THE EFFECTS OF GRAZING AND RANGE SITE CONDITION UPON YIELD AND UTILIZATION OF TRUE PRAIRIE VEGETATION

by

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INTRODUCTION

The Flint Hills of Kansas were grazed by herds of wild animals such as bison and antelope long before civilization began to move into this range land to exploit its luxuriant grasses. For many years the users of this range failed to observe the gradual changes that occurred as a result of exploitation and abuse. Fortunately, due to the relatively light stocking practiced under "commercial" grazing, the abuse was not extremely serious, but out of it arose the need for study and experimentation on these range lands.

Experimentation with the native grasses and grasslands has been carried out for a relatively short period of time. The ultimate objectives of the work have been to maintain the best possible grassland cover and still realize the greatest sustained profit from their continual use. Improper use of such practices as burning, intensive grazing, and others in the Flint Hills of Kansas has made continued experimentation necessary in an effort to maintain the grasslands and improve their value as range land. It is from such work on this and other ranges that new concepts concerning the management of these lands have developed.

It is from past work too, that the problem with which this thesis is concerned has arisen. Herbel (1956), in addition to his thesis, began an experiment from which the foundation of this problem has developed. From this work more concise conclusions will be drawn relating to the effects of grazing and range site condition upon the yield and usage of true prairie vegetation. Specifically, to measure the yield and utilization as affected by different stocking rates, deferred-rotation grazing, and different burning dates were the objectives of this study. This was done in an effort to help solve problems involved with stocking rates, deferred-rotation grazing, and pasture burning.

REVIEW OF LITERATURE

Almost from the time the first domesticated animals grazed the Flint Hills of Kansas the carrying capacity of this range has been decreasing. Aldous (1938) and Anderson (1940) reported that prior to 1900 the carrying capacity of these ranges for a six months period beginning May 1 was one mature cow or steer for every two acres of grazing land. By 1933 this had decreased until the best pastures could handle only one mature animal for every four acres and the average was one for every five acres. After the great drought the carrying capacity was further reduced in many cases to one mature animal for every seven acres of land.

Weaver (1954) described the effects that result from the natural stress of drought upon the native vegetation. Besides the natural stress of drought, which for a period of years helped reduce the carrying capacity of the Flint Hills, there are man-made stresses. Chief among these is overgrazing. The results of this stress have been tested both through actual grazing trials and simulated grazing trials by many workers.

Experiments conducted by Voigt and Weaver (1951) have shown that light to moderate grazing of climax vegetation will not change the natural composition except over long periods of time. It is only when animals are confined to definite areas by fences and the given area becomes over populated that grazing and trampling become so excessive that the normal vegetative cover cannot be maintained.

Selection of grass types and preference for certain species by livestock, also studied by Voigt and Weaver (1951), is marked when forage is abundant. Repeated partial removal of the most palatable grasses results in better growth of the remaining vegetation. If those plants which are preferred are grazed too early, too often, and too closely, they will tend to disappear from the pasture. The less desirable species will then receive the nutrients, light, and water once taken by the more desirable species and will flourish as a result, often increasing rapidly.

Work done in the mixed-grass prairie of Oklahoma by Smith (1940) has shown that little bluestem (_Andropogon scoporius_ Mich.)[a] and sideoats grama (_Boutelouea curtipendula_ Mich. (Torr.) decrease in abundance even under moderate grazing and are forced out of the community when grazing is severe and continued over long periods. Contrary to Smith's work with sideoats grama in Kansas on some sites it tends to increase before it begins to decrease. As these grasses are eliminated from the vegetation, dominance is assumed by buffalograss (_Buchloe dactyloides_ (Nutt.) Engelm), hairy grama (_B. hirsuta_ Lag.), and blue grama (_B. gracilis_ (H.B.K.) Lag. ex Steud.), grasses normally sub-dominant in the climax mixed-grass prairie of that region but dominant in the western half of this prairie and in the short grass plains. Continued severe overgrazing accompanied by erosion produces conditions unfavorable for buffalograss and grama grasses,

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[a] Botanical names of grasses according to A. S. Hitchcock's (1951) _Manual of the Grasses of the United States_: of forbs according to M. L. Fernald's (1950) revision of Grays Manual of Botany.

and they in turn are replaced by less desirable grasses, including windmillgrass (Chloris verticillata Nutt.), tumblegrass (Schedonnardus paniculatus (Nutt.) Trel.), six weeks fescue (Festuca octoflora Walt.), little barley (Hordeum pusillum Nutt.), purple threeawn (Aristida purpurea Nutt.), and others.

