	5.1
Mowed, June	.4	.4	0	.3	1.8	1.5	.5	1.2
Mowed, July	.2	.3	.1	.2	2.7	4.0	1.4	2.7
2,4-D, June	.1	.2	.1	.1	4.2	2.3	2.5	3.0
2,4-D, July	.2	.3	.1	.2	3.8	4.8	2.3	3.6
Average for management[4]	.2	.3	.1	.2	3.8	3.3	2.3	3.1
Standard error of the treatment mean	.1	.1	.1	.1	1.8	1.8	1.8	1.6

[1] Treatments applied in 1950 and annually thereafter.
[2] Differential management practices across which the weed control practices extended were as follows: A=Grazed as usual for the farmer's pasture; B=grazing deferred until June 15, rotationally grazed until September 1 to 15; and C=complete protection from grazing.
[3] Annual bromes were predominantly hairy chess, with a sparse stand of downy brome.
[4] The standard errors of the means for management are: Hairy chess=0.6, threeawn=0.3, slender cyperus=0.1, and total of 3 weedy species=1.3.
[5] Grasslike weeds were predominantly slender cyperus, with sparse stand of other sedges and rushes.

Grasses in Plowed and Reseeded Plots

Smooth Bromegrass

The basal density of the grasses found in the seeded plots is shown in table 19. The greatest basal density of bromegrass was in the protected areas and the least in those areas grazed as usual. Nevertheless, a moderately good stand of bromegrass was maintained even on the grazed-as-usual plots. Bromegrass tolerated overgrazing with less injury than intermediate wheatgrass. However, Kentucky bluegrass was beginning to encroach into the grazed-as-usual bromegrass plots and was almost equal to bromegrass in basal density. Other desirable grasses, primarily sand dropseed, had also increased in the bromegrass.

The total basal density for weed grasses in the grazed-as-usual plots of bromegrass was almost equal to the combined basal density of bromegrass and Kentucky bluegrass, but weed grasses were much less in the deferred-and-rotationally-grazed plots. Only a small amount existed in the protected area. Of the weed grasses, hairy chess was relatively minor, even in the grazed-as-usual plots. However, threeawn had invaded these plots generally. It was also the most important weed grass in the other two grazing management

TABLE 19. *Basal density of grasses in June 1953 on plots plowed and reseeded, as affected by grazing management practices,[1] Lincoln, Nebr.*

Grasses	Bromegrass A	Bromegrass B	Bromegrass C	Bromegrass Average	Intermediate wheatgrass A	Intermediate wheatgrass B	Intermediate wheatgrass C	Intermediate wheatgrass Average	Warm-season grasses A	Warm-season grasses B	Warm-season grasses C	Warm-season grasses Average	SE[3]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Desirable species:													
Bromegrass	5.9	6.2	9.2*	7.1									1.0
Intermediate wheatgrass					1.9	4.8	8.5**	5.1					1.0
Kentucky bluegrass	4.2	1.8*	.8**	2.3	4.4	3.6	1.5**	3.2	4.6	2.4*	0.8**	2.6	.6
Big bluestem									2.2	3.4	4.4	3.3	1.0
Switchgrass									4.1	5.3	3.4	4.2	.8
Sand lovegrass									1.2	4.2**	.2*	1.9	.3
Blue grama									2.1	1.3	.3	1.2	.4
White clover	.1	.1	0	.2	.4	0	0	.1	.2	.1	0	.1	
Other desirable grasses	.9	.2	.5	.5	.9	.4	.7	.7	.6	1.6	.8	.9	1.4
Total, desirable species	11.4	8.3	10.5	10.0	7.6	8.8	10.7	9.0	15.0	18.3	9.7*	14.3	1.4
Weed species:													
Hairy chess	0.4	0.6	0.3	0.4	1.4	1.4	0.9	1.2	0.5	3.4*	0.8	1.6	0.5
Threeawn	8.0	2.0	.6	3.5	15.0	1.2**	.1**	5.5	3.5	2.2	0	1.9	2.8
Other weed	1.3	.8	.2	.8	.3	.8	.1	.4	1.3	.9	.3	.8	2.8
Total, weed species	9.7	3.4	1.1*	4.7	16.7	3.4**	1.4**	7.1	5.3	6.5	1.1	4.3	2.9
All species, total	21.1	11.7*	11.6*	14.8	24.3	12.2**	12.1**	16.1	20.3	24.8	10.8*	20.2	2.0

[1] Grazing management practices: A=Grazed as usual for the farmer's pasture; B=deferred grazing until June 15, rotationally grazed thereafter; and C=protected from grazing.

[2] Each individual figure is the average occurrence of species in 48 random meter lines (4,800 cm.). Difference from grazed-as-usual practices: *=significant at 5-percent level; **=significant at 1-percent level.

[3] Standard error of the means shown under individual management practices.

practices for bromegrass. Other weed grasses found were the foxtails, barnyard grass, and crabgrass. They followed the same general trends as threeawn.

Intermediate Wheatgrass

The above discussion of grasses in the bromegrass plots as related to grazing management applies in general to intermediate wheatgrass (table 19). There are two important exceptions. The stand of intermediate wheatgrass under the grazed-as-usual management was much poorer than was bromegrass. Also, the invasion of Kentucky bluegrass was more extensive in the deferred-and-rotationally-grazed plots of intermediate wheatgrass. Secondly, associated with the poorer stands of intermediate wheatgrass was the greater increase of threeawn in the grazed-as-usual plots. Otherwise, the trends were very similar to those of the bromegrass plots.

