T H E S I S

EFFECT OF HERBAGE REMOVAL AT DIFFERENT SEASONS ON THE CURRENT GROWTH AND PRODUCTION OF RUSSIAN WILDRYE AND ALFALFA

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY Juan M. Gastó

ENTITLED EFFECT OF HERBAGE REMOVAL AT DIFFERENT SEASONS ON THE CURRENT GROWTH AND PRODUCTION OF RUSSIAN WILD-RYE AND ALFALFA

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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To my wife, Thelma, who aided in writing and typing the manuscript, the thesis is dedicated.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF FIGURES

LIST OF FIGURES--Continued

Chapter I

INTRODUCTION

The interest in establishing forage plants on lands formerly used to produce small grains has notably increased in the last decades in the western United States. Many native and introduced forage species have been studied with some proving successful. Artificial revegetation has proved to be a tool to increase forage production of the abandoned crop lands, conserve the soil, and improve the productivity of the land.

Russian wildrye and alfalfa are two introduced species which are extensively used for range revegetation and conservation in the Great Plains and Intermountain Region. They produce a good quality of forage with a high percentage of protein and a low percentage of fiber. Russian wildrye is a long-lived, cool-season bunchgrass which has abundant, long and dense basal leaves, and is both palatable and highly nutritious. Studies have shown that it tolerates frequent defoliation and makes faster recovery after clipping or grazing than many other grasses. Since alfalfa is also a nutritious forage species with outstanding ability for regrowth after clipping or grazing, it has been successfully used in mixtures with Russian wildrye for pasture and hay purposes.

However, even though we know that Russian wildrye and alfalfa are good forage producers, we do not know the best way to manage them when grown in mixtures. One of the most important considerations in the management of these forage species is the time of herbage removal. There is abundant evidence that the yield, stand, chemical composition, feeding value, and growth characteristics may be materially affected by varying the season or time of use.

The problem

The purpose of this study was to determine how the herbage removal at different seasons of the year affects the current growth and production of Russian wildrye and alfalfa plants and affects the floristic composition of a mixture of the two species.

Problem analysis.--The main problem was sub-divided into the following specific subject matter area for study:

1. What effect do different dates of simulated grazing have on the total forage production of Russian wildrye and alfalfa?

2. How does the growth curve of Russian wildrye clipped in the spring, summer, and spring-fall compare to the growth curve of unclipped plants?

3. What changes in the basal area and species composition of Russian wildrye and alfalfa are produced in

a pasture mixture under three different seasons of grazing?

Delimitations.--The studies on the effect of season of simulated grazing on the growth pattern and total production of Russian wildrye (Elymus junceus Fisch.) and alfalfa (Medicago sativa L.), and the study to determine the growth curve of ungrazed plants of Russian wildrye were both conducted on the Colorado State University Foothills Experimental Range at Fort Collins, Colorado. The studies were conducted on separate plantings of these two forage species and limited to the growing season of 1962. The following seasons of use were studied:

Spring:	April 25 through June 6
Spring-fall:	April 25 through June 6, and August 15 through September 12
Summer:	June 20 through August 1

The study to determine the changes in basal area of these two species resulting from four previous years of grazing at the seasons listed above was accomplished on six pastures sown to a mixture of Russian wildrye and alfalfa at the same experimental range.

Chapter II

REVIEW OF LITERATURE

The review of literature, which presents the effects of clipping and grazing of Russian wildrye and alfalfa and their growth and production characteristics, has been arranged under the following headings: (1) Russian wildrye, (2) Alfalfa, and (3) Reaction of Russian wildrye and alfalfa mixtures to grazing and clipping.

Russian wildrye

Growth and production characteristics.--Russian wildrye is an introduced long-lived perennial, and a cool-season drought-resistant bunchgrass which has abundant, long and dense basal leaves and leafless seedstalks. It is both palatable and highly nutritious, and makes remarkably fast regrowth after clipping, even after heading or maturity (Wasser and Nelson, 1945, and Rogler, 1951).

Barnes and Nelson (1950) reported that the production of Russian wildrye averaged 3.5 sheep months of grazing per acre per year as compared to 4.8 from crested wheatgrass and 2.0 from native vegetation. Rauzi, Lang, and Barnes (1958) found in a dual purpose

pasture, the average production to be 328 pounds of hay per acre and 68.1 lamb days. In twelve experiments reported by Heinrichs and Lawrence (1958), production of Russian wildrye ranged from 424 pounds per acre to 5250.

The production of Russian wildrye under dryland conditions changed very markedly from year to year (Rauzi, Lang and Barnes, 1958; Johnson, 1959; and Heinrichs and Clark, 1961). Johnson (1959) found that production on newly seeded stands of Russian wildrye increased each year for the first five years after planting. In this study, the increased production during the last two years may have been due to increased precipitation rather than to stand improvement. Hervey and Johnson (1954), and Dotzenko and Stegmeier (1959) found that after stand establishment drought does not cause a serious loss in Russian wildrye stands.

Differences in production may partially be due to row spacing. Lorenz and Rogler (1959) found that the trend was toward slightly higher yields at the wider spacings, particularly after the first harvest year when the plants at 36 inches had enlarged to compensate for lower plant populations. The production of stems and stem-leaves are relatively unimportant in close drilled stands of Russian wildrye. At Dickinson Station, it averaged 92.4 per cent of leaves over a four-year period

(Whitman and Kloesterman, 1955).

Reaction to grazing and clipping

Comparison of clipping and grazing.--Since the growth of Russian wildrye is practically all basal leaves, this species is not affected much by clipping. Whitman et al. (1961, 1962) found that Russian wildrye suffered very little from either pasture or hay clipping, and had a relatively high production under pasture clipping treatments. Considering their results as a whole, the stand deterioration of grass-alfalfa mixtures was less serious under hay clipping than under pasture clipping. However, the stand deterioration of Russian wildrye alone was the same under both simulated grazing and simulating haying, but the stand deterioration of a mixture of Russian wildrye with alfalfa was a little higher under pasture clipping than under hay clipping.

Newell and Keim (1947) found that forage production of Russian wildrye obtained from plots mowed once for hay and those mowed several times to simulate grazing were quite different. The hay treatment produced almost nine per cent more forage than the simulated pasture treatment. On the other hand, Heinrichs and Lawrence (1958) stated just the opposite, and suggested that rapid recovery after grazing of Russian wildrye is a characteristic which makes it more productive under pasture

use as compared with hay use.

Heinrichs and Clark (1961) attributed the generally low yield of Russian wildrye to the clipping techniques which did not remove many of the low basal leaves normally taken by grazing animals. Rauzi, Lang, and Barnes (1958) found that the hay from a mixture of alfalfa and Russian wildrye was mostly alfalfa, probably because Russian wildrye has mostly basal leaves.

Effects of season of herbage removal.--According to Blaisdell and Pechanec (1949) the effect of clipping bluebunch wheatgrass and arrowleaf balsamroot apparently depends upon the amount of herbage present during the storage period which follows cessation of growth.

Early spring grazing of the prairie grasses is very injurious (Anderson, 1940). He stated that as a result of spring protection, stands of grass on a deferred pasture have been maintained in better condition although subjected to much harder use. Cook, Stoddart, and Kinsinger (1958) found in the case of crested wheatgrass that early harvested plants produced a lower total yield than later ones even when clipping in early season was less harmful. Hedrick (1958) in his review of literature concluded that too early removal of herbage resulted in declining forage vigor, and the greatest damage occurred during periods of minimum food storage.

On the other hand, working with mountain forage plants, McCarty and Price (1942) found early grazing, when plants are four to six inches high, one of the safer periods of use. Sampson and McCarty (1930) stated that grazing or clipping once or twice early in the growth cycle had little or no influence on total herbage yield of Stipa pulchra Hitch., and herbage removal between the time of flower stalk production and seed maturity tends to prolong the vegetative growth of the plant.

Close to the end of the growing season, when the herbage is dry or drying, appears to be the safest period of summer use (McCarty and Price, 1942). The start of the season of safe grazing or clipping appears to be at the time of seed maturity. According to Hedrick (1958) in his review of literature, ranges used after seed maturity could be grazed more heavily than those used during the growing season. Stoddart (1946) found that clipping in fall had little detrimental effect on Agropyron spicatum (Pursh) Scribn., but in late spring and summer, the date of beginning clipping was the most important factor, a late beginning being the least harmful.

According to Conard (1954), in Nebraska, early cutting and the removal of an aftermath crop of tame pasture in mid-September reduced the vigor of the grasses the following spring, as compared with midseason cutting. Delaying the harvesting of the aftermath from

mid-September until early or late October increased the yields of the grasses the following summer 18 and 38 per cent respectively. The effect on the next years production could also be seen in the amount of flower stalks.

At the beginning and end of the growing season, the growth rate is slow, and before the flower and seed production, it is fast. Weinmann (1948) stated that persistence of range and pasture grasses under defoliation is best when forage removal is done at times corresponding to periods of slow growth rate of the grasses. Bird (1943), working with four grass species, found that the combined yield of four species showed a significant increase with each successive stage up to the beginning of the bloom stage, after which the increases in yield were not significant.

According to Johnson (1959) the production of Russian wildrye was not affected by any of the grazing intensities. Fluctuations in yields occurred from year to year as a result of rainfall variations, but they were not related to grazing intensities. The behavior of Russian wildrye under various systems of clipping was different from many other grasses since it yielded much the same under all treatments (Heinrichs and Clark, 1961). As a result, this grass is outstanding from the management standpoint.

Although Barnes and Nelson (1950) stated that Russian wildrye is an excellent spring pasture, they found no advantage in terms of production and animal gain over crested wheatgrass, but for summer, fall, or winter grazing, Russian wildrye has proved one of the most valuable grasses.

Chemical analyses suggested the value of Russian wildrye for fall and possibly winter grazing (Heinrichs and Carson, 1956), and also indicated that there was little danger of losing nutrients by delayed utilization. When used in mixtures with other grasses, Russian wildrye appeared very desirable for grazing, but was avoided until the latter part of June, and was not grazed until later in the season (Rogler, 1944).

Under favorable precipitation during summer and fall seasons, this grass produced remarkable growth until the ground had frozen and then a second period of grazing was permitted (Rogler, 1944; Hervey and Johnson, 1954; Wright, 1959; Rogler, Lorenz, and Shaaf, 1962). It also had the ability to recover rapidly after defoliation whenever sufficient moisture was available (Rogler, 1944). At Manitou, Colorado, Johnson (1959) found that the regrowth of Russian wildrye contributed to 47 per cent of the total production. At Swift Current, Saskatchewan, Kilcher (1958) found that favorable precipitation, especially during May, was important for

obtaining a high total yield of Russian wildrye and other grasses, independent of the distribution of the production throughout the year.

Effects of frequency of herbage removal.--Many studies conducted in the western part of the United States have demonstrated that the yield and vigor of the vegetation varies inversely with the frequency of clipping (Biswell and Weaver, 1933; Gertnert, 1936; Carter and Law, 1948; Heady, 1950; and Branson, 1956).

Aldous (1930a) found in prairie grass vegetation that the most severe treatment caused a very noticeable change in the yield and density of the stand. In another work (1930b), he stated that yield and stand reduction varies inversely with the frequency of cutting; they were reduced the most on the plots clipped at two-week intervals, and the least on those plots only clipped at maturity. Heinrichs and Clark (1961) found that Russian wildrye was very persistent under frequent clipping and should be more useful for long-term pasture than other grasses. Newell and Keim (1947) working with several grass species found that Russian wildrye maintained one of the best stands under clipping and simulated grazing. Whitman, Peterson, and Conlon (1961) found that Russian wildrye changed in stand from 100 to 84 per cent in five years, and that this change was exactly the same under both pasture

clipping and hay clipping treatment. Cook, Stoddart and Kinsinger (1958) also found that an increase in frequency of clipping decreased the yield of herbage, but the exact response was dependent upon the date and number of clippings.

In southeastern Wyoming, Lang and Barnes (1942) found midgrasses yielded significantly more when harvested at the end of the growing season than when clipped frequently. On the other hand, short grasses yielded more when harvested frequently than when protected during the growing season and harvested after the growth had ceased.

Biswell and Weaver (1933), working in prairie sod, found the amount of growth of big bluestem, when clipped at 14-day intervals, increased gradually for the first four clippings, after which the rate of growth and amount of dry matter decreased considerably.

Heinrichs and Clark (1961) found that Russian wildrye produced more for five years when cut at six-week intervals than at three or eight. More frequent clippings resulted in more yield, except under too short of a cutting frequency. According to them, this outstanding ability to resist the effects of frequent clipping makes this grass display the strongest competitive abilities when clipped frequently.

Thaine and Heinrichs (1951), working in a greenhouse, found that the total yield of Russian wildrye was progressively reduced with an increased number of clippings. On the other hand, Thaine (1954), working in the field, found a significantly greater yield of leaves and stems of Russian wildrye when either three or five clippings were made rather than one or two.

Alfalfa

Growth and production characteristics.--Pasture-type alfalfas, according to Archer and Bunch (1953), are generally suited to dryland conditions, are cold resistant, and many of the varieties exhibit a strong tendency for tillering or rhizome production under proper environmental conditions. Generally creeping-type alfalfas do not produce as much herbage as hay-type alfalfas, but are valuable for grazing in pasture mixtures in dryland areas.