Weaver and Darland (1948) have pointed out that Kentucky bluegrass (Poa pratensis L.) behaves as an increaser in the true prairie when dominant species are weakened by abuse. Anderson (1940) concluded that in actuality it is an invader as shown by its rapid decline during the drought of the 1930's. In the above work of Weaver and Darland they stated that the change in plant population from that of prairie to bluegrass was in itself not only a sign of degeneration but also one of decreased forage production. Growth of bluegrass, although greater in early spring and late fall than that of prairie grass, is much less during the summer. Thus, when prairie gives way to bluegrass the seasonal yields are often decreased 40 percent or more.

In work done at Manhattan, Kansas, Herbel (1956) concluded that plant density may also be reduced by undergrazing, but the total amount of forage produced remains unchanged. The large amount of mulch that accumulated with undergrazing seemed to make the ordinary upland and limestone breaks sites less desirable to the grazing animal. This shifted grazing use to the clay upland site where the mid and short grasses prevailed. In addition, Herbel's study pointed out that reduced amounts of mulch resulted from overgrazing. Lower mulch production resulted in increased water runoff. With less soil moisture lower forage yields were obtained.

With regard to mulches Dyksterhuis and Schmutz (1947) stated the following:

> With few exceptions, mulches are the primary factor in determining infiltration of rain water and in prevention of erosion. The chief factor limiting growth in grassland climates is water supply, which in turn is now largely limited by amount of water entering the soil. The most practical means of annually making more water available to the vegetation on vast acreages of grassland is through infiltration of a greater percentage of the precipitation that each climate has to offer.

Six years of overgrazing brought about a reduction in the amount of forage produced due to a loss of vigor of the range plants and a shift of plant species to that typical of the less productive pre-climax sites. This resulted in a less desirable, lighter mulch cover.

Herbel also pointed out that under-utilization resulted in a significantly larger accumulation of mulch than did moderate stocking. He cited work by Weaver and Fritzpatrick (1934) which showed that heavy accumulations of debris may greatly retard spring growth. Weaver and Rowland (1952) reported that a dense mulch also resulted in a thinner stand of the dominant species as well as reducing the yield of the dominant forage species, however, the prairie grasses can withstand considerable amounts of mulch without significantly altering the plant population.

Earlier work in Kansas, by Aldous (1930) has shown that clipping at two-week intervals in true prairie grass decreased the density of vegetation about 60 percent in three seasons. The disappearance of desirable species was proportional to the frequency of cutting. The higher nutritive value gained from frequent harvesting did not compensate the loss in yield.

Aldous (1938) further pointed out that average yields of forage over the seven years, 1927 to 1933 inclusive, varied inversely with the frequency of cutting. The highest yield was obtained from the plots that were clipped only at the end of the growing season. The lowest yield was obtained from the plots clipped each two weeks. Over 50 percent of the material clipped from this plot was annual growth as was shown by the studies on succession. One third of the foliage the plot clipped at three week intervals was weedy annual growth.

In this test Aldous measured the density of big bluestem (Andropogon gerardi Vitman) and little bluestem. There was little decrease in the density in unclipped plots. The other extreme was exhibited in the plots clipped each two weeks. These two grasses were eliminated with the exception of scattered plants that were the remnants of once vigorous clumps. The plots clipped each three weeks throughout the year had retained approximately a fifth of a stand, but the plants were greatly reduced in vigor.