It should be pointed out that the deferred-and-rotationally-grazed plots in this experiment were managed to favor the warm-season grasses and thus the best utilization of cool-season grasses was not possible. By the time livestock were turned into the plots June 15, bromegrass was in full head and intermediate wheatgrass was in the boot stage. Generally the warm-season grasses were 10 to 16 inches tall. Since livestock tended to concentrate on the weedfree seeded plots, restricted periods of grazing were necessary to prevent overgrazing in the areas deferred and rotationally grazed. Here grazing was adjusted to take about two-thirds of the forage from the warm-season grass plots (fig. 8). This is a little greater utilization than is sometimes recommended for conservative grazing practice. So far, these plots have tolerated such grazing practice without appreciable deterioration.

Warm-Season Mixture

The four grasses seeded in the warm-season mixture included big bluestem and switchgrass, two of the tall-grass types; sand lovegrass, a mid-grass; and blue grama, a short-grass type. These species responded differentially to the grazing managements practiced and the trends were definite, although in some instances not statistically significant (table 19).

Big bluestem had a stand of 2.2 percent basal density in the spring of 1951 before any grazing had occurred, and it has been maintained at that percentage in the grazed-as-usual plots despite the severe overgrazing. However, the greatest basal density was found in the protected areas where it had increased to 4.4 percent.

The stands of switchgrass had declined slightly by 1953. The best stand, which was 5.3 percent, was maintained in the deferred-and-rotationally-grazed plots. Again, a surprisingly good stand, 4.1 percent, was maintained under the grazed-as-usual management. In the protected areas a density of 3.4 percent was found. The differences in stand were not statistically significant.

Sand lovegrass had a 6.4 percent stand in 1951; however, it had almost disappeared by 1953 from the protected areas, in which only 0.2 percent basal density remained. Also, it had declined to 1.2 percent in the grazed-as-usual plots, but had maintained relatively good stands, 4.2 percent, in the deferred-and-rotationally-grazed areas. In the latter areas some seed was produced each year and later in the season ground cover was reduced by the grazing. This undoubtedly allowed new seedlings to be established each year. Such seedlings were noted in the surveys made in June. Also, a few clumps of sand lovegrass have become established in the adjacent bromegrass plots.

Blue grama almost maintained its basal density in the grazed-as-usual plots from 1951 to 1953, 2.2 percent to 2.1 percent, respectively. Under the other management practices it declined, with only 0.3 percent remaining in the protected area and 1.3 percent in the deferred-and-rotationally-grazed area. The taller grasses, when ungrazed or lightly grazed, almost eliminated this short grass.

In the warm-season grass mixture, the total basal density of weed grasses was somewhat less in the plots grazed as usual than for bromegrass or intermediate wheatgrass when grazed as usual (table 19). In the deferred-and-rotationally-grazed plots the opposite was true, with most weed grasses occurring in the warm-season grass mixture. Where the plots were protected they were all about equal.

Of the weed grass total, hairy chess made up a relatively minor part in the grazed-as-usual plots of the warm-season mixture, because under close grazing hairy chess produced little seed. In the deferred-and-rotationally-grazed plots, hairy chess produced an abundance of seed and increased from 0.4 percent basal density in 1951 to 3.4 percent in 1953. The grazing later in the season reduced the vegetative cover and the hairy chess seedlings were able to become established in the fall. Hairy chess did not increase to the same extent in the plots that were protected. Here, hairy chess had the same opportunity for seed production, but no foliage was removed by grazing.

Threeawn increased in the grazed-as-usual and the deferred-and-rotationally-grazed plots of the warm-season mixture, but by 1953 had disappeared in the protected plots. However, the increase of threeawn in the grazed plots of warm-season grasses was not so great as in the cool-season grass plots. The other warm-season weed grasses, made up primarily of foxtails, barnyard grass, and crabgrass, follow trends similar to the threeawn.

Forage as Affected by Treatments

Forage Consumed

In the preceding sections, the effects of treatments upon weed control and the changes in vegetative composition of the grasses as related to treatments have been shown. An equally important measure of effectiveness of weed control and grazing management treatments is their effect upon the forage produced, both in volume and in quality. In figure 14 are shown the effects of weed control treatments upon the amounts of forage eaten by cattle.

All weed control treatments increased the amount of vegetation consumed (table 20). With weed control, unpalatable weeds were greatly reduced and the density of desirable grasses was increased, making such areas more attractive to the grazing cattle.

Consumption of vegetation increased most for the desirable forage species on plots plowed and seeded to the adapted grasses (table 20). Appreciable increase in consumption of weed grasses was also associated with increases in broad-leaved weed control.

The consumption of broad-leaved weeds varied considerably. The least amounts were consumed in plots of three treatments: Intermediate wheatgrass, bromegrass, and sprayed with 2,4-D in July (table 20).