Tysdal (1952) stated that in many areas, alfalfa has proved more productive than permanent grass pastures. When alfalfa is used for pasture it is commonly grown with a grass. In some areas of the western United States, pasturing alfalfa in the growing season is a common practice; moderate, continuous grazing has not proved injurious to the stand or yield.

Reaction to grazing and clipping

Effect of season of herbage removal.--According to Salmon, Swanson and McCampbell (1925), cutting in the bud stage and at the tenth-bloom stage decreased the vigor and yield of alfalfa, although at the tenth-bloom stage the effects were not noticeable until much later. Permitting the plants to reach the full-bloom stage or seed stage maintained the vigor of the plants even when the last one reduced the yield.

Cutting alfalfa in the pre-budding stage, according to Woodman, Evans and Norman (1934), injured the plant, gave less production, and shortened materially the life of the stand much more than at the budding stage. Dent (1959) found that greater dry matter yields were obtained when cut at the bud stage than when cut earlier, and there was no advantage in cutting the second growth before the flower stage, even when earlier cutting produced no apparent ill effect on the plant or upon following yields. Far more damage may be done to the crop by faulty autumn cutting management than by variations in spring and early summer cutting. The results of the experiment of Deker et al. (1960) showed that alfalfa may be cut as early as the full-bud stage of growth in the spring.

Salmon, Swanson and McCampbell (1925) and Granfield (1934) reported that cutting alfalfa in the bud stage

markedly decreased the stand of alfalfa. Cutting when the plants were at the tenth-bloom stage also injured the plants and reduced the stand, but permitting the plants to reach the full-bloom stage before cutting maintained the stand of the plants for at least eight years. Delayed cutting until seed maturity reduced the yield but not the stand of the plants. Woodman, Evans, and Norman (1934) thought that cutting the plants at the pre-budding stage affected and shortened the life of the stand much more than at a more mature stage, such as the bud or flower stage. Grauman, Webster, Canode and Murphy (1954) stated the earliest period for cutting alfalfa plants was one-tenth bloom or later because earlier cutting affected the stand. Earlier and more frequent clipping of a mixture of bromegrass and alfalfa kept a lower percentage of alfalfa than clipping at the hay stage.

Higher yields of alfalfa can be obtained if the interval between clippings is extended up to full bloom (Kiesselbach and Anderson, 1926; Wilsie and Takahashi, 1937; Kauter, 1946; and Gross, Wilsie and Pesek, 1958). Dotzenko and Ahlgren (1950) found that cutting at tenth-bloom markedly reduced the yield of alfalfa in a mixture of alfalfa-bromegrass. Later the same authors (1951) stated that maximum yields of alfalfa were obtained at

the one-half bloom stage. Cutting at the preflowering period, according to Bar and Tseretheli (1943) arrested the root development for several weeks, but this effect was not noticeable in the flowering stage or later.

Even though one-tenth in bloom is accepted as a basis for cutting alfalfa, according to Crowder, Vanegas and Silva (1960) this was not a reliable basis because plants remained vegetative throughout the year and appearance of flowers was sporadic and erratic.

Jackobs (1950), and Jackobs and Oldmeyer (1955) stated that spring clipping of alfalfa did not produce a residual effect on the yield the following year. Willard (1950) stated that the later the first cutting is made, the better the stand is maintained. Smith (1956) found that a second cutting in mid- to late-August helped to maintain a vigorous and productive alfalfa.

A significant reduction in yield from the fall cutting was found by Jackobs and Oldmeyer (1955). The last cutting in the late fall had a pronounced effect the next spring, but according to Jackobs (1950), it diminished rapidly as the season progressed.

Grazing alfalfa late in the fall also may weaken the plants and increase the danger of winterkilling. Alfalfa that was allowed to make at least six weeks of undisturbed growth prior to the freezing of the soil was

healthy and vigorous over the winter and maintained a better stand (Ahlgren, Sprague and Bear, 1945). Fall growth, according to Nelson (1944) made a protective cover on the plant during the winter and helped to maintain a good stand.

Alfalfa plants cut in September developed fewer crown buds per plant than those which were not cut (Rather and Harrison, 1938; and Silket, Magee and Rather, 1937). Based on the production obtained the following spring, the latter authors and Graber and Sprague (1938) agreed that fall cuttings were harmful, but the late fall cuttings were definitely less harmful than earlier ones as far as productivity and survival of the plant is concerned.

Effect of frequency of herbage removal.--The more frequent and drastic the cutting treatment, the less was the yield of tops, rhizomes and roots (Nelson, 1925; Albert, 1927; Graber, Nelson, Luekel and Albert, 1927; Hildebrand and Harrison, 1939; Jackobs, 1950; Jackobs and Oldmeyer, 1955; Hedrick, 1958; Dennis, Harrison and Erickson, 1959; and Parson and Davies, 1960). Work by Nelson (1925) indicated that frequent cuttings of alfalfa in premature stages resulted in depleted root reserves; this caused slow recovery and rate of growth after cutting, low yields of hay, increased weed infestation and retarded root growth. An

increase in the number of crown bud shoots and main stems occurred as an immediate effect with frequent and early cutting, but the average height and total yields of their top growths was much less than with less frequent cutting at a more mature stage.

In legumes where the reserves are stored in roots or stolons, below or at ground level, defoliation in itself did not remove the carbohydrate reserves (Sprague, Robinson and Garber, 1952; and Sprague, 1952). It was evident that the height to which a legume was cut back was not a serious problem, but the length of the recovery period before the next cutting was very important. Willard, Thatcher and Cutler (1934) stated that in Ohio the recovery of alfalfa was always from the crown, regardless of the height of cutting. Hence, it was desirable to clip alfalfa as low as possible since it had no injurious effects on the plant. Hedrick (1958) in his review of literature also arrived at the conclusion that in legumes the height of clipping was not as critical as the frequency and season of defoliation, and required a practice of intermitent grazing followed by an adequate time of recovery. Nevertheless, Harrison (1939) and Hilderbrand and Harrison (1939) found that lower cuttings of alfalfa significantly reduced subsequent growth of alfalfa. Cutting at a one-inch level gave significantly lower yields than cutting at three,

nine, or twelve inches, but cuttings at six inches appeared to interfere only slightly with the functioning of the plant.

Crowder, Venegas, and Silva (1960) found that cutting alfalfa at an interval of nine weeks gave higher yields than shorter or longer intervals. Dennis, Harrison and Erickson (1959) stated that yields of alfalfa obtained from plots cut at four-and six-week intervals were greater than those cut at one- and two-weeks, and longer periods between cutting resulted in much higher production of dry matter.

Willard (1930), Willard, Thatcher and Cutler (1934), Willard (1950), Jackobs and Oldmeyer (1955), Parson and Davies (1960), and Kust and Smith (1961) found that two, four, five or six cuttings gave less yield than three.

The vigor of alfalfa was greatly reduced and both winter and summer mortality of alfalfa plants was accentuated by frequent and early removal of top growth (Graber, Nelson, Luekel, and Albert, 1927).

Parson and Davies (1960) agreed that good stand-longevity of alfalfa was observed from four-cutting treatments that started in late May and ended by September 10. These authors and Willard, Thatcher and Cutler (1934) stated that the best stand was maintained with a three-cutting schedule. On the other hand, Brown and Munsell (1942), and Davies, Davies and Harvard (1960)

found production of stands clipped three times a year was greatly reduced in comparison with the two-clipping treatment. Cutting five times, according to Willard (1930), resulted in a total loss of stand from winter-killing.

Apparently there is close relation between the effect on the plant from the number of cuttings and the moisture conditions of the year. Davies (1960), in one study, found that while three cuttings may be the optimum in average years; in wet years, this may be fatal. According to Willard (1950) alfalfa can be cut four times or more in dry seasons without serious injury, but the same cutting system in a normal or wet year will destroy the stand.

Reaction of Russian wildrye and alfalfa mixtures to grazing and clipping

Several studies have been conducted on the performance of pastures seeded with a mixture of Russian wildrye and alfalfa. Rauzi, Lang and Barnes (1958) found that a pasture seeded with this mixture showed a dominance of alfalfa during the first two years, but during the last three years alfalfa gradually decreased from 31 per cent in the third year until few plants remained in the fifth year. On the other hand, Russian wildrye became very well established in the third year, increasing in the percentage of floristic composition

from 48 to 94 per cent.

In a five-year experiment conducted in North Dakota by Whitman, Peterson, and Conlon (1962), a mixture of Russian wildrye and alfalfa clipped to simulate grazing produced a 42 per cent higher yield than Russian wildrye alone; under hay clipping, the mixture produced almost 2.3 times more yield than the Russian wildrye alone. The production of the grass was about the same when clipped as hay or as simulated grazing. Under pasture or hay clipping, the loss of the stand of Russian wildrye was negligible where seeded alone or in mixtures, but alfalfa was greatly reduced in the mixture. At Swift Current, Brandon, and Lacombe, Canada, Heinrichs and Lawrence (1958) found that the production of a mixture of Russian wildrye and alfalfa was greater than that of Russian wildrye seeded alone.

Chapter III

METHODS AND MATERIALS

The following chapter is divided into four parts: (1) The study area, (2) The determination of the effects of simulated grazing during the spring, summer and spring-fall on the growth pattern and total production of Russian wildrye and alfalfa, (3) The determination of the normal growth curve of ungrazed plants of Russian wildrye, and (4) The determination of the effect of season of use after four years of grazing on the floristic composition of a pasture seeded with a mixture of Russian wildrye and alfalfa.

The study area

The study was conducted at the Foothills Experimental Range operated by Colorado State University and located immediately west of Fort Collins, Colorado.

> Geologically, the study area is located in the Colorado Piedmont Section of the Great Plains Province. The area is a pediment surface of alluvial material which slopes eastward from the foothills to the Cache la Poudre River. The alluvial deposit is underlain by Pierre shale formation and the parent material of the soils is a combination of sandstones, shales, igneous and metamorphic rocks. These rocks come from geologic formations varying in age from very ancient to the rather recent (Miller, 1960).

The soil of most of the study area has been classified as Cass fine sandy loam. At the surface, it is loose and friable but it becomes slightly heavier with depth. At approximately 15 inches deep, the surface soil grades into slightly lighter brown, and fine sandy loam which is somewhat heavier in texture, but is friable under favorable moisture conditions. Below an average depth of 24 inches, the deeper sub-soil becomes lighter brown and the texture becomes more sandy. At widely varying depths, this layer rests on sand and stream gravel. In places, gravel in varying amounts is scattered on the surface, through the surface soil, and through the sub-soil. Drainage of the higher laying areas is good, but considerable areas are low laying, shallow, and are thus under the influence of a high water table.

The average precipitation at Fort Collins for the period 1956-1962 is indicated in Table 1.

Effects of simulated grazing during the spring, summer, and spring-fall on the growth pattern and total production of Russian wildrye and alfalfa

Russian wildrye.--The measurement of the effect of season of herbage removal on the total and seasonal production was studied on two plantings of Russian wildrye seeded in 1951 in the forage nursery. Each planting measured approximately 15 by 100 feet with rows spaced at 14 inches.

Table 1.--AVERAGE PRECIPITATION AT FORT COLLINS, COLORADO FOR THE PERIOD 1956-1962

Month	1956	1957	1958	1959	1960	1961	1962	Long Term Mean
				inches				
Jan.	.70	.70	.17	.46	.37	.21	1.17	.36
Feb.	.66	.52	.40	.58	.53	.64	.70	.56
March	.71	.42	1.87	1.36	.84	3.38	.55	1.00
April	1.67	3.94	1.95	2.71	.88	1.00	1.00	2.01
May	2.62	6.04	5.30	3.54	2.50	7.06	2.36	2.81
June	.31	1.02	2.30	.39	.72	1.83	2.13	1.66
July	2.23	.43	1.58	.31	.80	4.27	2.07	1.53
Aug.	1.91	3.07	1.01	.60	.03	4.00	.31	1.45
Sept.	.03	.81	.46	1.97	.39	4.00	.41	1.25
Oct.	.05	1.99	.85	2.71	2.11	1.17		1.10
Nov.	.79	.62	.57	.04	.28	.62		.50
Dec.	.51	T	.98	T	.56	.24		.45
Total	12.19	19.56	17.44	14.67	10.01	28.42		14.68

Both areas were relatively uniform with the exception of two outer rows on the borders, where the plants were bigger, had longer and more abundant leaves, were more vigorous, remained green for a longer time, and had a higher proportion of stems and seeds. For these reasons the outer rows were excluded from the study.

Two replications were established on each planting, with three plots in each replication (Figure 1). Each plot was 28 inches wide by 48 inches long; the width was chosen to permit inclusion of two rows per plot. After uniform plots were chosen, the treatments were randomly assigned to each plot.

The following clipping treatments were used: (1) Spring, (2) Summer, and (3) Spring-fall. The herbage of the three treatments was removed by imitating the pattern of grazing of yearling heifers which were grazing in six nearby pastures seeded with Russian wildrye and alfalfa. Observations were made of the percentage of plants grazed, stubble height, amount of herbage removed, and the parts of the plants taken by the animals.