In Wisconsin supporting evidence of the decrease in density of true prairie grasses was supplied by Nieland and Curtis (1956). Of the six grasses tested, big bluestem, swithgrass (Panicum virgatum L.), Canada wildrye (Elymus canadensis L.), indiangrass (Sorghastrum nutans (L) Nash.), and little bluestem were found to decrease in density in direct relation to increase in the intensity of grazing or clipping in that relative order, while sideoats grama at first increased and then decreased as defoliation became severe.

Gernert (1936) concluded the same as many others - that the oftener and closer the clipping or grazing the greater the damage to the vegetation.

In relation to total yield, further evidence agreeing with Aldous and others was proposed by Weaver and Hougen (1939). They obtained their information by analysis of data from combined clipping and grazing plots. Quadrats of little bluestem which had been clipped during two preceding years produced only 58 percent as much top growth as those clipped during a single preceding growing season. Compared with the controls, the yield was only 32 percent as great. Yield of plants clipped for two years was 54 percent of that of the controls. Moreover change in population was marked. Both bluestems practically disappeared and were replaced in part by sideoats grama.

Work done on solid stands of big bluestem showed that thinning of the grass after a single year of clipping was marked and infestation by weeds pronounced. The yield during a second year of cutting was only 72 percent of that on undisturbed quadrats. Quadrats clipped a second year yielded only 63 percent as much as those similarly treated for a single year.

On a pasture consisting of both big and little bluestem it was evident by the middle of June of the first year of the experiment that the bluestems had been handicapped by a single year of heavy grazing and trampling. Only remnants remained above the ground. Often the bunches and sods were merely outlined by living stems. Kentucky bluegrass, benefitting by the decreased composition of the native species, had increased rapidly.

Caird (1945) further substantiated forage production data when he showed that yield of blue grama-buffalograss pastures is reduced greatly by overgrazing. Plots adjacent to each other exemplifying both overgrazed and protected areas were compared. Clippings from these plots taken at a height of one inch showed widely different yields. Although the density was greater on the overgrazed area it still produced less than the protected area.

Bruner (1926) summarized effects of overgrazing and stated that early spring growth as well as the flowering and fruiting are retarded, grasses do not develop sufficiently to cover the soil and weedy plants are able to get a start, disturbances in the plant cover result in several important changes in the habitat, little humus is returned to the soil and its fertility is not maintained, lack of humus increases the runoff since decaying plant remains absorb large quantities of water, and finally the lack of a good plant cover promotes erosion of the steeper slopes.

One probable cause of overgrazing, and thus indirectly a cause of decreased yields of forage, is improper distribution of cattle over the range. A study by Moorefield and Hopkins (1951) based on observations of a two-hundred-animal herd during one grazing season disclosed that much vegetation was poorly utilized due to a tendency to graze some areas closely and to neglect others. Lowland comprised only 10 percent of the area, but the cattle spent about half of the time there except in July when greater use was made of the upland. Preference was determined in part by type and succulence of vegetation and location of salt and water.

In considering yield and utilization of vegetation the importance of soil and soil conditions should not be overlooked. Experiments by Cornelius (1946) have shown that under conditions of relatively low soil fertility and high summer rainfall, warm season native tall and mid grasses produced a higher yield of vegetation than native short grasses or any cool season grasses. A mixture of big bluestem, little bluestem, sideoats grama, and tall dropseed (Sporobolus asper (Michx.) Kunth.) gave highest production. These grasses used in a mixture appear to be satisfactory for pasture or hay and erosion control where sloping cultivating upland is being revegetated to grass in the eastern half of Kansas. Controlling the erosion of the soil will greatly aid in maintaining the soil fertility, thus inducing better yields and encouraging greater utilization.

More work by Smith (1940) indicated the importance of good soil care. When erosion began to occur following severe overgrazing, even the invading plant species dropped out of the prairie community. Many plants which were favored by overgrazing were unable to tolerate conditions produced by erosion, and as a consequence tended to decrease rapidly as erosion intruded.