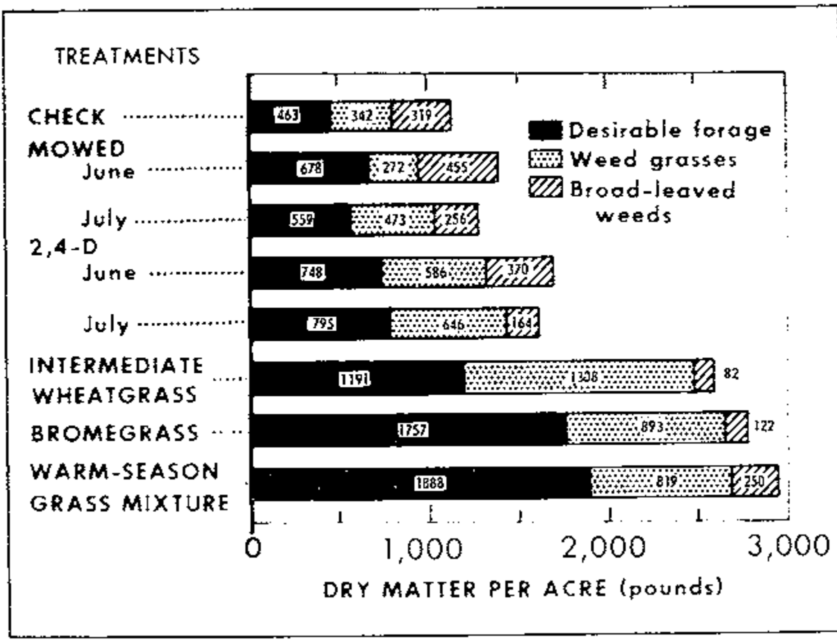

FIGURE 11. Effect of weed control treatments upon average pounds of dry matter per acre eaten by cattle, 1951–53.

Considerably more forage was taken from the grazed-as-usual plots than from the deferred-and-rotationally-grazed plots, especially in the first five treatments (table 20). This differential was largely the result of the reduced amount of time that the deferred-and-rotationally-grazed areas were exposed to grazing. Here grazing was not permitted until June 15, and then only for limited times to prevent overgrazing of the seeded plots. The high consumption on the seeded plots in the deferred-and-rotationally-grazed areas, in spite of the short grazing time, was largely because stock tended to concentrate on the seeded plots. Consumption of forage on the plots having weed control was increased to 252 percent of the check in the grazed-as-usual plots and up to 318 percent of the check in the deferred-and-rotationally-grazed plots.

The grazed-as-usual management of this study is fairly typical of the continuous grazing management practiced by many farmers. Under this grazing management, forage eaten was 25 and 11 percent more in plots mowed in June and July, respectively, than in the untreated plots. Control of weeds by spraying was more advantageous; increases of 62 and 52 percent of forage were eaten, respectively, on plots sprayed in June and July as compared with the untreated plots. Forage eaten on the sprayed plots was 33 percent greater than on mowed plots.

The greatest increases in forage consumed resulted from plots plowed, reseeded, and given supplemental 2,4-D treatments each year for weed control (table 20). When grazing was not restricted, forage eaten was 252, 237, and 224 percent of the untreated plots, respectively, for plots of bromegrass, intermediate wheatgrass, and warm-season grasses. The high consumption figures on these plots

Table 20. *Forage consumed: 3-year average amounts of desirable grass species, weed grass species, weed forbs, and total vegetation eaten as affected by weed control methods and grazing management practices, Lincoln, Nebr., 1951–53*

Treatment	Dry matter per acre eaten on plots [1]											
	Desirable grass species			Weed grass species			Weed forbs			Total vegetation		
	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Check	604	322	463	386	297	342	334	305	319	1,324	924	1,124
Mowed, June	770	586	678	336	209	272	554	356	455	1,660**	1,151**	1,405**
Mowed, July	603	516	559	430	516	473	443	68	256	1,476	1,100	1,288*
2,4-D, June	641	855*	748*	923*	249	586	581	160	370	2,145**	1,263**	1,704**
2,4-D, July	982*	608	795*	749	542	646*	282	45	164	2,014**	1,195*	1,605**
Intermediate wheatgrass [2]	1,294**	1,089**	1,191**	1,710**	906**	1,308**	133	31	82	3,136**	2,026**	2,581**
Bromegrass [2]	1,857**	1,658**	1,757**	1,388**	398	893**	96	149	122	3,340**	2,205**	2,773**
Warm-season grasses [2]	1,703**	2,073**	1,888**	913*	694*	810**	326	174	250	2,972**	2,942**	2,957**
Average for management	1,057	963	1,010	858	476	667	344	161	252	2,258	1,601	1,930
Standard error of the treatment mean	132	132	93	132	132	93	132	132	93	65	65	46

[1] Difference from check: * = significant at the 5-percent level; ** = significant at the 1-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except mowing was substituted for spraying on warm-season grasses in 1950).

were a little surprising in light of the continuous and severe overgrazing that had occurred each of the 3 years of grazing.

Total forage consumed was separated into three component parts: Desirable grasses, weed grasses, and weed forbs. Consumption of desirable grasses was not significantly different among the averages of mowed plots and the check (table 20). Plots sprayed with 2,4–D gave significant increases in consumption, and the seeded plots gave highly significant increases. The three seeded-grass treatments, even under the severe overgrazing of the grazed-as-usual practice, averaged a consumption of desirable grasses two to three times that of the check plot. Between the grazing management treatments the consumption of desirable species did not differ greatly.