Clippings were made every two weeks with hand clippers. Dates of clippings for each treatment were as follows:

Spring

Date	System of herbage removal
April 25	Simulated grazing
May 9	Simulated grazing
May 23	Simulated grazing
June 6	Ground level

Spring-fall

Date		System of herbage removal
April	25	Simulated grazing
May	9	Simulated grazing
May	23	Simulated grazing
June	6	Simulated grazing
August	15	Simulated grazing
August	29	Simulated grazing
September	12	Ground level

Summer

June	20	Simulated grazing
July	4	Simulated grazing
July	18	Simulated grazing
August	1	Ground level

Alfalfa.--Three plots of Sevelra alfalfa, located in different places in the nursery, seeded in 1956, 1957, and 1958 were chosen for studying the effect of season of herbage removal.

Sevelra alfalfa, the variety used in this study, has been described by Wheeler (1957) as a northern variegated alfalfa, which likely resulted from natural crosses between Cremburg, Semipalatinsk, and Grimm. It has been grown for many years in southern Idaho under conditions of low precipitation and no irrigation. It is classified as a creeping or pasture type alfalfa,

but it may be used for both hay and pasture mixtures.

Each original 5 feet by 10 feet-plot was divided into three smaller plots of 32 by 60 inches; spring, spring-fall, and summer clipping treatments were randomly located in each original plot. The same system and dates of clipping were used as in Russian wildrye.

In both Russian wildrye and alfalfa, the amount of forage clipped each time was air-dried and weighed separately; the yield was expressed in pounds per acre. Before clipping each treatment, ten measurements of maximum leaf height on each plot were made and an average taken.

Cumulative growth of Russian wildrye

The growth curve of Russian wildrye was studied in the same plantings used for the seasons-of-clipping studies of this grass. Eleven uniform plots were randomly selected to be clipped at ground level every two weeks starting on April 25 and ending September 12, 1962.

On the day a plot was to be clipped, measurements were made of maximum leaf height of ten plants and of the maximum height of the seedstalks. Also, the number of culms per plot were counted. Finally, leaves and seedstalks were clipped, air-dried, and the weight expressed in pounds per acre.

At the end of the experiment, the ground cover of

each plot was measured. Ten line intercepts were located perpendicularly to the rows of grass at a spacing of 4.8 inches between lines (Figure 2). The percentage of ground cover was calculated by dividing the total amount intercepted by the total length of the lines.

Effect of season of use after four years of grazing on the floristic composition of a pasture seeded with a mixture of Russian wildrye and alfalfa

The study was done on a field of 13.75 acres seeded with a mixture of seven pounds of Russian wildrye and one pound of Sevelra alfalfa per acre. Prior to the original planting in April, 1955, the soil was plowed and harrowed. Unfavorable weather conditions prevented plant establishment and made it necessary to reseed in 1956 directly on the 1955 seeding without any additional soil preparation. The 13.75 acres were divided into six pastures of approximately the same carrying capacity, the size of each varying from 1.7 to 3.0 acres.

The objectives of the study were to determine through several years of actual grazing the effect of season of use on a pasture seeded with a mixture of Russian wildrye and alfalfa, to study the changes in the cover of each of the species, the size of the plants, and the proportion of each.

Every year since 1958 two pastures were grazed in the same season: spring, spring-fall, or summer.

Figure 1.--Replication I and II of Russian wildrye. Plots used to measure the cumulative growth and the effect of simulated grazing.

Figure 2.--Sampling frame used to delimit the plots. It shows the ten-line intercepts as used to measure ground cover.

Measurements of the cover and changes in the composition were made with the line interception method. Forty-eight permanent transects were located in the whole field, eight in each pasture. Half of the transects in each pasture were located within the rows and the others across the rows. These twenty-foot long transects have been measured at two-year intervals.

On each transect measurements were made of the basal area intercepted, and counts made of the number of segments of plants intercepted. Later the average width of each intercepted segment was calculated by dividing the total amount of feet intercepted by the total number of segments intercepted.

Chapter IV

ANALYSIS OF DATA

The results of the study have been arranged under the following headings: (1) Effects of simulated grazing during the spring, summer, and spring-fall on the growth pattern and total production of Russian wildrye and alfalfa, (2) The determination of the normal growth curve of ungrazed plants of Russian wildrye, and (3) The determination of the effect of season of use after four years of grazing on the floristic composition of a pasture seeded with a mixture of Russian wildrye and alfalfa.

Effects of simulated grazing during the spring, summer, and spring-fall on the growth pattern and total production of Russian wildrye and alfalfa

Russian wildrye.---The amount of herbage produced with four clippings throughout the spring grazing season was very similar to the amount of herbage produced with only one clipping at the end of the spring (Table 2 and Figure 3). Statistical analysis (t-test) of the total amount of forage produced under simulated grazing for a total period of six weeks compared with only one clipping made at the end of the grazing season showed that there was no difference in the production at either

a 0.05 or 0.10 level of significance.

The total amount of forage produced under simulated grazing during the spring-fall season exceeded by almost 300 pounds that obtained with only one clipping at the end of the grazing period (Table 2). This difference was significant for a 0.20 level of probability.

Table 2.--YIELD OF RUSSIAN WILDRYE AT THREE DIFFERENT SEASONS AS INFLUENCED BY CLIPPING TREATMENT

Replication	Spring		Spring-fall		Summer	
	Simulated Grazing	One Clipping	Simulated Grazing	One Clipping	Simulated Grazing	One Clipping
	Pounds per Acre					
1	597	1174	950	523	971	555
2	992	1078	800	928	875	1259
3	1078	950	1280	790	907	1099
4	1227	1163	1739	950	1654	1750
Mean	974	1091	1192	798	1102	1166

There was not a statistically significant difference at the 0.20 level between the yields of Russian wildrye clipped to simulate grazing during the summer and clipped only once at the end of the summer. Differences in yields from single clippings (Table 2) are related to the cumulative growth curve (Figure 5).

A comparison of the yields under simulated grazing

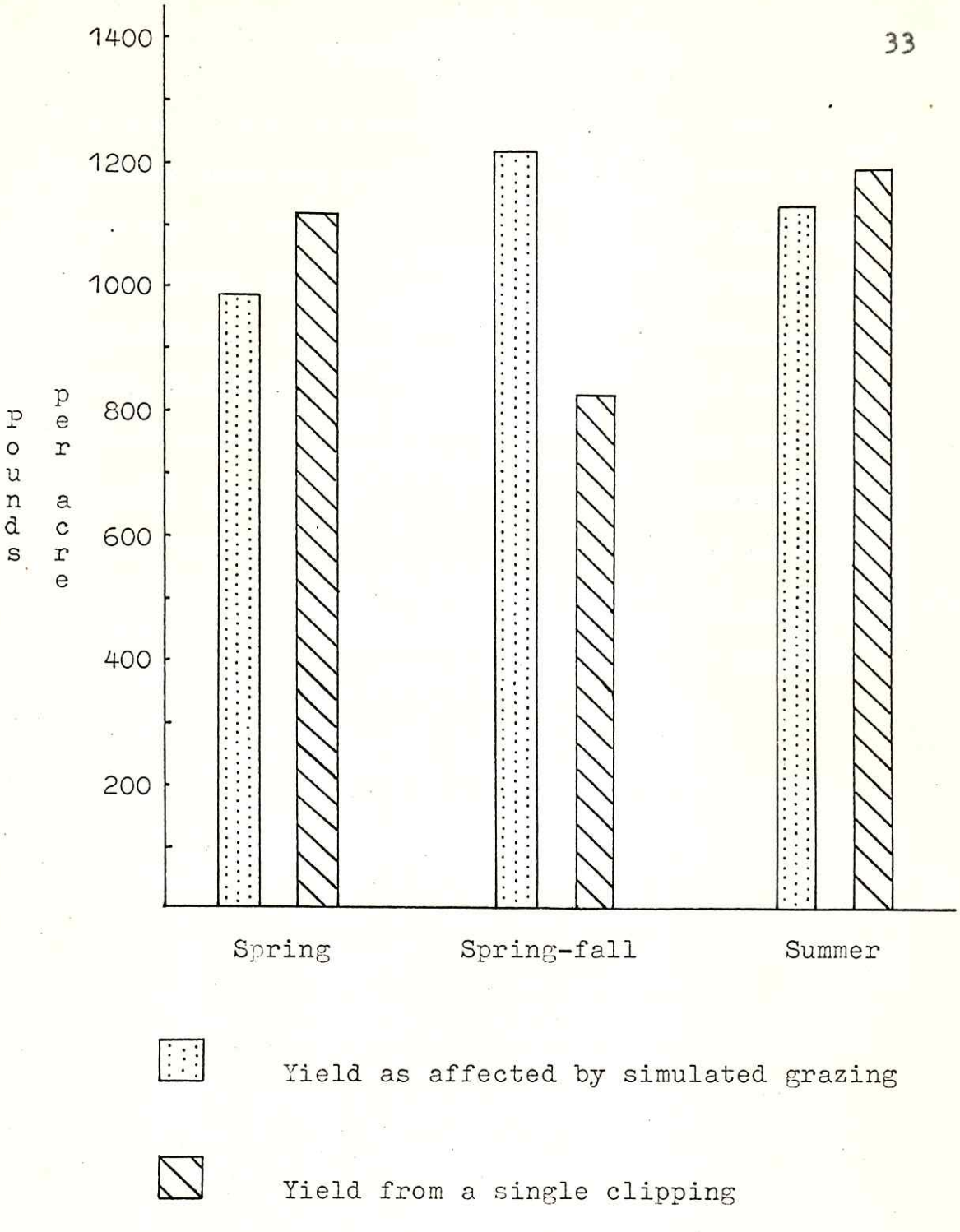

Figure 3.--Yield of Russian wildrye with a single clipping at the end of the grazing period as compared with the total yield under simulated grazing.

during the spring, spring-fall, and summer showed that differences were not significant at a 0.10 level of probability. A difference for 0.25 level of significance was found between the yields of spring and spring-fall clippings. On the other treatments, differences were only significant for a 0.50 level. Half of the production obtained during the fall season on the spring-fall treatment can be considered as belonging to the forage remaining on the ground at the end of the spring. The last clipping in spring was made at about 2.5 centimeters stubble height, and the last clipping in fall was made at ground level.

Table 3.--YIELD OF RUSSIAN WILDRYE CLIPPED AS SIMULATED GRAZING DURING THE SPRING, SUMMER, AND SPRING-FALL SEASONS

Treatment	Replications				Mean
	I	II	III	IV	
	Pounds per Acre				
Spring	597	992	1078	1227	974
Spring-fall					
spring	(608)	(480)	(854)	(1302)	(811)
fall	(342)	(320)	(426)	(437)	(381)
total	950	800	1280	1739	1193
Summer	971	875	907	1654	1102

The average per cent of ground cover on the sample plots was very similar, with a range of only 1.6 per cent (Table 4). On the average, there were greater differences between replications than between treatments.

Table 4.--PERCENTAGE OF BASAL GROUND COVER OF THE RUSSIAN WILDRYE PLOTS CLIPPED AS SIMULATED GRAZING AT THREE GRAZING SEASONS

Treatment	Replications				Mean
	I	II	III	IV	
	Per Cent				
Spring	10.9	12.3	10.7	14.1	12.0
Spring-fall	11.5	9.6	12.9	15.7	12.4
Summer	11.8	11.8	14.5	16.2	13.6
Mean	11.4	11.2	12.7	15.3	

The mean of the maximum leaf height of Russian wildrye when the grazing season started was very similar for both spring and spring-fall treatments (Table 5), whereas summer clippings started when the plants had reached almost full size. Fall measurements of leaf heights were made on the plots which had undergone simulated grazing during the spring; at the end of the spring season, the stubble height averaged approximately 2.5 centimeters. At the beginning of the fall, leaf height under simulated grazing treatment had increased to an average of 9.4 centimeters.

Table 5.--MEAN MAXIMUM LEAF HEIGHT OF RUSSIAN WILDRYE WHEN THE FIRST SIMULATED CLIPPING OF THE RESPECTIVE GRAZING SEASON WAS MADE

Treatment	Replications I	II	III	IV	Mean
	Centimeters				
Spring	12.1	14.1	12.7	15.1	13.5
Spring-fall					
spring	11.8	12.0	10.7	14.4	12.2
fall	8.2	8.9	9.5	11.0	9.4
Summer	18.2	17.4	16.1	19.7	17.9

Alfalfa.--Only a small part of the total current growth of the alfalfa was taken from the plots clipped during the spring season treatment (Table 6). Following the herbage removal in the spring, the plants continued growing actively. During the spring when the production was the lowest, the apparent quality of the forage was the highest. At this time, there was a high percentage of leaves and soft stems.

Spring regrowth was also of good quality, considering the exterior characteristics such as amount of leaves, and stem color and softness. The yield of the regrowth was not very high, but relatively good considering the weather conditions of the year.

Table 6.--YIELD OF ALFALFA CLIPPED TO SIMULATE GRAZING AT THREE DIFFERENT SEASONS

Treatment	Replications I	II	III	Mean
	Pounds per Acre			
Spring	1586.5	1911.5	1276.8	1591.6
Spring-fall				
spring	1394.9	1717.2	1173.4	1426.7
fall	1099.6	1195.5	560.9	779.8
total	2494.5	2907.7	1734.3	2378.8
Summer	3254.5	5025.1	1793.3	3364.3

The summer season treatment yielded appreciably more than the other two treatments, but the forage was made up of a high percentage of coarse stems. Although the plants were large, with abundant leaves, the stems were coarse and rough. The steers selectively grazed the larger plants, taking mostly leaves, the tips of the branches, or any other soft material. Selective grazing of the alfalfa occurred only during the summer.