The above study has also shown that the reference to change in the soil itself caused by overgrazing the percentage of coarser particles declined as overgrazing and erosion proceeded. On the other hand, the percentage of clay in the upper six inches of soil showed a continuous increase as erosion becomes severe. The amount of organic matter in the soil declined steadily as overgrazing continued and was reduced to 34 percent below that of undisturbed prairie in areas both overgrazed and eroded.

Caird pointed out that yields of grasses were dependent upon their location within a given area. Grasses situated in low areas would be in position to receive more moisture and consequently a higher yield would be expected. This corresponds somewhat with Kansas research relative to upland production versus lowland production in which higher yields are received from lowland sites where there is opportunity to make use of the larger amount of moisture.

In this study by Caird sites are referred to as areas which have poor, fair, or good soil conditions for grass production. Tall plants on sites with good soil conditions produced more forage than the shorter plants on sites with poor soil conditions even after the total yield on good sites had been reduced by assuming a high level of grazing. When different sites are in the same pasture, cattle usually eat the short grass on the fair sites closer to the ground than they do the taller grass on the good sites. With poorer soils and more runoff, this differential grazing tends to perpetuate the stunted growth on the uplands. The accumulation of the previous year's grass in the clumps after a year of excessive rainfall caused the cattle to take the new grass off the top of the clumps instead of grazing closely. The grass consequently assumes a taller growth form and provides better soil protection. The grass yield "off the top" equals or exceeds that on the closely grazed areas, according to the data on overgrazed and protected pasture areas.

Heavy grazing and especially heavy grazing on range sites in poor soil condition, causes much of the good forage to be produced so near the ground that it cannot be grazed off by the cattle.

Another indication of the effect of overgrazing on production of vegetation is found by examining the root systems plants of abused range land. Weaver (1950) made extensive studies of this nature and reported that as the native mid and tall grasses weakened and died due to heavy grazing and were replaced by low growing Kentucky bluegrass and blue grama, both depth of soil occupied by roots and the amount of root material decreased greatly.

Three selections of little bluestem roots were made. One each from a high grade, mid grade, and low grade pasture was obtained. Decrease in the density of the root mass at all levels from the high grade to the low grade pastures was clearly evident. The roots were nearly 5 feet deep in the high grade sample, about four feet in the mid grass sample, and they are extended nearly to 3 feet in the low grade sample. The dense crown of the high grade sample was separated with much difficulty. The more open crown of the mid grade sample was easily torn apart, while the low grade was so nearly decayed that it fell apart. Root weight decreases from high grade to low grade as well. Thus, root weight of a species, like the weight of the top, varies from place to place, according to soil type, but especially according to the proper use or abuse of the vegetation.

Aldous (1938) stated that the yield of roots as well as the top growth decreased as the clipped treatments extended from year to year. The root content of the more closely clipped plots were composed of from 30 to 60 percent annuals and weeds during the last of the three years the roots were measured.

In work that was carried on three years earlier Aldous (1935) showed that pastures were reduced in productivity mainly by close grazing. This resulted in a gradual weakening of the plants, the amount of weakening depending upon the closeness of the grazing and upon weather conditions. All of the carbohydrates (starch and sugars) are elaborated in the leaves of the plant while the water and mineral nutrients (calcium, potash, phosphorus, iron, etc.) are taken in through the roots. The continual close removal of the top growth reduces the food making capacity of the plant. Without good top growth the carbohydrates cannot be produced. The close cropping of the top growth also results in a proportionate decrease in the quantity of roots. With fewer roots produced less of the necessary water and mineral nutrients can be taken up. Defoliation is most detrimental to plant growth at the beginning of the season. Because the plant draws on stored food reserves to make its initial growth this withdrawal continues until the foliage has developed sufficiently to supply its growing needs. Consequently, foliage that is kept closely cropped may never reach sufficient size to produce enough food to satisfy plant growth and other current needs, and the plant will continue to deplete the reserve supplies which should normally be building back to full strength.