The amount of forage furnished by the weed grasses in this pasture was surprising (table 20). There was 81 percent as much weed grasses as desirable grasses eaten in the plots given grazed-as-usual management. In the first five treatments, most of the weed grasses consumed were hairy chess early in the spring and lesser amounts of young threeawn later in the season. In the seeded plots, large quantities of threeawn, foxtails, and barnyard grass were eaten. Since crabgrass made up a relatively small part of the population of weed grasses, it did not contribute greatly in forage consumed, although it was readily eaten when present. Threeawn, while normally considered unpalatable, was eaten in large quantities on the seeded plots where it was continuously grazed to heights of ½ to 2 inches.

A smaller quantity of the weed grasses was eaten in the deferred-and-rotationally-grazed plots, partly because of the short time of exposure to grazing, but principally because the weed grasses were allowed to grow beyond their palatable stages of growth before grazing was started in the late spring (table 20). Many of these weed grass species, if allowed to grow beyond the early vegetative stages, were not relished by livestock.

The weed forbs made up a small percentage of the total forage consumed, even though appreciable amounts were eaten (table 20). The differences between treatments and the check in the amount of weed forbs consumed were not significant. Detailed data as to which species of the weed forbs were eaten are not available, but some observations were made. Ironweed and false boneset were never grazed in these pastures; usually the milkweeds were avoided, but they were grazed in 1953. Hoary vervain was usually avoided, but occasionally small portions of plants were eaten. Considerable quantities of ragweed were grazed, though not readily eaten. Dandelions, where present, were palatable and readily eaten.

Aftermath

The aftermath on plots at the end of a grazing season was important only insofar as it affected the vigor and production of plants in years that followed. Aftermath data also gave indication of the degree of utilization (table 21). All weed control treatment plots, regardless of grazing management practiced, gave lower total amounts of aftermath than was present on the check plots. In the check plots a large portion of the aftermath was composed of broad-leaved weeds. The least amounts of aftermath were found in the seeded plots grazed as usual. The mowed plots also had considerably lower amounts of aftermath as compared to weed control treatments with 2,4–D and the check.

TABLE 21.—*Aftermath: 3-year average amounts of desirable grass species, weed grass species, weed forbs, and total vegetation remaining at the end of the grazing season as affected by weed control and grazing management practices, Lincoln, Nebr., 1951–53*

Treatment	Dry matter per acre aftermath on plots [1]											
	Desirable grass species			Weed grass species			Weed forbs			Total vegetation		
	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Check	499	981	740	315	403	359	1,706	2,273	1,990	2,520	3,658	3,089
Mowed, June	280	627	453	217	339	278	659**	508**	584**	1,156**	1,475**	1,315**
Mowed, July	406	775	591	166	419	292	518**	504**	511**	1,090**	1,699**	1,393**
2,4-D, June	1,048*	1,429	1,238*	505	677	591	584**	225**	404**	2,137	2,331**	2,234**
2,4-D, July	902	1,294	1,098*	559	699	629	375**	627**	501**	1,836*	2,619**	2,228**
Intermediate wheatgrass [2]	55	1,238	647	733	752	742*	60**	339**	200**	849**	2,329**	1,589**
Bromegrass [2]	107	1,149	628	165	393	279	61**	103**	82**	333**	1,645**	989**
Warm-season grasses [2]	142	1,072	607	114	366	240	41**	134**	88**	298**	1,572**	935**
Average for management	430	1,070	750	347	506	426	500	589	545	1,277	2,166	1,721
Standard error of the treatment mean	173	173	122	173	173	122	173	173	122	179	179	126

[1] Difference from check: * = significant at the 5-percent level; ** = significant at the 1-percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ¼, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spraying on warm-season grasses in 1950).

The amount of aftermath of desirable grasses was more important than total aftermath, and considerably different trends were evident (table 21). When the two grazing management treatments were averaged together, the plots given 2,4–D treatments had the greatest amounts of desirable grasses left as aftermath, and the mowed plots the least amounts. When the management treatments were considered separately, the least amounts of desirable species aftermath were found in the seeded plots grazed as usual. In these, less than 8 percent of the total production of desirable grasses (see table 22) was left in the plots as aftermath (table 21). In the same seeded treatments given deferred and rotational grazing there was 34 to 53 percent of the total production of the desirable grasses left as aftermath. The greatest relative amounts of aftermath of the desirable grasses were in the plots sprayed with 2,4–D.

Data for aftermath of weed grasses are of little value other than to indicate the amount of mulch that these grasses contributed at the end of the season (table 21). The amounts of aftermath of weed grasses on the various weed control treatments did not differ greatly from the check, although the plots sprayed with 2,4–D and the intermediate wheatgrass plots tended to have slightly more weed grasses remaining than did the other treatments.

As was expected, the check plots, which had the greatest population of weed forbs, had the greatest amount of weed forbs left as aftermath (table 21). By comparing the average total vegetation aftermath in table 21 with the average of weed forbs aftermath it will be seen that 64 percent of the total aftermath of the check was contributed by the weed forbs. Ironweed, false boneset, and ragweed made up the greatest share. The plots having weed control treatments had greatly reduced amounts of weed forb aftermath, but they did not differ greatly from each other. The mowed plots show up relatively better with the other weed control treatments in this comparison than they did when compared by stand counts, primarily because the mowing removed all of the top growth earlier in the season. The aftermath thus was made up only of regrowth of weed forbs after the time of mowing. Also, plots given 2,4–D treatments had the weeds still standing, although some of the leaves had been dropped before the end of the season. Grazing management did not greatly influence the amount of weed forb aftermath.