The yields obtained for the season of grazing of alfalfa were not significant for a 0.10 level. Only summer clippings yielded significantly more than spring clippings at that level of significance (Table 6).

The mean maximum height at the beginning of the simulated grazing treatment was much greater for the

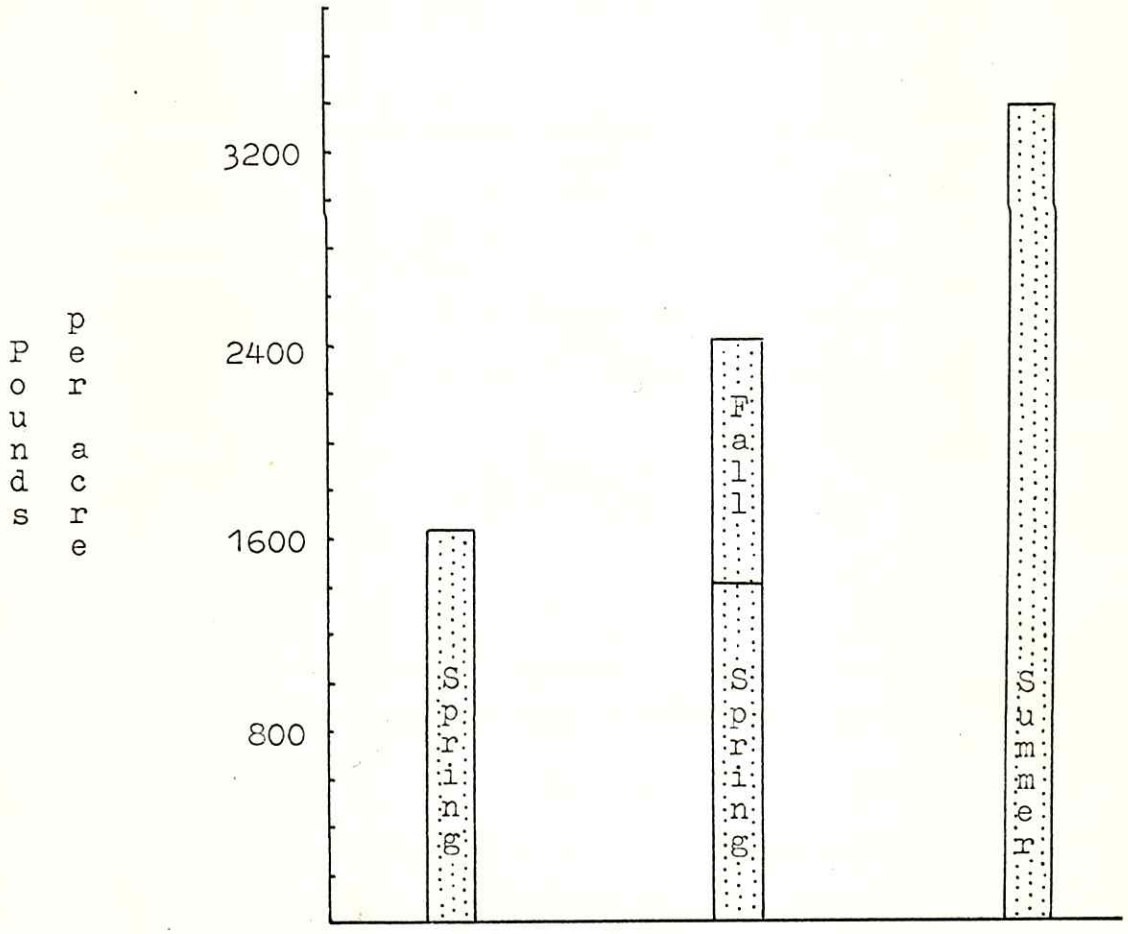

Figure 4.--Yield of alfalfa clipped to simulate grazing at three different seasons.

Table 7.--MEAN MAXIMUM LEAF HEIGHT OF ALFALFA WHEN THE FIRST SIMULATED CLIPPING OF THE RESPECTIVE GRAZING SEASON WAS MADE

Treatment	Replications			Mean
	I	II	III	
	Centimeters			
Spring	23.0	24.6	20.2	22.6
Spring-fall				
spring	24.6	25.7	20.9	23.7
fall	33.8	43.6	26.3	34.6
Summer	60.0	69.7	40.9	56.8

summer treatment than for the other seasons (Table 7). At the beginning of the summer season, the plants were twice the height of those eight weeks earlier when the spring grazing season started. The ten-week recovery period of the spring-fall treatment gave an opportunity for the alfalfa plants to recover and become taller than at the beginning of the grazing season. However, this second growth, even though taller than the first, yielded less (Tables 6 and 7).

Cumulative growth of Russian wildrye

A few weeks after growth started, the first ground level clipping was made on April 25, yielding an average of 832 pounds per acre (Table 8 and Figure 5). The stems, which were about the same height as the leaves, were

soft and green and contributed only four per cent to the yield. As the season advanced, the rate of growth was rather constant until June 6. After this date, the rate increased rapidly and growth reached the maximum for the season on June 20. As rapidly as it had increased the previous month, the yield decreased in the following month, until July 18, when it reached its lowest mid-season point. The total production at that date was about the same as the production at the beginning of June. On August 1 a second peak in production was reached, but this was much lower than the amount obtained on June 20. After August 1, the yield decreased slowly until August 29, and rapidly during the period of August 29-September 12. The total amount of forage available at the end of the grazing season (September 12) was almost the same as that at the beginning of the grazing season on April 25, even though no grazing had taken place.

The percentage of cover of the plots clipped at the different dates of the growing season was relatively uniform. The range in the mean cover of the plots clipped at different dates was 3.8 per cent. The average basal cover was 12.8 per cent. The range in mean basal cover for each replication was also 3.8 per cent. The cover was fairly constant within each replication. The lowest percentage of cover was on replications I,

Table 8.--CUMULATIVE GROWTH OF RUSSIAN WILDRYE MEASURED BY WEIGHT

Date of Clipping			Replications I	II	III	IV	Mean
			Pounds per Acre				
April	25	L[1]	469.5	896.3	704.2	1141.7	802.9
		S	21.3	32.0	32.0	42.7	32.0
		T	490.8	928.3	736.2	1184.4	834.9
May	9	L	628.8	725.6	971.0	1077.7	874.3
		S	21.3	42.7	21.3	32.0	29.3
		T	704.1	768.3	992.3	1109.7	893.6
May	23	L	725.6	928.3	1045.7	917.6	904.3
		S	---	64.0	49.4	32.0	61.4
		T	725.6	992.3	1195.1	949.6	965.7
June	6	L	1088.3	1067.0	906.9	1141.7	1051.0
		S	85.4	10.7	42.7	21.3	40.0
		T	1173.7	1077.7	949.6	1163.0	1091.0
June	20	L	981.6	1120.3	1515.1	1462.0	1269.8
		S	74.7	21.3	138.7	32.0	66.6
		T	1056.3	1141.6	1653.8	1494.0	1336.4
July	4	L	746.9	1077.7	1109.7	1429.8	1091.0
		S	--	181.4	224.1	42.7	112.0
		T	746.9	1259.1	1333.8	1472.5	1203.0
July	18	L	821.6	1131.0	1173.7	1312.4	1109.6
		S	--	10.7	32.0	42.7	21.4
		T	821.6	1141.7	1205.7	1355.1	1131.0
August	1	L	554.8	1109.7	1035.0	1717.9	1104.3
		S	--	149.4	64.0	32.0	61.4
		T	554.8	1259.1	1099.0	1749.9	1165.7
August	15	L	885.6	832.3	1237.7	1216.4	1043.0
		S	--	10.7	21.3	21.3	13.3
		T	885.6	843.0	1259.0	1237.7	1056.3
August	29	L	859.7	843.3	979.1	1337.9	1005.0
		S	21.3	53.4	64.0	53.4	48.0
		T	881.0	896.7	1043.1	1391.3	1053.0
September	12	L	522.8	896.3	778.9	949.6	786.9
		S	--	32.0	10.7	--	10.7
		T	522.8	928.3	789.6	949.6	797.6
Mean			713.6	928.3	1021.4	1171.4	960.7

1. L-Leaves, S-Stems, T-Total

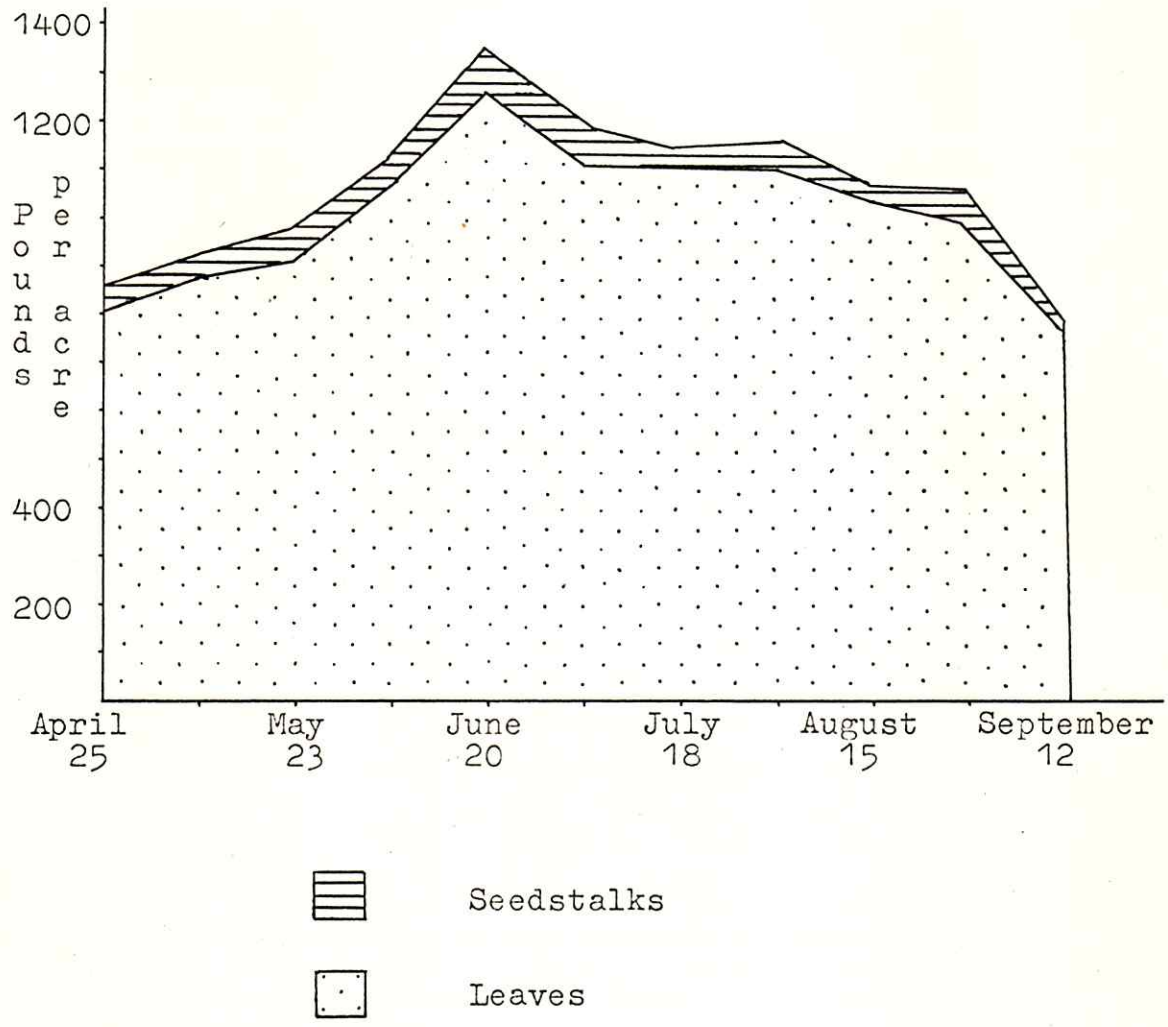

Figure 5.--Cumulative growth curve of Russian wildrye based on the weight of herbage produced.

and increased progressively to replication IV (Table 9).

Table 9.--PERCENTAGE OF BASAL GROUND COVER OF RUSSIAN WILDRYE ON PLOTS USED TO MEASURE THE CUMULATIVE GROWTH CURVE

Clipping Date		Replications I	II	III	IV	Mean
		Per Cent				
April	25	11.8	12.0	13.4	17.0	13.6
May	9	10.6	12.1	14.1	12.0	12.2
May	23	8.7	13.3	11.8	11.2	11.2
June	6	14.4	14.8	12.0	17.7	14.7
June	20	12.9	11.5	13.8	16.4	13.6
July	4	8.7	14.1	12.9	15.1	12.7
July	18	8.9	14.6	13.9	12.2	12.4
August	1	9.0	11.6	13.5	15.4	12.4
August	15	11.6	11.4	15.1	12.4	12.7
August	29	12.6	14.6	12.5	15.3	13.7
September	12	8.6	10.9	15.3	15.3	12.5
Mean		10.7	12.8	13.5	14.5	12.8

The replications with the greatest production were also those with the greatest ground cover (Tables 8 and 9).