Another man-made stress placed upon range land is that of annual burning. Herbel (1954) reported that the date of burning affected the density of plant cover, density here referring to the ground surface area covered by the basal portions of culms and clumps of grasses and forbs. He pointed out that the earlier the burning in the spring the less the density of the cover. This was due in part to the close in surface protection which halts water runoff and aids in holding the soil in place. Duley and Domingo (1949) and Duley and Kelley (1939) as quoted by Anderson (1951) revealed that grasslands with cover removed suffer severe losses. They emphasized the great importance of native sod in retaining a high infiltration rate. Removal of the grass tops made the remaining soil surface very nearly comparable to that of cultivated land. Soils that are well grassed and covered show little or no erosion on slopes up to 15 or 20 percent. Under normal conditions there can be no accelerated erosion under climax cover, but if this vegetation is removed by burning and the soil left bare and if the new coming vegetation is less dense then range site conditions and grazing intensity will be affected.

In recent work by Hanks and Anderson (1957) the long time effects of pasture burning on moisture conservation was studied. They found that an unburned check plot had 6.5 inches of available water in the surface five feet of soil compared with 1.05 inches for the late fall burned plot.

That burning influences intake of water by the soil and evaporation of water from the soil was also shown in the work by Hanks and Anderson. Following a two week period during which 4.47 inches of rain was received, soil moisture samples were taken. Of the 4.47 inches of rain 3.75 came in one storm and the soil moisture samples showed that of the total rainfall the unburned plot retained 83 percent of the moisture and the late-fall-burned plot retained 39 percent. Other burned plots varied in percent of moisture retained between these two figures, the one closest to the unburned being the late-spring-burned plot with 46 percent.

In tests by Robocker and Miller (1955) in Wisconsin burning appeared to be injurious to Canada and Virginia wildrye (Elymus virginicus L.), which began their growth early in the spring, and to big bluestem, little bluestem, and sideoats grama on areas in which erosion was extensive. Switchgrass and little bluestem increased under burning and big bluestem increased under burning in areas where competition from Kentucky bluegrass and other plants was severe. Indiangrass also tended to increase and sideoats grama showed no real changes in density as a result of burning. The increase of such grasses as big bluestem, switchgrass, and indiangrass under burning would seem to contradict the results obtained in earlier work done in Kansas, Nebraska, and other grassland states. However, the Wisconsin experiments were done on forest soils, the Miami and Crosby. These grasses were hand planted and represented preclimax vegetation on those soils. Therefore anything such as burning that would tend to dry out the soil would be likely to cause preclimax communities to increase at the expense of the true climax just as preclimax grass communities had resulted in the trials by Aldous.

According to Penfound and Kelting (1950) the effects of winter burning on utilization and certain environmental factors in a little bluestem pasture were as follows: there was little or no utilization in the unburned area whereas the degree of use in the burned area ranged from 90 percent during the spring to 15 percent in late August.

Various workers have measured the actual yield of different species of prairie grasses under normal growing conditions. Reigel (1947) in a study at Hays, Kansas, measured eight different species consisting of buffalograss, bluegrama, sideoats grama, big bluestem, little bluestem, switchgrass, tall dropseed, and sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray). These were clipped four times during the summer. The short grasses were clipped at one-half inch, while the taller grasses were clipped at one inch. In all the species the largest yield occurred from the earliest (June 15) cutting. The yields for the entire season were as follows: little bluestem 3,315 lbs. per acre, switchgrass 2,840 lbs. per acre, big bluestem 2,823 lbs. per acre, buffalograss 2,240 lbs. per acre, tall dropseed 2,002 lbs. per acre, sideoats grama 1,938 lbs. per acre, blue grama 1,842 lbs. per acre, and sand dropseed 1,114 lbs. per acre.

Additional work by Riegal and others (1950) in western Kansas measured both production and utilization on short grass pasture, wheatgrass-short grass pasture, mid grass pasture, and lowland pasture. On the mid grass type 1,075 lbs. per acre of forage (air dry weight), had been produced and 68.4 percent had been utilized by the end of the year. Both production and use were greatest on the lowland type. Total available forage on lowland was 6,324 lbs. per acre and nearly 92 percent was consumed. The lowland or postclimax type of vegetation represented true prairie climax.