Production of Vegetation as Affected by Treatment

Total production of vegetation was determined by adding the number of pounds of forage consumed during the season to the pounds of aftermath remaining at the end of the grazing season. In figure 15 are shown the effects of weed control treatments upon total production of dry matter per acre.

In overall production of dry matter per acre, the mowed treatments resulted in reduced total production. This reduction is partially the result of the sampling methods used in that mowed material was not recovered. Because these data do not give an accurate indication of total production of the mowed plots, the discussion will be limited to the other six treatments. In total production the check gave slightly greater yields, as an average of the 3-year period, than did the five plots on which weed control had been accomplished. However, the average of the last five treatments was 93 percent that of the

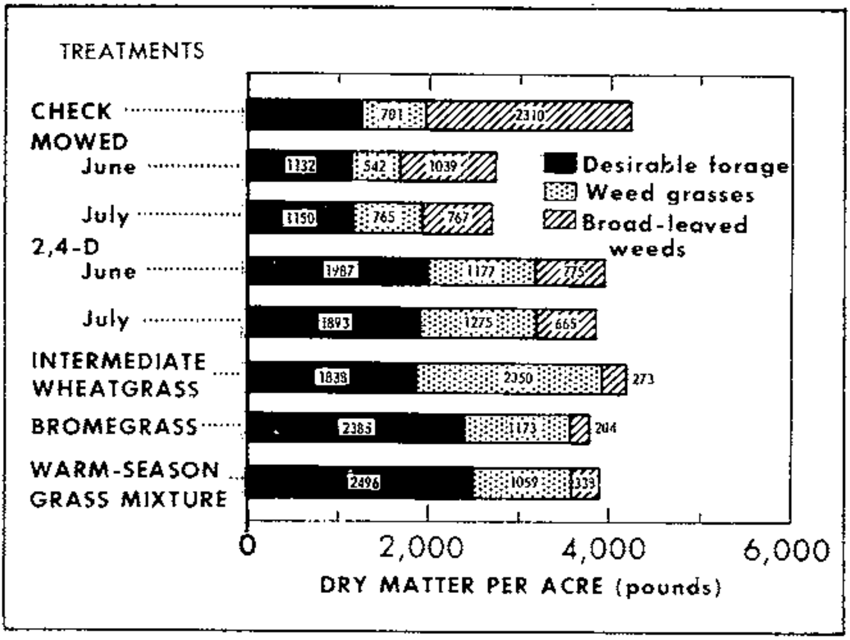

FIGURE 15.—Effect of weed control treatments upon the total production of dry matter per acre; data are averages of 1951, 1952, and 1953.

check (table 22). The increased production of grasses almost compensated for the loss in production of the broad-leaved weeds, although this increase varied with the seasons.

Table 23 shows the differential in total production of vegetation as affected by the 1951, 1952, and 1953 seasons. In 1951, the average yield of the last 5 treatments was 116 percent of that of the check. A very wet season occurred in 1951. Also, in that year the seeded grasses were only 1 year old, and there may have been added nitrates becoming available in these plots in 1951 through increased nitrification of organic material as a result of the October 1949 plowing as preparation for seeding these plots. In 1952, which was more nearly an average year climatically, the last 5 treatments gave 91 percent of the check in total vegetation produced, while in 1953 the last 5 treatments gave 73 percent of the check in total production. The growing season in 1953 was extremely dry. Based on these data it would appear that in wet seasons plots having good weed control gave equal to or greater total yields of dry matter than plots having weeds. In years of moderate rainfall, weed control resulted in a slight reduction of total dry matter produced, and in times of severe drought the grasses were not able to compensate for the weeds eliminated.

Although weed control treatments only slightly depressed the total yields of dry matter as compared to the check, the components of that total yield were radically different (fig. 15). In the check, over 50 percent of the total production was made up of broad-leaved weeds, while in treated plots the percentage was much smaller. With broad-leaved weed control the production of desirable grasses was greatly increased. The weed grasses also tended to increase in production of dry matter to compensate partially for the decrease of the broad-leaved weeds.

TABLE 22.—*Production of vegetation: 3-year average amounts of desirable grass species, weed grass species, weed forbs, and total vegetation produced as affected by weed control and grazing management practices, Lincoln, Nebr., 1951–53*