The mean maximum length of the leaves of Russian wildrye increased as the season advanced (Table 10). The increase was small, but in general constant through

Table 10.--MEAN MAXIMUM LEAF HEIGHT OF RUSSIAN WILDRYE AT VARIOUS TIMES DURING THE GROWING SEASON

Date of Measurement		Replications I	II	III	IV	Mean
		Centimeters				
April	25	15.0	15.7	18.0	22.3	17.7
May	9	18.4	16.8	18.6	19.7	18.4
May	23	17.4	17.6	15.2	20.5	17.7
June	6	23.3	18.3	18.1	19.1	19.7
June	20	19.2	23.3	19.8	19.9	20.5
July	4	20.6	19.6	16.9	24.9	20.5
July	18	19.4	24.2	20.5	23.7	21.9
August	1	19.5	24.3	19.8	25.8	22.3
August	15	20.3	20.8	22.1	24.8	22.0
August	29	22.3	21.5	23.3	26.5	23.4
September	12	19.7	21.6	19.7	21.9	20.7
Mean		19.5	20.3	19.3	22.6	

most of the growing season, except at the end when the maximum height started to decrease. The length of the leaves did not follow consistently the same pattern as the yield (Tables 8 and 10, and Figures 5 and 6). The leaves were shortest when first measured early in the grazing season; they continued elongating until almost the end of the growing season on August 29; from this date until September 12 the length decreased.

Table 11.--MEAN MAXIMUM HEIGHT OF SEEDSTALKS OF RUSSIAN WILDRYE AT VARIOUS TIMES DURING THE GROWING SEASON

Date of Measurement		Replications				Mean
		I	II	III	IV	
		Centimeters				
April	25	13.0	16.0	11.7	12.4	13.3
May	9	24.0	36.0	28.6	37.5	31.5
May	23	--	49.7	48.4	55.0	51.0
June	6	56.5	36.3	62.4	69.0	56.1
June	20	63.5	45.0	69.7	73.0	62.8
July	4	--	79.0	70.2	66.5	71.9
July	18	--	68.0	64.6	58.0	72.0
August	1	--	68.0	64.6	58.0	63.3
August	15	--	53.7	86.0	71.0	70.2
August	29	51.0	50.6	84.0	76.0	65.4
September	12	--	69.0	64.0	--	66.5

The pattern of elongation of the seedstalks was also different from the yields (Tables 8 and 11, and Figures 5 and 6). Seedstalks grew at a uniform rate from the beginning of the growing season until May 23; after that they grew at a slower rate until July 4 when they reached a maximum height. After July 4 there was an apparent change in average maximum height, but this apparent change was probably due to differences in

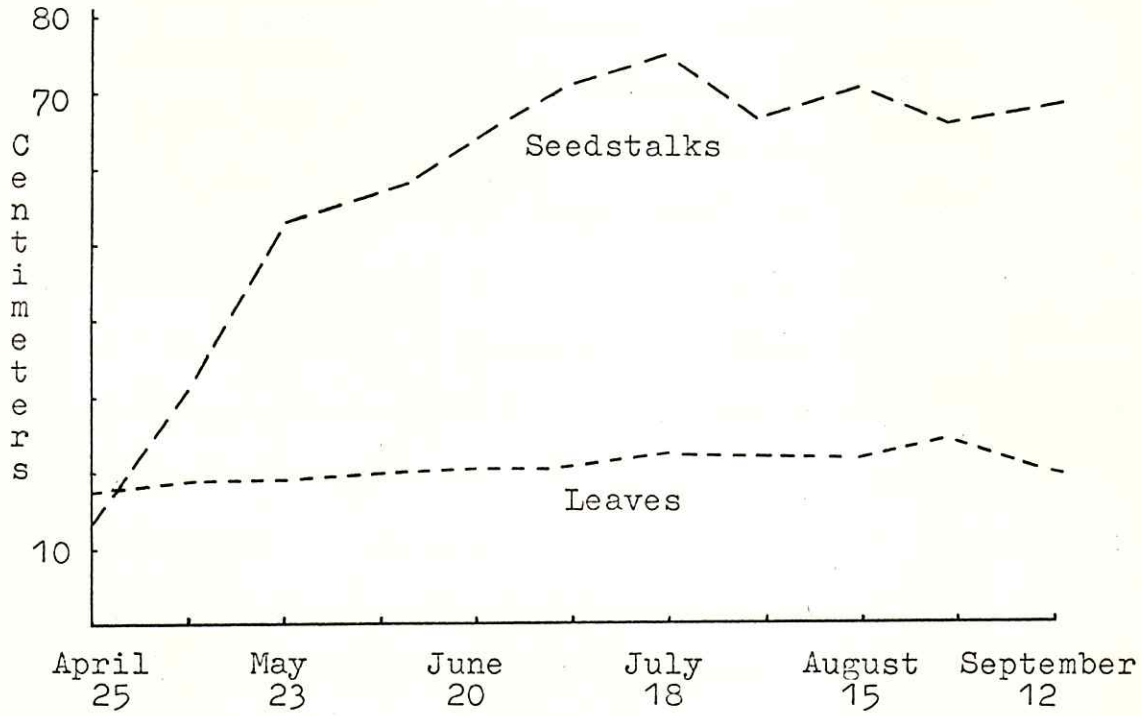

Figure 6.--Mean maximum leaf and seedstalk height of Russian wildrye at various times during the growing season

plot characteristics and to mechanical damage of the seedstalks.

Effect of season of use after four years of grazing on the floristic composition of a pasture seeded with a mixture of Russian wildrye and alfalfa

Cover.--The transects located both within and across the rows on the spring-fall pastures showed an appreciable decrease in the number of feet of Russian wildrye intercepted after five years of grazing, especially in the last two years (Table 12 and Figure 7). The transects located across the rows showed an increase in the number of feet intercepted during the first years of grazing, after which it slowly decreased. On alfalfa, the changes were consistent; the amount of feet intercepted decreased very rapidly with the use of the pastures during the five years of study, both on the transects located within and across the rows (Table 12 and Figure 8).

Under summer grazing there was an increase in the number of feet of Russian wildrye intercepted during the first two years. In the last two years there was little change in the percentage of cover of this grass. With alfalfa, the results were not so clear-cut. On the transects located within the rows there was a decrease in the ground cover by alfalfa during the first half of the study, but there was a slight increase in

the ground cover during the second part. On the transects located across the rows, the alfalfa plants showed a decrease in the amount of feet intercepted during the whole period of study; at the end of the study period there was about half the original amount.

Table 12.--AVERAGE AMOUNT OF RUSSIAN WILDRYE AND ALFALFA INTERCEPTED ON 20-FOOT-LONG PERMANENT TRANSECTS ON PASTURES GRAZED AT THREE DIFFERENT SEASONS

Treatment	Russian wildrye			Percent of Original	Alfalfa			Percent of Original
	1958	1960	1962		1958	1960	1962	
	---Feet---			%	---Feet---			%
Within the rows								
Spring	3.1	3.6	2.7	87	1.0	1.0	0.6	60
Summer	4.5	5.7	5.4	120	2.3	1.3	1.5	65
Spring-fall	6.7	6.6	4.6	68	1.4	0.6	0.4	29
Across the rows								
Spring	0.7	0.9	1.0	146	1.0	1.1	0.9	90
Summer	0.8	1.2	1.3	165	1.3	0.9	0.7	54
Spring-fall	0.8	1.4	1.2	150	0.8	0.2	0.1	12

The pastures grazed only during the spring season showed an increase of the Russian wildrye cover at the middle of the study period; after that, the transects

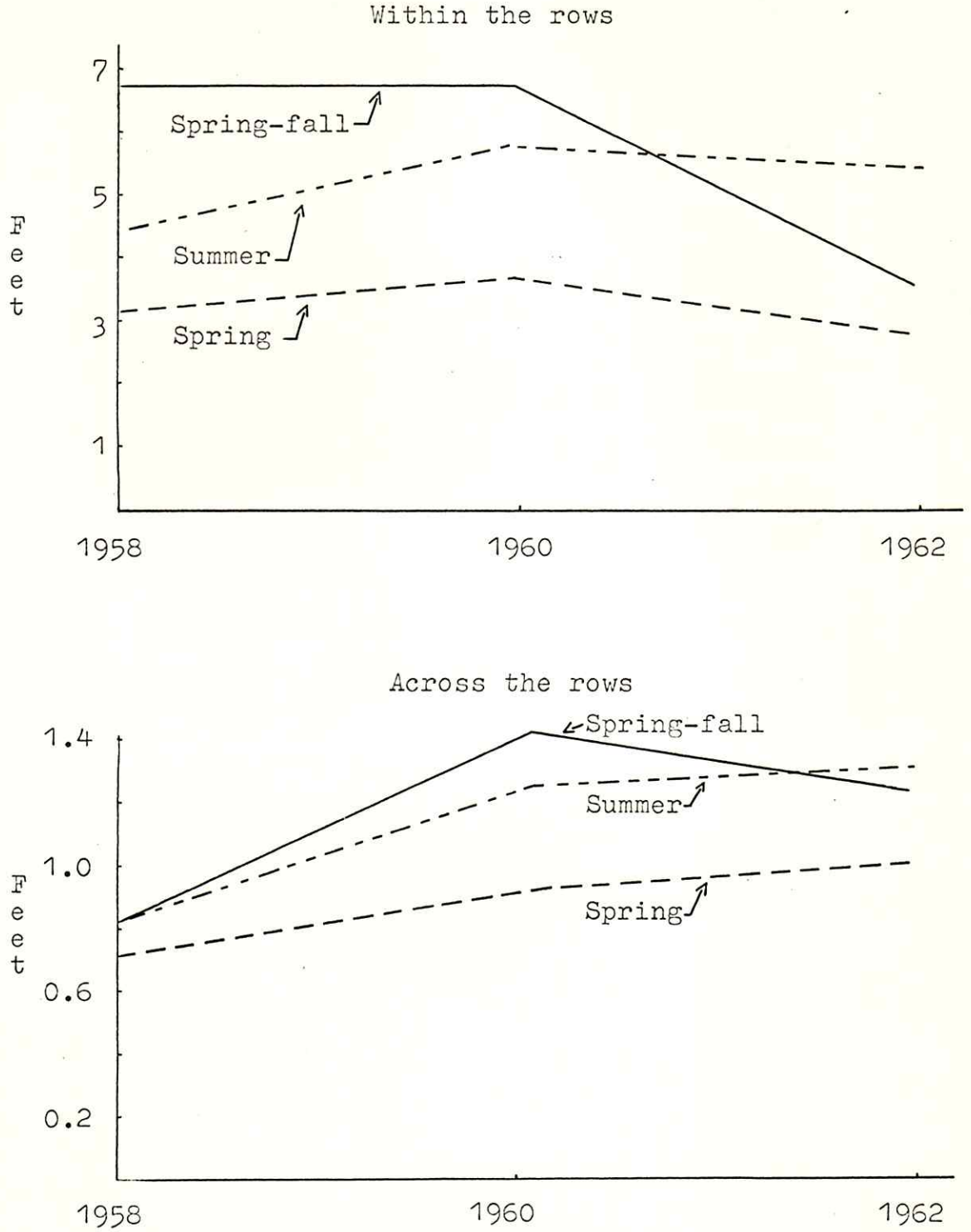

Figure 7.--Average amount of Russian wildrye intercepted on 20-foot-long permanent transects in pastures grazed at three different seasons.