Darland and Weaver (1945), working in relict prairie vegetation, found the total yield per acre to be slightly over three and one-half tons, of which nearly three tons were consumed. Both the amount of forage produced and the amount consumed on true prairie were much greater than those on Kentucky bluegrass. Also more forage was left unconsumed.

In the Flint Hills of Kansas, Anderson and Fly (1955) found population differences due to site. The sites were differentiated largely by soil conditions and slope. Ordinary uplands and limestone breaks sites exhibited greater percentages of the mid and tall grass dominants of the climax than did other range sites although populations on postclimax lowland sites were not reported. Either of those sites was shown to be capable of producing full regional climax vegetation, but limestone breaks tended to support somewhat more sideoats grama and the ordinary uplands somewhat more Kentucky bluegrass. Clay upland and claypan were typified by greater percentages of the short grass species and were classed as a preclimax sites.

According to Dyksterhuis (1949) a site separation for any area may be justified if: (1) there is a sufficient difference in species composition in the climax or, (2) there is a sufficient difference in productivity to justify recommendation of a different stocking rate. Herbel (1956) added another justification based on accessibility or degree to which animals use it. The limestone breaks site was separated from ordinary upland largely upon this basis.

The development and use of systems for classifying range condition were traced back to the work of Sampson (1919). "Common denominators" then currently in use seemed to be: (1) recognition of secondary succession toward a climax type and, (2) the use of floristic composition to indicate condition or position of a range in the succession.

Dyksterhuis continued to point out that the evaluation of a quantitative system of range condition classification was reviewed, particularly the practical problems enocuntered by field technicians and how these problems included such things as: (1) distinction between factors relating to trend in condition and factors determining condition at any one time, (2) development of a site classification not dependent upon current vegetation so that both current and potential range conditions under the climax theory could be recognized, (3) replacing an empirical grouping of range plants with an ecological classification, namely decreasers, increasers, and invaders, based upon response to grazing, and (4) quantitatively determining range conditions rather than quantitatively describing selected conditions.

After a number of years of field testing and development, the system now includes: (1) declination of sites based upon floristic composition differences or foliage production of the climax, which are caused by edaphic conditions, (2) declination of range condition classes based upon percentages of decreasers, increasers, and invaders as measured from relative amounts in the climax for the site, (3) a recommended stocking rate based upon stocking experience locally and at experimental stations, supplemental where necessary with differences in plant production associated with sites and condition classes within a belt of similar average rainfall, and (4) permanent line interception transects in key areas to provide quantitative checks on effectiveness of management. Quantitative guides are prepared by field technicians for their local areas. The guides are easily revised to incorporate new findings by research pertinent to their use.

With no outside stress applied yields could be different from site to site, as could grazing intensities, due both to species preference by the livestock and to physical condition of the sites.

Anderson and Fly (1955) further concluded that a close relationship continued to exist between site conditions and species composition even after some degree of degeneration has resulted from grazing. This was emphasized by the fact that the most favored sites still contained the greatest amounts of decreasing species.

Earlier work by Anderson (1953) has brought to attention the fact that the actual climax vegetation of the Flint Hills contains very little nonpalatable plant growth. The yield generally is high, ranging from 1000 to 3000 pounds of dry matter per acres on range in excellent condition.

Close forage removal according to Anderson results in retrogression as evidenced by rapid decrease of csrtain major grass species typified by the bluestems and by such forbs as perennial sunflowers and legumes. At the same time other grasses such as the gramas, certain dropseeds, and numerous forbs and shrubs, such as Baldwin ironweed (Vernonia baldwini Torr.), hoary vervain (Verbena stricta Vent.), perennial ragweed (Ambosia psilostachya

DC.), coralberry (Symphoricarpos orbiculatus Moench), and smooth sumac (Rhus glabra L.) became more abundant. Invasion, principally by annual grasses and forbs at first and later by perennials, also occurred.