Treatment	Dry matter per acre produced on plots[1]											
	Desirable grass species			Weed grass species			Weed forbs			Total vegetation		
	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average	Grazed as usual	Deferred and rotationally grazed	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Check	1,103	1,304	1,203	701	701	701	2,041	2,578	2,310	3,844	4,583	4,214
Mowed, June	1,050	1,213	1,132	553	549	551	1,213	805**	1,039**	2,816**	2,627*	2,721**
Mowed, July	1,009	1,292	1,150	596	936	766	961*	573**	767**	2,566**	2,801*	2,684**
2,4-D, June	1,689	2,284*	1,987*	1,427	926	1,177	1,165*	384**	775**	4,282*	3,595*	3,938
2,4-D, July	1,885	1,902	1,893*	1,308	1,241	1,275	657**	672**	665**	3,850	3,815	3,833*
Intermediate wheatgrass[2]	1,348	2,327*	1,838*	2,413**	1,657*	2,050**	175**	371**	273**	3,966	4,355	4,161
Bromegrass[2]	1,964*	2,807**	2,385**	1,553*	792	1,173	155**	252**	204**	3,673	3,850	3,762*
Warm-season grasses[2]	1,846	3,147**	2,496**	1,057	1,060	1,059	367**	308**	338**	3,270*	4,514	3,892
Average for management	1,457	2,034	1,760	1,205	953	1,091	842	750	796	3,581	3,707	3,651
Standard error of the treatment mean	299	299	211	299	299	211	299	299	211	148	148	105

[1] Difference from check: * = significant at the 5-percent level; ** = significant at the 1 percent level.

[2] Plots reseeded in spring of 1950, supplementally sprayed with ½, ½, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spraying on warm-season grasses in 1950).

TABLE 23.—*All vegetation: Total production each year as affected by weed control treatments, Lincoln, Nebr., 1951–53*

Treatment	Dry matter per acre on plots [1] for—			
	1951	1952	1953	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*
Check	3,651	5,201	3,700	4,214
Mowed, June	2,570*	3,945**	1,648**	2,721**
Mowed, July	2,079**	3,844**	2,129**	2,684**
2,4-D, June	3,620	5,542	2,653*	3,938
2,4-D, July	3,952	4,870*	2,676*	3,833*
Intermediate wheatgrass [2]	4,777*	4,839*	2,867*	4,161
Bromegrass [2]	4,832*	4,113**	2,341**	3,762*
Warm-season grasses [2]	4,020	4,695**	2,963	3,893*
Average for years	3,688	4,642	2,622	3,651
Average of last 5 treatments	4,240	4,812	2,700	3,917
Standard error of treatment means	320	118	265	105

[1] Average of grazed-as-usual and deferred-and-rotated management practices. Difference from check: *=significant at the 5-percent level; ** significant at the 1-percent level.
[2] Plots reseeded in spring of 1950, supplementally sprayed with $\frac{1}{4}$, $\frac{1}{2}$, and 1 pound of 2,4-D ester per acre, respectively, in 1950, 1951, and 1952 (except that mowing was substituted for spray in warm-season grasses in 1950).

Yields of total vegetation were also obtained for the two grazing management practices (table 22). As indicated, the total production of vegetation was not greatly affected by management practice. The plots deferred and rotationally grazed appeared to give only slightly higher total yields than those of the grazed as usual.

Where the land is partially denuded, other species of plants tend to take the place of the vegetation removed. If perennial grasses are reduced by overgrazing, annual species of grasses and broad-leaved weeds almost immediately encroach on the area. In these experiments the total production was not greatly affected by weed control treatments or by grazing management. Even the seeded plots, although they were kept almost bare of vegetation in the grazed-as-usual management, produced nearly as much as the deferred-and-rotationally-grazed plots or the check plots (table 22). The check plots included large and vigorous perennial weeds. This indicated that the potential of fertility and moisture would find expression in plant growth of one sort or another, and if the undesirable plants were selectively removed by weed control, then the more desirable species would be expected to increase proportionately. This is partially shown in the average production under desirable grass species in table 22.

With the exception of the mowed plots, all plots given weed control treatments increased in the production of desirable grasses; such increase in production ranged from 152 percent of the check in the intermediate wheatgrass to 207 percent of the check in the warm-season grass mixture. Under the deferred-and-rotationally-grazed management, the increased production of desirable grass ranged from 146 percent of the check in plots given 2,4-D treatment in July to 241 percent for the warm-season grass mixture. In general, the production of desirable grasses was greater under deferred-and-rotationally-grazed management than under the grazed-as-usual management. Also, the production of desirable grasses was slightly higher in the check where conservatively grazed than where continuously grazed (table 22). The production of desirable grasses in the intermediate wheatgrass plot was reduced by the grazed-as-usual management practice. However, the production of desirable grasses in the plots of bromegrass and the warm-season grass mixture was surprisingly good through the 3 years of intensive grazing. This was partly because bromegrass and some of the other grasses tended to have a small amount of prostrate growth that was unavailable to the grazing livestock even when grazed closely. For instance, according to notes taken August 26, 1952, switchgrass and big bluestem had prostrate stems 2 to 5 inches long, even though all the grasses were grazed to less than one-half inch in height. These prostrate stems were not observed with intermediate wheatgrass.

In general, the weed grasses responded with greater production in plots where broad-leaved weeds were controlled (table 22). The greatest increase in production of weed grasses occurred in the intermediate wheatgrass plots. Conversely, intermediate wheatgrass also gave the lowest production response of the desirable grasses. This further illustrates that the potential of fertility and moisture if not used by one type of plant was utilized by another. Most of the production of weed grasses in the intermediate wheatgrass and bromegrass plots was of the warm-season type, consisting chiefly of threeawn, foxtails, barnyard grass, and crabgrass. On the other plots, the production of weed grasses consisted primarily of hairy chess and threeawn.