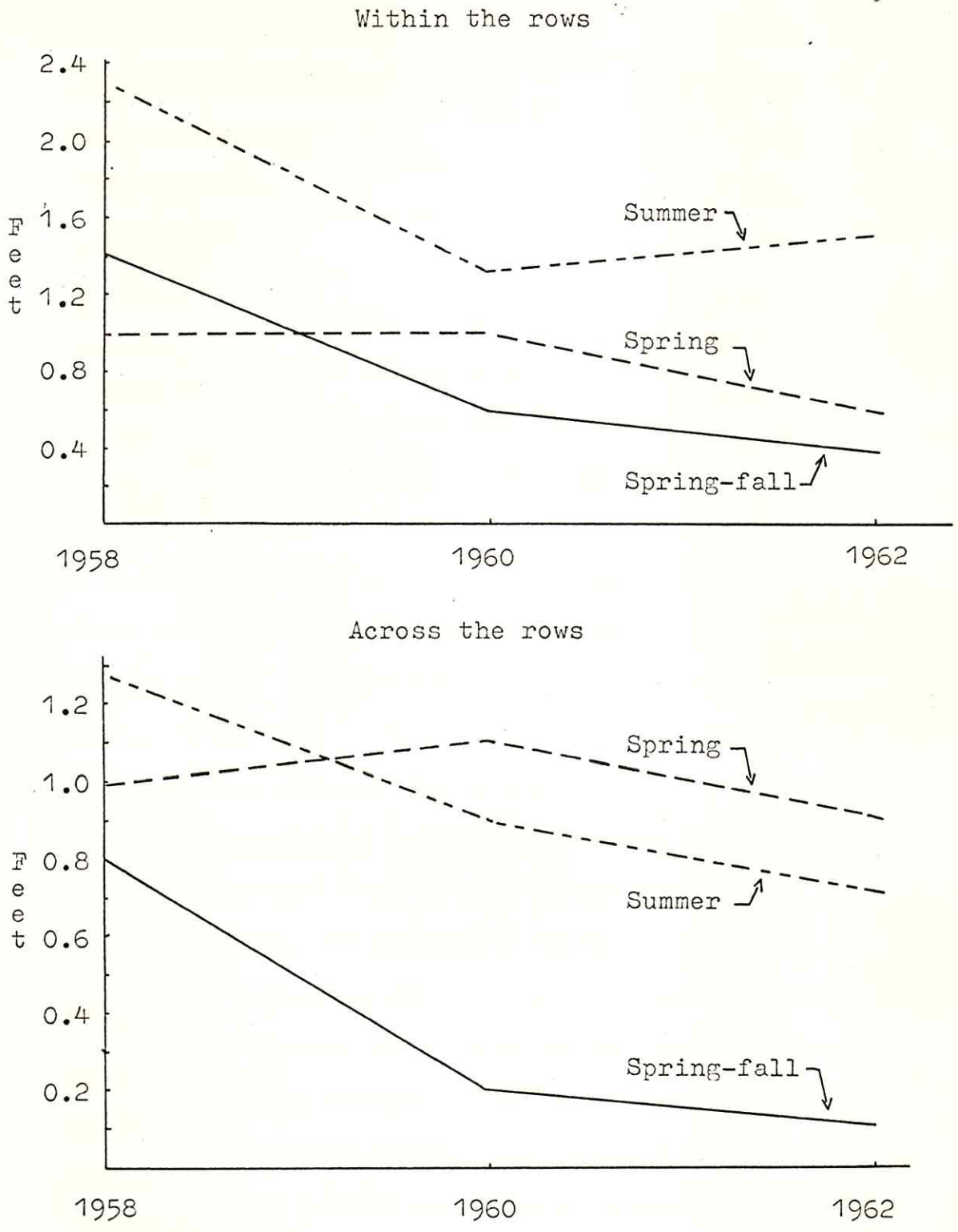

Figure 8.--Average amount of alfalfa intercepted on 20-foot-long permanent transects in pastures grazed at three different seasons.

located within the rows showed an appreciable decrease in the basal interception of the grass cover. On those located across the rows, the last two years of study indicated a slight increase in the amount of feet intercepted.

Under spring grazing alfalfa was fairly stable during the first half of the study, with a slight increase in the amount intercepted for both the transects located within the rows and those located across the rows. During the last part of the study period, there was a slight decrease in the amount intercepted across the rows and a greater decrease of alfalfa intercepted within the rows. Percentage-wise, the amount of alfalfa remaining at the end of the study period was greatest under the spring grazing treatment (Figures 9 and 10).

Number of segments intercepted.--Even though the size of the segments does not necessarily indicate the size of the plants, it is a good index for comparing the changes in the relative size of the individual plants. The number of segments is related to the changes in the amount and shape of the individual plants or degree of "breaking up" of large plants into several smaller ones; the combination of number and size of segments is related to the changes which occurred in cover and composition.

The pastures grazed under all of the grazing

treatments showed an increase in the number of segments of Russian wildrye during the whole study period, both on the segments located within or across the rows (Table 13 and Figure 11). The amount and percentage of change throughout the years of study showed some differences among the treatments. In spring-fall pastures, the number of segments increased more than under any other treatment. With spring grazing there was a slightly greater increase in number of segments than under summer grazing. In the spring-fall treatment, the tendency of Russian wildrye to increase in number of segments was greater during the second half of the study.

On alfalfa the results were quite different, with one exception. In general, the number of segments decreased from the first through the last year (Table 13 and Figure 12). On the pastures grazed during the summer, the decrease was slight, and on those grazed during the spring-fall, the decrease in the number of segments was a little more pronounced. However, on the pastures grazed only during the spring, there was a small, but constant increase in the number of segments on the transects located within the rows, and a greater increase on the transects located across the rows.

Average size of the segments.--The average size of the segments was calculated by dividing the total number of feet intercepted by the number of segments intercepted.

Table 13.--AVERAGE NUMBER OF SEGMENTS OF RUSSIAN WILDRYE AND ALFALFA INTERCEPTED ON 20-FOOT-LONG PERMANENT TRANSECTS ON PASTURES GRAZED AT THREE DIFFERENT SEASONS

Treatment	Russian wildrye			Percent of Original	Alfalfa			Percent of Original
	1958	1960	1962		1958	1960	1962	
	--Number of Segments---			%	--Number of Segments---			%
Within the rows								
Spring	15.4	16.7	26.5	174	5.6	6.0	6.4	114
Summer	19.5	22.4	26.1	135	8.6	8.4	7.5	87
Spring-fall	23.3	28.3	43.8	188	10.1	10.7	4.4	44
Across the rows								
Spring	4.7	7.2	7.7	164	5.7	5.4	9.7	167
Summer	7.6	9.5	4.0	53	6.6	6.2	5.9	89
Spring-fall	7.0	8.9	11.2	160	4.0	2.0	1.1	27

This value gives an idea of the changes of the size of the plants independent of their total ground cover.

During the first two years, the average size of the segments of Russian wildrye in the spring and summer pastures increased on the transects located within the rows (Table 14 and Figure 13). After that they both decreased each year. On the transects located across the rows the average size of the segments of Russian wildrye

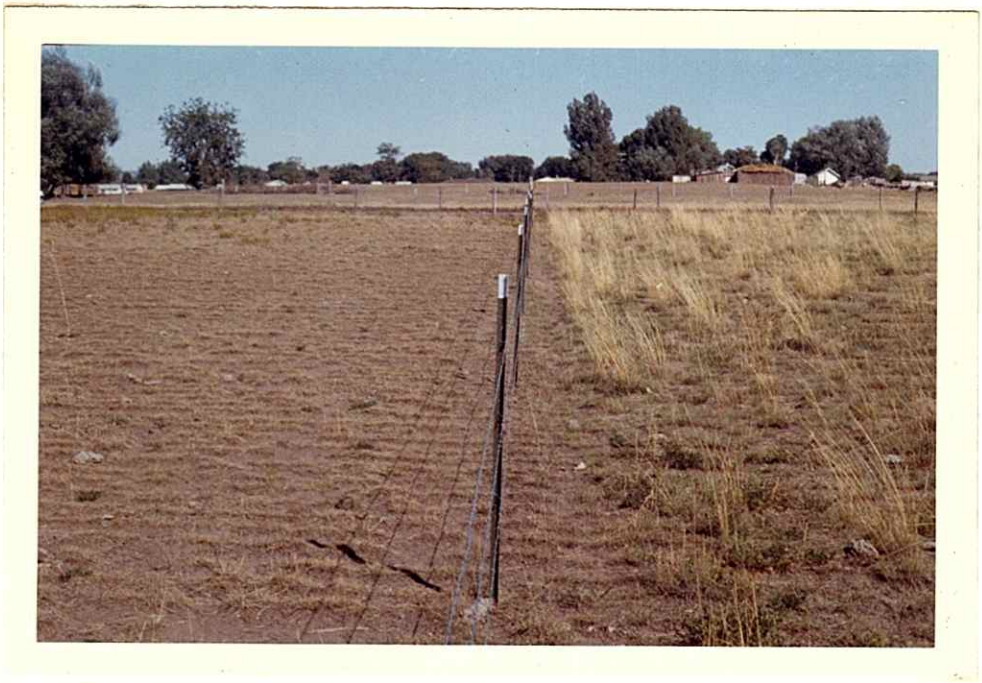

Figure 9.--Russian wildrye and alfalfa mixture at the Fort Collins Foothills Range after five years of grazing. Left, spring-fall grazing, and right, summer grazing.

Figure 10.--Russian wildrye and alfalfa mixture at the Fort Collins Foothills Range after five years of grazing. Left, summer grazing, and right, spring grazing.

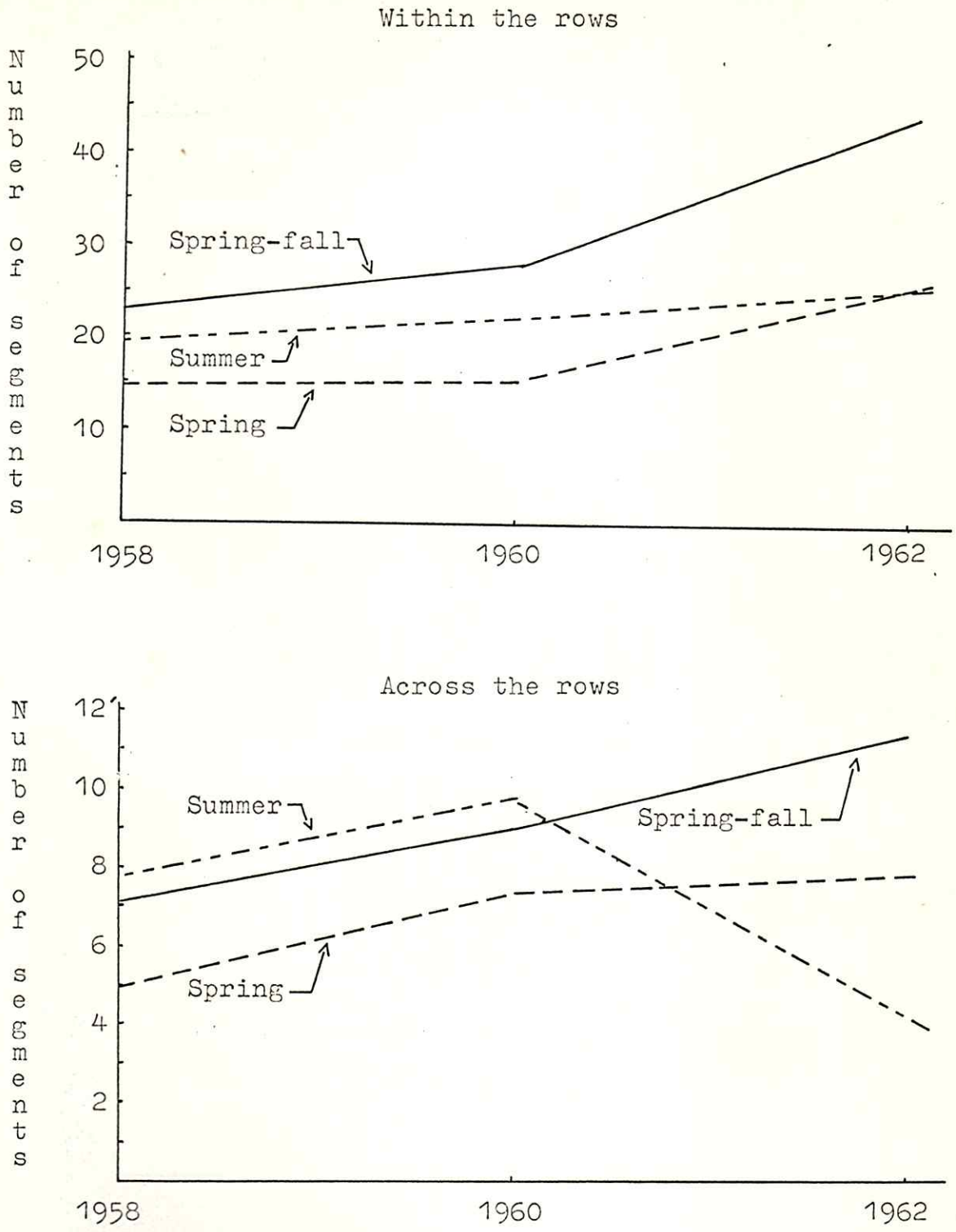

Figure 11.--Average number of segments of Russian wildrye intercepted on 20-foot-long permanent transects on pastures grazed at three different seasons.