In experimenting with various systems of grazing Anderson (1940) revealed that the most "ideal" method whereby one might use the native range and still maintain a good ecological climax or subclimax condition was through a system of deferred rotation grazing. This system if properly used could help halt the steady decrease in carrying capacity of Kansas ranges caused by overgrazing, burning, and other exploitation.

MATERIALS AND METHODS

This experiment has been carried out with the intention of finding the effects of management and range site conditions upon the yield and utilization of true prairie vegetation. Range site condition is used here in the ecological sense, as determined by the mutual relationships of the vegetation with its environment, and not in the sense that the range technician means when he says a range is in excellent or fair condition.

The range technician generally refers to a range condition determined by the percent of original vegetation which the present plant population represents. The ecologist generally refers to a range site condition in relation to its ecological sere. The sere being a series of stages through which a plant community passes as it develops from its first pioneering stages to its climax stage. Range site condition is described and determined by the stage of development in the sere. This is often spoken of as preclimax, being some stage below true climax, climax representing the optimum soil-vegetation equilibrium, or post climax being some stage above that accepted as climax.

Experimental Area

General Description. The Flint Hills occupy about 4,000,000 acres in the western half of the eastern third of Kansas. Of this approximately 2,800,000 acres still are native grassland. The nine pastures on which these experiments were conducted occupy a portion of a 1,143 acre tract of land purchased by the Kansas Agricultural Experiment Station in 1946. This tract of land is known as Donaldson Pastures and is located about six miles northwest of Manhattan, Kansas. The approximate legal description is Sec. 27 R7E T9S; E1/4 Sec. 28 R7ET9S; and N1/2 Sec. 34 R7ET9S. Six of these pastures have been reported by Anderson and Fly (1955) to be typical and representative of Flint Hill pastures. Since the other three are part of the same tract of land and are of the same general physical nature it is assumed that they are also representative.

The climate of the Flint Hills is typically true prairie. The rainfall ranges from 30 to 38 inches from northwest to southeast. Nearly 75 percent of it falls during the growing season which is 150 days long in the north and 170 days in the south.

The elevations of the Flint Hills region varies from 1,500 feet in the central part to 850 feet at the extreme southeast corner. The area geologically represents a highly dissected plain. The terrain is rolling to hilly with relatively smooth, narrow divides bordered by rock outcrops and steep slopes. Escarpments occur adjacent to major stream valleys. The soil is residual and has developed from Permean formations. Massive limestone forms the bedrock.

In terms of cultivation the soil is shallow but the limestone is broken under the ridge slopes and moisture and root penetration is deep. The ridgetops often have shallow soil over tight clay, resulting in less moisture relations. The soils generally are rocky, often with cherty materials at the surface, consequently only limited areas can be brought under cultivation. Cultivation is confined to the small valleys and to certain gently sloping uplands ,Anderson (1951). Wide variation exists in the ability of the soils to support regional climax type vegetation. The surface soils are slightly acid in reaction and the fertility is high to moderate.

Specific Description. The nine pastures concerned in this work have been mapped out into range sites. Six different sites were ultimately designated. A detailed account of the range site determination can be found in work done by Anderson and Fly (1955). Briefly the six sites are:

Ordinary Upland Range Site. Lands having sufficient depth of soil with medium or loamy texture and hence with suitable soil-plant moisture relations to support the type of vegetation that is climax on the zonal soils of the regional climate.

Limestone Breaks Range Site. Land similar to the above but occurring on slopes of 35 degrees or more and therefore subject to somewhat greater loss of moisture by runoff and with less development. The vegetation, however, is like that of the above site in its major features and may be considered climax in nature.

Clay Upland Range Site. Lands having sufficient depth of soil but somewhat less infiltration, slower permeability, and a smaller percentage of water available to plants than ordinary upland, hence supporting a somewhat preclimax vegetation.

Claypan Range Site. Lands having sufficient depth of soil, but with even more restrictive water relations than the clay upland sites, thus supporting a preclimax vegetation.