The reduction of total weed forbs, associated with weed control treatments, ranged from 55 percent to 91 percent of the check (table 22). The plots mowed in June gave the poorest reduction of weed forbs; all other treatments gave a reduction of approximately 70 percent or better. Grazing management did not greatly influence the production of weed forbs, although there were some rather wide individual fluctuations.

SUMMARY

Mowing in either June or early July for 3 years (1951–53) reduced stands of perennial broad-leaved weeds about 35 percent, while 1 pound of 2,4–D ester per acre on the same dates reduced stands 70 percent, and plowing and seeding grasses (plus 2,4–D) reduced perennial weed stands 89 to 94 percent. The 2,4–D was clearly superior to mowing for perennial weed control. The same trends were evident for annual broad-leaved weed control except that mowing in July approached the 2,4–D treatments in effectiveness, but mowing in June was ineffective. Plowing and seeding (plus 2,4–D) reduced annual weeds 62 to 95 percent.

Ironweed was reduced in stand 53 percent by mowing in mid-June for 3 seasons, but mowing in early July was relatively ineffective. The 2,4–D treatments gave 93 and 76 percent reduction for the June and July dates of application, respectively. Plots plowed and seeded to grasses (plus 2,4–D) had over 98 percent control of ironweed. In a supplemental study of date of mowing and 2,4–D applications, it was found that the optimum dates of mowing ranged between June 5 and July 3 and that the optimum dates of 2,4–D application coincided with optimum dates for mowing. Applications of 2,4–D were greatly superior to mowing for control of ironweed on each of the 8 dates.

Plowing, seeding to grasses, and supplemental treatment with 2,4–D eliminated over 95 percent of the false boneset; 2,4–D treat-

ments averaged about a 70 percent reduction in false boneset, and mowing resulted in a slight increase in stem numbers.

All treatments, except mowing in June, reduced the stand of hoary vervain 68 percent or more. All treatments were effective on many-flowered aster.

The effects of grazing management upon stands of individual perennial weed species were statistically significant only with yarrow; however, when all species of perennial weeds were considered together, the stands were significantly affected by the differential grazing managements. The grazed-as-usual management resulted in 430 stems of perennial broad-leaved weeds per 40 square feet; deferred-and-rotationally-grazed plots had 286 stems; and land protected from grazing had 135 stems. The interaction of management × treatment was not significant.

With the reduction of number of weeds by weed control treatments, basal density of desirable grasses increased greatly and weed grasses increased somewhat less.

Weed control treatments increased the amount of forage consumed. Consumption of vegetation on plots having weed control was increased up to 252 percent of the check with the grazed-as-usual management and up to 318 percent of the check when grazing was deferred to June 15 and rotationally grazed thereafter. Forage consumption was increased an average of 20 percent by mowing and 47 percent by spraying with 2,4-D.

Although more vegetation was eaten in plots having weeds controlled than in the check, there also was more desirable grass aftermath at the end of the season on many of the plots. When grazed as usual the plots given 2,4-D treatments had approximately 200 percent of the check remaining as aftermath, while seeded plots had only 20 percent, and mowed plots had 68 percent. On the deferred-and-rotationally-grazed plots, 2,4-D treatments had 140 percent of the check remaining as aftermath of desirable grasses, seeded plots had 118 percent, and mowed plots had 71 percent.

The 3-year average production of all vegetation on plots with weeds controlled, excepting mowing, was 92 percent that of the untreated check. Grasses largely compensated in production for the broad-leaved weeds eliminated by treatments. In the check, 55 percent of the total production was broad-leaved weeds, but where broad-leaved weeds were controlled only 11 percent fell in this category.