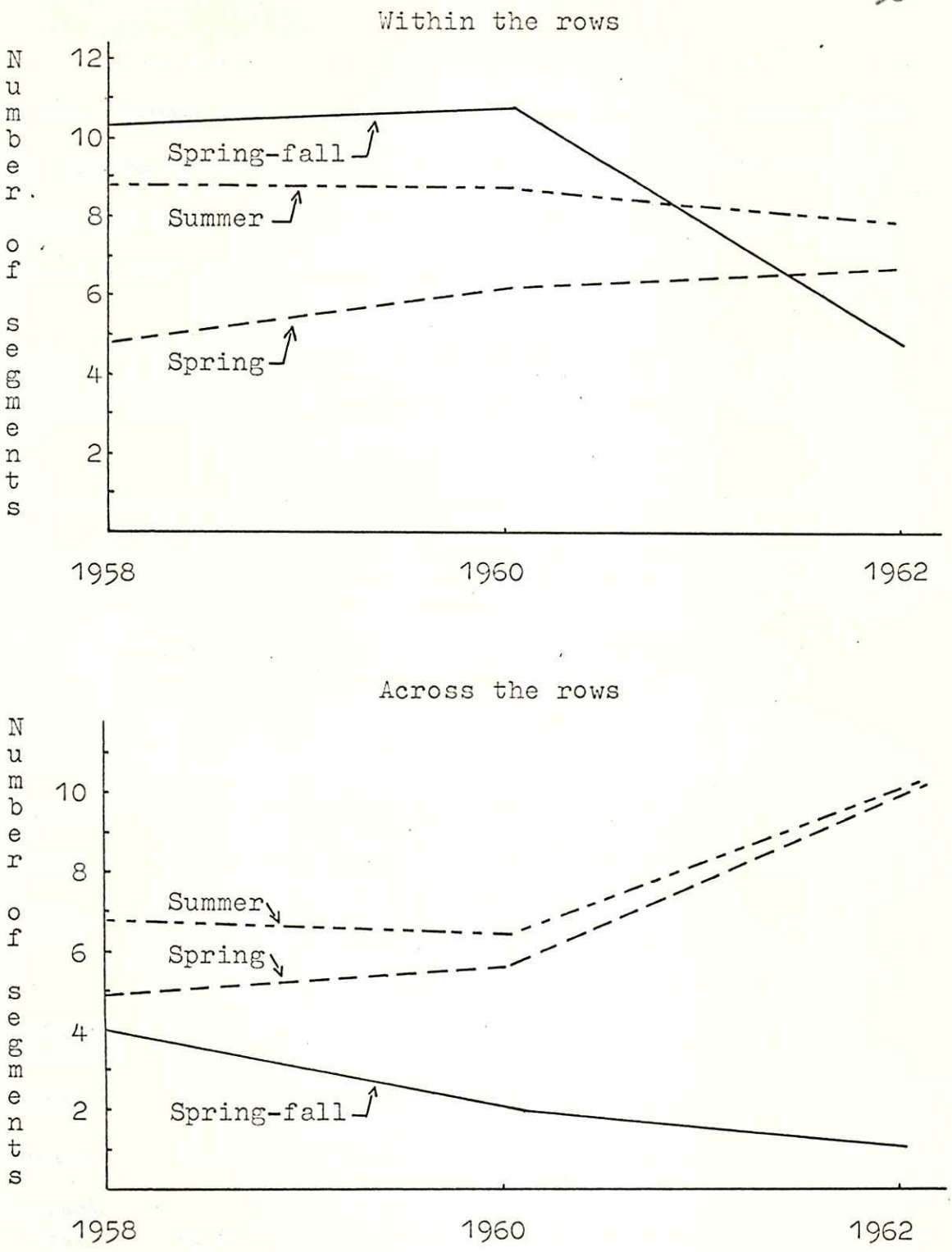

Figure 12.--Average number of segments of alfalfa intercepted on 20-foot-long permanent transects in pastures grazed at three different seasons.

intercepted increased on the summer pastures but decreased on the spring and spring-fall. Nevertheless, both summer and spring grazing showed a general tendency to maintain about the same size of Russian wildrye plants during the second half of the study period.

Table 14.--AVERAGE SIZE OF SEGMENTS OF RUSSIAN WILDRYE AND ALFALFA INTERCEPTED ON 20-FOOT-LONG PERMANENT TRANSECTS ON PASTURES GRAZED AT THREE DIFFERENT SEASONS

Treatment	Russian wildrye 1958	1960	1962	Percent of Original	Alfalfa 1958	1960	1962	Percent of Original
	--Hundredths of feet---			%	--Hundredths of feet---			%
Within the rows								
Spring	20.6	21.4	10.2	48	17.9	17.5	9.6	54
Summer	23.1	25.4	20.7	90	26.5	15.8	19.4	73
Spring-fall	28.8	23.4	10.6	37	13.8	5.3	10.0	72
Across the rows								
Spring	15.0	13.0	12.7	85	17.2	20.0	9.3	54
Summer	10.8	13.2	12.1	112	19.0	15.3	11.7	62
Spring-fall	12.1	15.4	10.6	88	20.5	11.6	5.2	25

During the first two years, alfalfa decreased in the size of the segments on the transects located both across and within the rows on the pastures grazed under summer

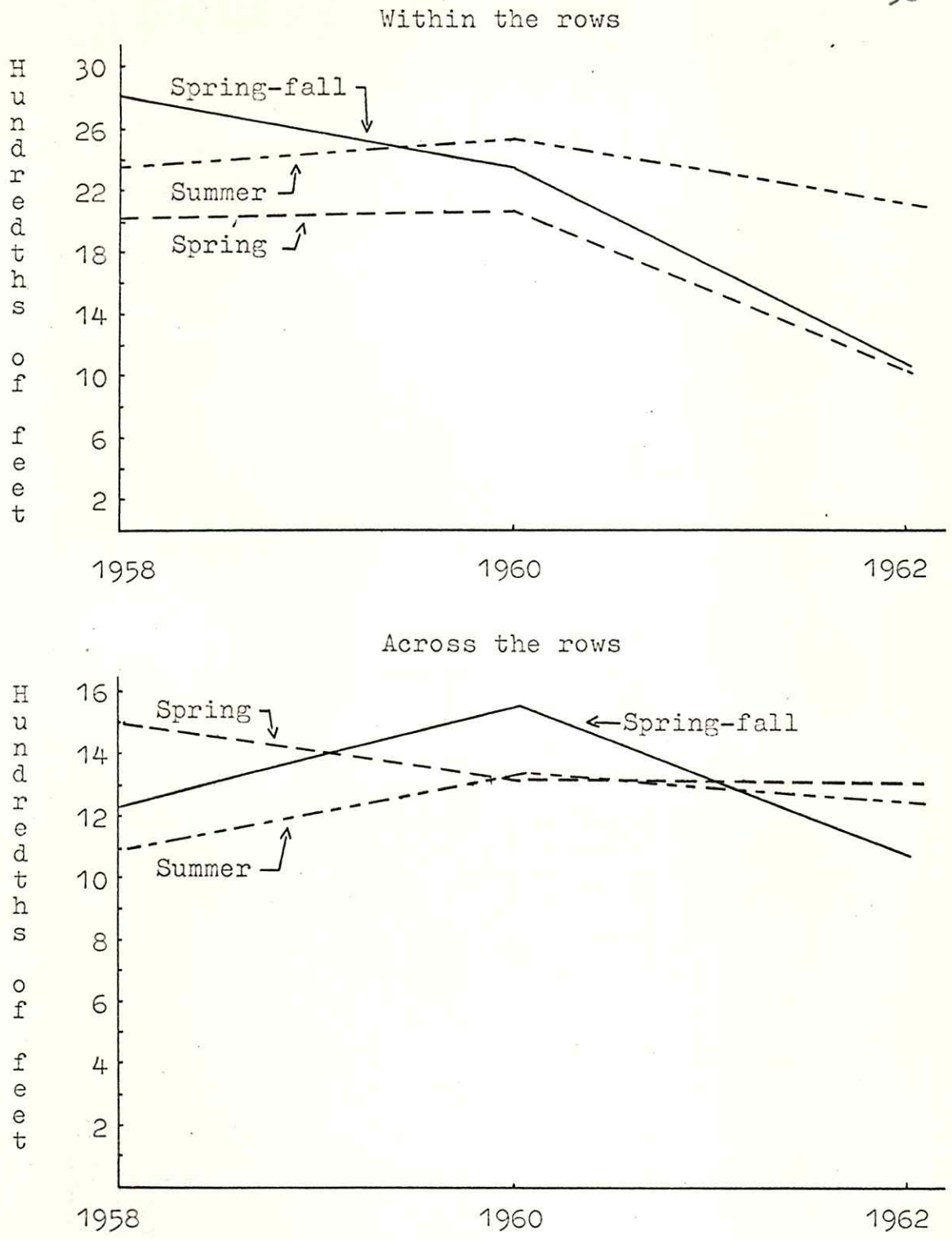

Figure 13.--Average size of segments of Russian wildrye intercepted on 20-foot-long permanent transects on pastures grazed at three different seasons.

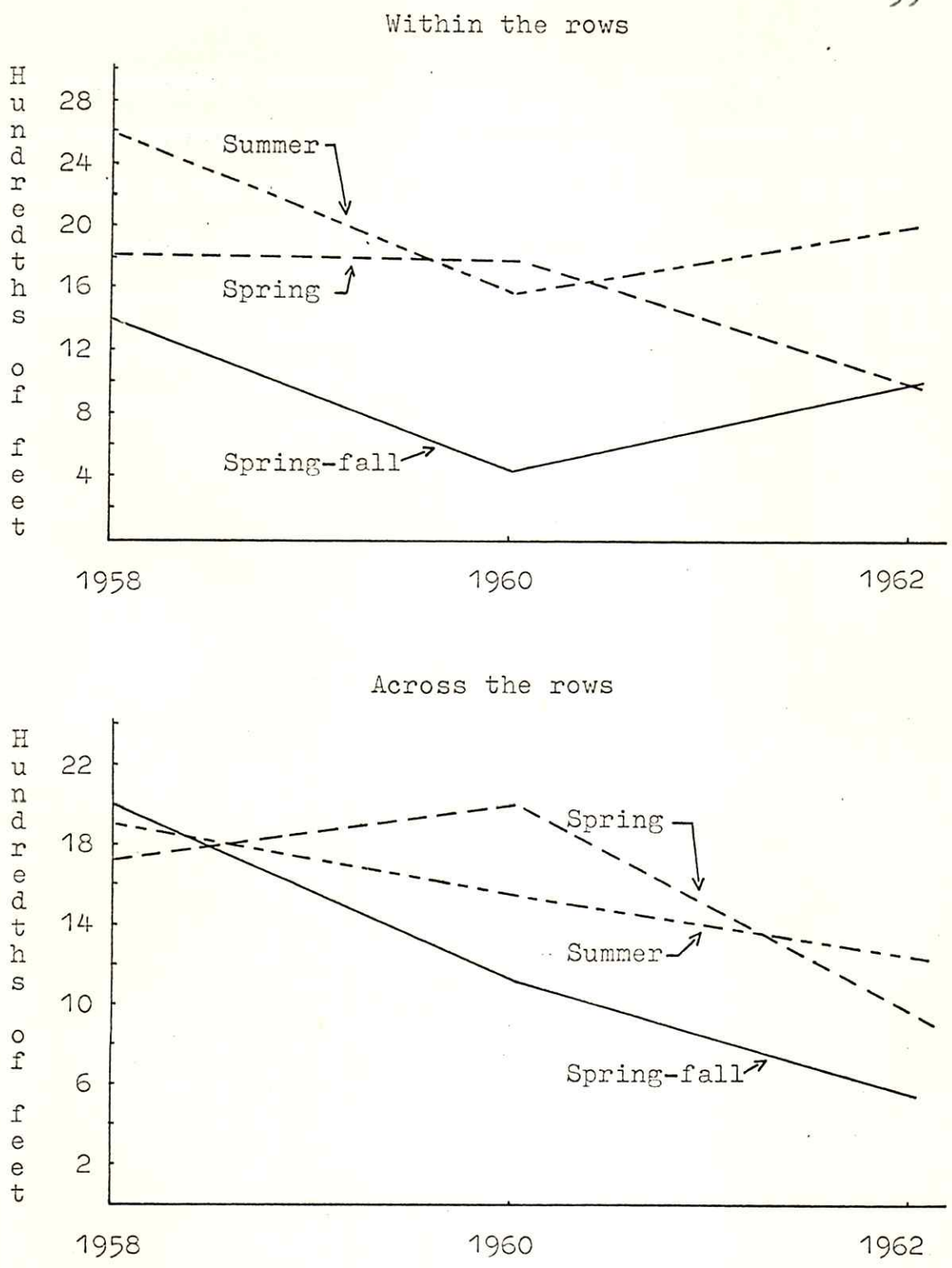

Figure 14.--Average size of segments of alfalfa intercepted on 20-foot-long permanent transects on pastures grazed at three different seasons.

and spring-fall grazing (Table 14 and Figure 14). After that the transects located within the rows showed an increase in the size of the segments, but those located across continued to decrease in size. On transects in spring-grazed pastures, the average size of the segments was maintained or increased during the first part of the study; after that, they rapidly decreased.

Chapter V

DISCUSSION

Effects of simulated grazing during the spring, summer and spring-fall on the growth pattern and total production of Russian wildrye and alfalfa

Russian wildrye.--The plots clipped during the spring and spring-fall seasons produced about the same amount of herbage during the spring. The grass was growing rapidly but the height was still relatively short at the time of the first clipping. The seedstalks were about the same size and hardly distinguishable from the leaves because they were still green and tender. The regrowth on the spring-fall treatment, after the spring clippings were concluded, was very little. This was due to the scarcity of precipitation during summer (Table 1). After September 12, when the last fall clipping was made, there was little regrowth. However, on the spring and summer treatment, there was a considerable amount of green tissue at the end of the growing season.

Simulated summer grazing did not remove any forage during most of the active growing period, and thus, permitted the plants to complete their growth before herbage removal. During the summer, the clippings were selective, as were the steers in their grazing, and not

many seedstalks were removed; mostly leaves were taken. The stubble height was higher and less uniform than on the spring and spring-fall treatments, and a higher proportion of leaves and stems remained standing after the clipping period.

The scarcity of precipitation during the middle and latter part of the growing season did not produce adequate moisture conditions for much regrowth during the summer and fall. Thus, most of the herbage yield was produced during the first part of the growing season.

Alfalfa.--All of the spring clippings of alfalfa plants were made during the time they were actively growing. After the spring clippings were concluded, the plants continued growing for a few more weeks.

On the spring-fall season of grazing, the yield obtained during the spring clippings was a measure of growth produced during the first part of the study, and the yield obtained in fall showed the regrowth produced after the spring clippings were concluded. The regrowth of alfalfa was much more than the regrowth of Russian wildrye.

The plants in the summer treatment were able to make the best use of the soil moisture. The plants grew actively during the spring when there was abundant soil moisture. After the summer season clippings were concluded, observations of the plots showed that there was

regrowth of the alfalfa plants during the last part of the growing season.

Cumulative growth of Russian wildrye

The cumulative growth of Russian wildrye as measured by its yield (Figure 5) reached the highest point during the first part of the growing season on June 20. This early growth was very rapid and at about the same rate; this was probably a consequence of the favorable moisture conditions at that time of year, due both to spring precipitation and snow accummulation during the dormant season. After the highest yield of the season was attained, there was an actual decrease in the total amount of herbage weight until July 4; the cumulative yield was maintained at about the same amount during the rest of the growing season until August 29. After August 29, the decrease in total herbage weight was considerable.

In a dry year like 1962, (Table 1) the total yield of Russian wildrye should be smaller than in a normal or wet year. The distribution of the yield throughout the growing season would be more affected by the distribution of the moisture. The variations in yield that were found after the maximum yield was reached were probably due to the scattered rains that fell during the growing season. Even a small amount of moisture during

this period produced considerable growth of the plants, which was immediately reflected in the yields. Periods of no precipitation corresponded to periods when low yields were obtained.

The percentage of yield contributed by the seedstalks was very small in proportion to the total yield (Table 8). Whitman and Kloesterman (1955) found that small amounts of seedstalks are produced when the plants are closely spaced. This was very possibly the reason in our study since a high proportion of seedstalks was found on the unsampled border rows, where there was little or no competition from Russian wildrye or other plants.

The average maximum leaf height increased until August 29, but after that, it decreased at the very end of the study period, on September 12. The average maximum height of the seedstalks continued elongating from the first date of sampling until July 4 (Figure 6 and Table 11). After July 4 there were some changes in the seedstalk height, but they were related to the several kinds of mechanical damage that broke some of the seedstalks in some plots, which changed the average height obtained at several dates of the growing season. The height of the seedstalks was probably more closely related to the stage of development of the plants than

to the moisture conditions of the year.

The fact that the average maximum height of the leaves and seedstalks showed no relationship with yield possibly indicates that yield is more a function of clump size than of height. Also there was no relationship between the height of the leaves and of the seedstalks. The seedstalks started to elongate later than the leaves, but they grew faster and reached the tallest maximum height at the middle of the growing season when they matured and dried. On the other hand, the leaves never dried during the growing season, and made good growth after any favorable moisture conditions.

Effect of season of use on the floristic composition of a pasture seeded with a mixture of Russian wildrye and alfalfa

The amount of cover of Russian wildrye decreased appreciably on the pastures grazed during the spring-fall season (Table 12 and Figure 7). On the pastures grazed only during the spring there was a slight tendency to maintain the same amount of cover at the end of the five-year period of study. The different reactions to grazing on spring and spring-fall pastures indicate that the additional fall grazing was harmful to the stand of Russian wildrye. The amount of cover of Russian wildrye on the pastures grazed during the summer increased during the first half of the study period

about the same amount as the spring-fall grazing pastures. During the second half of the study period, on the pastures grazed during the summer, the amount of cover continued to increase but at a lesser rate. Summer grazing was the treatment which maintained the best cover of soil.

The average number of segments of Russian wildrye intercepted per each 20-foot-long permanent transect increased the most on the pastures grazed in spring-fall (Table 13 and Figure 11). The increase in the number of segments intercepted can be interpreted as indicating a breakdown of the plants, and this in itself is a sign of deterioration. The excessive decrease in size of the segments intercepted is also a sign of the deterioration of the pastures grazed during spring-fall (Table 14 and Figure 13). On the pastures grazed during the spring only, there was a slight increase in the average number of segments intercepted on each 20-foot-long transect, and a slight decrease in the average size of the segments. Summer grazing was the only treatment that maintained segments of about the same size during the whole study period.

Considering the results on the number and size of the segments intercepted, we could consider that the most favorable season of grazing for Russian wildrye was summer grazing. Spring grazing was also favorable for

Russian wildrye, even though deterioration of the pastures was apparently more than under the summer grazing treatment during the period 1960-1962. The smaller and more numerous plants of Russian wildrye found in the spring grazed pastures would probably protect the soil better than the larger and more widely spaced plants in the summer grazed pastures.

The reaction of the plants to different seasons of grazing could possibly be interpreted as closely related to the carbohydrate accumulation in the plants. The effect of herbage removal, according to Blaisdell and Pechanec (1949) apparently depended upon the amount of herbage present during the storage period which follows cessation of growth. On the spring and summer treatments, there was a considerable amount of green tissue at the end of the growing season, thus permitting the plants to accumulate an adequate amount of carbohydrates during the period following cessation of grazing. Sampson and McCarty (1930) and McCarty and Price (1942) stated that early grazing or clipping once or twice early in the growth cycle did not affect the plants. Summer grazing started just after seed maturity, which according to McCarty and Price (1942) appeared to be the starting of the season of safe grazing or clipping.

Close to the end of the growing season, when the herbage is dry or drying, appeared to be the safest

period of herbage removal. Fall grazing on the spring-fall treatment, was accomplished just before this safest period at the end of the growing season, and just in a period which according to Conard (1954), would affect the plants. He stated that the removal of an aftermath crop in mid-September reduced the vigor of the plants the following spring, as compared with mid-season cuttings, and that delaying the harvesting until early or late October increased the yield of the grasses the following growing season. It is, therefore, apparent that fall grazing on the spring-fall treatment would not always permit adequate carbohydrate storage by the plants, and even with deferred grazing, it is necessary to leave a certain amount of forage to maintain the vigor of the plants which was not always done in the spring-fall grazing treatment.

On alfalfa, the decrease in cover on the pastures grazed during the spring-fall season was very pronounced, and at the end of the study period, the amount of alfalfa cover remaining was quite small (Table 12 and Figure 8). On the pastures grazed during the spring, the decrease of alfalfa cover was slight; ocular observation showed that after five years of grazing during the spring there was adequate cover of vigorous alfalfa plants. On the pastures grazed during the summer, the decrease in cover was about the same as in the spring

grazed pastures, but it appeared to be more because the amount of alfalfa cover at the beginning of the study period was greater on the spring pastures. The summer grazed pastures showed that, apparently, there was a tendency to maintain or make slight changes in the alfalfa cover during the second half of the study period.

Both number and size of the segments of alfalfa intercepted decreased in the pastures grazed during the spring-fall season. The pastures grazed during the spring showed an increase in the number of segments intercepted, but a decrease in the average size of the segments. On the summer pastures there was a slight decrease in the average number of segments intercepted per each 20-foot transect, but the average size of the segments diminished considerably.

Spring-fall treatment was apparently damaging to the plants, since it reduced the cover and left only a few alfalfa plants in the field. Summer treatment left enough big and vigorous plants, and spring also left sufficient alfalfa plants.

The results on both alfalfa and Russian wildrye show that spring-fall treatment is damaging for both kinds of plants. The amount of cover of both kinds of plants was appreciably reduced, but the disappearance of alfalfa plants was more noticeable. In the spring-fall pastures, even when the Russian wildrye plants

looked very weak, there were no bare spots. Ocular observation showed a considerable amount of both annual and perennial weeds.

At the end of the study period, there was a sufficient cover of Russian wildrye and alfalfa in the spring pastures, and ocular observation showed a marked increase of annual and short-lived perennial weeds.

In summer pastures, the grass and the legume cover at the end of the five-year study period was satisfactory. The vigor of the plants as estimated by ocular observation looked good, but there was considerable invasion of annual weeds, mostly cheat grass (Bromus tectorum), and a complete absence of perennial weeds. This was the treatment that better controlled the weed invasion.

Suggestions for additional studies

On the study of the effect of different seasons of herbage removal as simulated grazing, it would be valuable to measure its effect on the production and behavior of the Russian wildrye and alfalfa plants on the following growing season.

On the cumulative growth curve, as it was suggested in this paper, a close relationship could exist between the amount and distribution of the production throughout the growing season and the amount and

distribution of the precipitation. In this respect, it would be of interest to determine if this relationship exists, and if it exists, how much the amount and distribution of the precipitation affects the production.

The third part of the study, the effects of grazing on the floristic composition, suggested that it would be of great value to relate the effects of grazing on the reseeded forage species as well as in the amount and kind of weeds that appears under each season of grazing. It also suggests the importance of maintaining the same degree of utilization for all seasons of use.

Chapter VI

SUMMARY

A study was conducted to determine how the herbage removal at different seasons of the year affects the current growth and production of Russian wildrye and alfalfa plants and how it affects the floristic composition of a mixture seeded with the two species. The experimental work was accomplished on the Colorado State University Foothills Experimental Range at Fort Collins, Colorado.

One phase of the study consisted of the measurement of the effect of different dates of simulated grazing on the total forage production of Russian wildrye and alfalfa. Yields of the grass and the legume were similar when subjected to simulated grazing in spring, spring-fall or summer season of grazing.

Means of forage production obtained under simulated grazing in spring, spring-fall, and summer as compared with only one clipping made at the end of the respective season were not statistically different at the .05 level of significance. Mean yields obtained by simulated spring-fall grazing were more than those obtained from only one clipping made at the end of fall, at a .20 level of significance.

A second part of the study was a determination of the cumulative growth of Russian wildrye. The results showed that there existed a very rapid growth rate during the first part of the growing season until June 20, when the moisture conditions were adequate for the grass growth. After June 20, there was actually a sharp decrease in the yield until July 4. From July 4 until August 29 relatively uniform yields were obtained. During this period there were ups and downs in the yields, probably due to scattered rains falling during the growing season. Yields tended to decrease as the season advanced. From August 29 until September 12 there was a sharp decrease in the cumulative yield of the Russian wildrye.

The third part of the study consisted of the determination of the changes that occurred in the basal area of a pasture seeded with a mixture of Russian wildrye and alfalfa after five years of grazing in spring, summer and spring-fall.

The pastures grazed during the spring and fall showed a decrease in amounts of both Russian wildrye and alfalfa cover. The alfalfa plants practically disappeared and the Russian wildrye plants were reduced in both diameter and height. These pastures also showed a great invasion of both annual and perennial weeds.

The pastures grazed during spring maintained an

adequate cover of Russian wildrye and alfalfa plants throughout five years of grazing. The plants were vigorous and there was a good mixture of both the grass and the legume. Nevertheless, there was a considerable invasion of short-lived perennial weeds as well as some annuals.

On the summer grazed pastures, the cover was maintained through the five years of study better than under the other two grazing treatments. Both the Russian wildrye and alfalfa plants were vigorous and covered most of the soil. They protected the soil from weed invasion and only cheat grass was present in appreciable amounts.

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Abstract of Thesis

EFFECT OF HERBAGE REMOVAL AT DIFFERENT SEASONS ON THE CURRENT GROWTH AND PRODUCTION OF RUSSIAN WILDRYE AND ALFALFA

A study was conducted to determine how the herbage removed at different seasons of the year affects the current growth and production of Russian wildrye and alfalfa plants and how it affects the floristic composition of a mixture seeded with the two species. The experimental work was accomplished on the Colorado State University Foothills Experimental Range at Fort Collins, Colorado.

One phase of the study consisted of the measurement of the effect of different dates of simulated grazing on the total forage production of Russian wildrye and alfalfa. Yields of the grass and the legume were similar when subjected to simulated grazing in spring, spring-fall or summer season of grazing.

Means of forage production obtained under simulated grazing in spring, spring-fall, and summer as compared with only one clipping made at the end of the respective season were not statistically different at the .05 level of significance.

A second part of the study was a determination of the cumulative growth of Russian wildrye. The results showed that there existed a very rapid growth rate during the first part of the growing season until June 20, when the moisture conditions were adequate for the grass growth. After June 20, there was actually a sharp decrease in the yield until July 4. From July 4 until August 29 relatively uniform yields were obtained. During this period there were ups and downs in the yields, probably due to scattered rains falling during the growing season.

Yields tended to decrease as the season advanced. From August 29 until September 12 there was a sharp decrease in the cumulative yield of the Russian wildrye.

The third part of the study consisted of the determination of the changes that occurred in the basal area of a pasture seeded with a mixture of Russian wildrye and alfalfa after five years of grazing in spring, summer and spring-fall.

The pastures grazed during the spring and fall showed decrease in amounts of both Russian wildrye and alfalfa cover. The alfalfa plants practically disappeared and the Russian wildrye plants were reduced in both diameter and height. These pastures also showed a great invasion of both annual and perennial weeds.

The pastures grazed during spring maintained an adequate cover of Russian wildrye and alfalfa plants throughout the five years of grazing. The plants were vigorous and there was a good mixture of both the grass and the legume. Nevertheless, there was a considerable invasion of short-lived perennial weeds as well as some annuals.

On the summer grazed pastures, the cover was maintained through the five years of study better than under the other two grazing treatments Both the Russian wildrye and alfalfa plants were vigorous and covered most of the soil. They protected the soil from weed invasion and only cheat grass was present in appreciable amounts.

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