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APPENDIX

Species Mentioned in the Text

Common name	*Scientific name*
Aster, many-flowered	*Aster multiflorus* Ait.
Barley, little wild	*Hordeum pusillum* Nutt.
Barnyard grass	*Echinochloa crusgalli* (L.) Beauv.
Bluegrass, Kentucky	*Poa pratensis* L.
Bluestem	*Andropogon* spp.
Bluestem, big	*Andropogon gerardi* Vitman [1]
Bluestem, little	*Andropogon scoparius* Michx.
Boneset	*Eupatorium* spp.
Boneset, false	*Kuhnia glutinosa* Ell.
Bromegrass [2]	*Bromus inermis* Leyss.
Buckbrush	*Symphoricarpos* spp.
Buttercup	*Ranunculus* spp.
Buttercup, plantainleaf	*Ranunculus alismaefolius* Geyer
Cassia	*Cassia* spp.
Chess, hairy	*Bromus commutatus* Schrad.
Clover, white	*Trifolium repens* L.
Crabgrass	*Digitaria* spp.
Cyperus, slender	*Cyperus filiculmis* Vahl
Dandelion	*Taraxacum officinale* Weber
Dock	*Rumex* spp.
Downy brome	*Bromus tectorum* L.
Dropseed, sand	*Sporobolus cryptandrus* (Torr.) A. Gray
Fleabane, daisy	*Erigeron* spp.
Foxtail	*Setaria* spp.
Goldenrod, smooth	*Solidago glaberrima* Martens.
Goldenrod, stiff-leaved	*Solidago rigida* L.
Grama, blue	*Bouteloua gracilis* (H. B. K.) Lag. ex Steud.
Grama, sideoats	*Bouteloua curtipendula* (Michx.) Torr.
Groundcherry	*Physalis* sp.
Gumweed	*Grindelia squarrosa* (Pursh) Dunal
Hemp	*Cannabis sativa* L.
Ironweed	*Vernonia baldwinii* Torr.
Lovegrass, sand	*Eragrostis trichodes* (Nutt.) Wood
Marestail, horseweed	*Erigeron canadensis* L.
Milkweed	*Asclepias syriaca* L.
Milkweed, whorled	*Asclepias verticillata* L.
Nettle, perennial	*Urtica dioica* L.
Pennyroyal, rough	*Hedeoma hispida* Pursh
Plantain, Pursh's	*Plantago purshii* Roem. & Schult.
Poverty grass	*Sporobolus vaginiflorus* (Torr.) Wood
Primrose	*Oenothera* spp.
Ragweed, annual	*Ambrosia artemisiifolia* L.
Ragweed, perennial	*Ambrosia psilostachya* DC.
Ragwort	*Senecio jacobaea* L.
Rush	*Juncus* spp.
Sagebrush, sand	*Artemisia filifolia* Torr.
Sage, prairie	*Artemisia gnaphalodes* Nutt.
Sedge	*Carex* spp.
Sneezeweed	*Helenium nudiflorum* Nutt.
Snow-on-the-mountain	*Euphorbia marginata* Pursh
Squirreltail	*Hordeum jubatum* L.
Switchgrass	*Panicum virgatum* L.
Tarweed	*Iva ciliata* Willd.
Thistle, bull	*Cirsium vulgare* (Savi) Tenore
Thistle, creeping, Canada thistle	*Cirsium arvense* (L.) Scop.
Thistle, wavyleaf	*Cirsium undulatum* (Nutt.) Spreng.
Threeawn	*Aristida oligantha* Michx.
Vervain, hoary	*Verbena stricta* Vent.
Wheatgrass, intermediate	*Agropyron intermedium* (Host) Beauv.
Yarrow	*Achillea millefolium* L.

[1] Species name listed as A. *furcatus* Muhl. in U. S. Agr. Mktg. Serv., "Service and Regulatory Announcement No. 156." 1956.
[2] Smooth brome listed for *Bromus inermis* in reference cited in footnote 1.

TABLE 24.—*Mean square values obtained in analyses of variance of stands of weed species near Lincoln, Nebr., 1953*

PERENNIAL SPECIES

Source of variation	Degrees of freedom	Mean squares[1] Ironweed	False boneset	Hoary vervain	Many-flowered aster	Dandelion	Ground-cherry	Perennial ragweed	Yarrow	All perennial species
Replications (R)	3	14,437*	9,905	2,117	2,725	211,733	10.3	761	1,629*	280,333
Management (M)	2	7,782	12,069	9,176	2,165	272,997	22.0	1,055	2,666*	696,036*
R × M	6	1,994	4,965	2,017	1,890	95,713	7.5	506	317	89,244
Treatments (T)	7	25,271**	11,186**	1,603	10,872**	109,385**	18.4*	201	1,414*	472,909**
R × T	21	2,597	2,204	1,403	1,367	21,070	6.2	389	517	39,535
T × M	14	1,663	2,818	674	705	19,417	4.6	277	391	27,701
R × T × M	42	1,830	2,150	1,394	839	13,625	5.8	370	304	18,134

ANNUAL SPECIES

Source of variation	Degrees of freedom	Annual ragweed	Snow-on-the-mountain	Marestail	Wild hemp	All other annual weeds
Replications (R)	3	2,318,616	487	491	351	34,143
Managements (M)	2	209,018	3,639**	2,281*	841	313,177*
R × M	6	850,066	224	430	510	50,191
Treatments (T)	7	1,263,581	2,452**	345	248	99,077**
R × T	21	395,085	166	186	152	10,740
T × M	14	133,069	765**	59	204	32,082
R × T × M	42	71,928	131	152	167	17,708

[1] * = Significant at 5-percent level; ** = significant at 1-percent level.

TABLE 25.—*Mean square values obtained in analyses of variance of stands of weed species near Lincoln, Nebr., 1950 (prior to treatment)*

PERENNIAL SPECIES

Source of variation	Degrees of freedom	Mean squares [1]					
		Ironweed	False boneset	Hoary vervain	Many-flowered aster	Ground-cherry	Yarrow
Replications (R)	3	8.37	27.8*	0.17	21.52	0.25	74.08
Management (M)	2	.69	.94	.09	23.70	.07	32.25
R × M	6	1.29	3.7	.17	8.60	.17	20.87
Treatments (T)	4	2.76	7.3**	.16	14.70	.19	18.54
R × T	12	1.84	.99	.14	4.70	.26	10.05
T × M	8	1.45	2.13	.11	9.70	.39	22.62
R × T × M	24	1.16	2.05	.14	8.00	.29	14.00

ANNUAL SPECIES

Source of variation	Degrees of freedom	Annual ragweed	Snow-on-the-mountain	All other annual weeds
Replications (R)	3	489.88	10.0**	575.6*
Management (M)	2	250.12	.47	43.9
R × M	6	579.17	.75	67.3
Treatments (T)	4	159.36	3.28	124.6
R × T	12	604.96	1.60	129.2
T × M	8	300.04**	.34	71.4
R × T × M	24	53.03	1.42	120.8

[1] * = Significant at 5-percent level; ** = significant at 1-percent level.

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