Very Shallow Range Site. Lands having insufficient depth of soil for normal water storage, hence supporting under proper grazing a vegetation distinctly preclimax.

Lowland Range Site (gullied). Lands receiving more water than normal and having, because of position and soil depth, such moisture relations as to support a post climax vegetation under proper grazing (with gullies controlled).

Of these six range sites, two occurred through all nine pastures in areas large enough to allow adequate sampling. Those two were ordinary upland and limestone breaks. In six of the pastures the clay upland range site also was extensive enough to be sampled adequately. In the other three claypan was present in areas of adequate sampling size. These particular three pastures are forty-four acres each in area. They are moderately stocked (5 acres per animal unit) season long and have been used in comparing early, mid, and late spring burning, hence they will be referred to as burned pastures from this time on. They carry the numbers 9, 10, and 11, pasture 9 burned in early spring (mid March), 10 in mid spring (about April 10), and 11 in late spring (about April 30).

The remaining pastures, Herbel (1954), contain sixty acres each. They are designated by numbers 1 through 6. No burning has been done in them, but they represent various stocking rates. Three of the six are grazed season-long (May 1 through October or until such fall date as it becomes necessary and practical to remove the livestock), and the other three are grazed in a deferred-rotation plan as shown in Table 1. Season-long grazing is at three rates of stocking, light (7.5 acres per animal unit), moderate (5 acres), and heavy (3.5 acres). One of the three pastures in the deferred-rotation system has been deferred until July, while the other two carry the stocking load for all three pastures until that time. After July 1, all of the cattle have been placed upon the deferred pasture for the remainder of the grazing season. However, if the grass on the deferred pasture became closely grazed the gates to the other two were thrown open in the fall and the cattle were allowed to graze all three pastures the remainder of the grazing season. This system has been rotated annually in order to defer each pasture once each three years. The average stocking rate of these deferred pastures is at the moderate rate.

Sampling Methods

In 1954 and 1955 four-by four-foot cages were placed at randomized locations on the ordinary upland, limestone breaks, and clay upland range sites in the six sixty-acre pastures. Later, like cages were also placed on the ordinary upland, limestone break and claypan range sites in the burned pastures. It is from clippings taken from these cages and corresponding clippings taken from representative areas outside the cages that data for this problem have been collected.

Table 1. Stocking rates and management practices of Donaldson Pastures 1 through 6 and 9 through 11.*

Pasture number	1	2	3	4,5 & 6	9	10	11
Stocking Rate	Moderate Stocking	Heavy Stocking	Light Stocking	Each Moderately Stocked	Moderate Stocking	Moderate Stocking	Moderate Stocking
Acres per animal unit	5.0	3.5	7.5	5.0	5.0	5.0	5.0
Management practice	Normally Stocked	Over Stocked	Under Stocked	Deferred Rotation	Early Spring burned	Mid Spring burned	Late Spring burned

*Taken in part from Kansas Agricultural Experiment Station Circ. 358. 1958.

Ahlgren (1947) has pointed out that pasturage, under natural conditions is harvested directly by livestock, whereas forage used for hay or ensilage, small grains, corn, and other feed crops are generally harvested by machines. In pasture research both livestock and mechanical equipment are used in measuring results even though it is realized that animals graze preferentially and affect the sward in a manner which cannot be duplicated by mechanical harvesting.

To be most effective any method or technique used in measuring results must (a) be relatively inexpensive, (b) be reliable and reasonably unbiased, and (c) provide results within a reasonable period. Methods of measurement must take into a consideration the variables caused by differences in species, relative palatability, storage of growth, management, fertility, and climate.

Robinson and others (1937) have shown that yields from clipped permanent plots gradually decrease in relation to the yields obtained in grazing, but there were high correlations between the yields from clipping and those from grazing from year to year.

Brown (1937) concluded that yields from continuously clipped, permanently caged areas were lower than those of cages mowed annually.

A pasture improvement committee of the American Society of Agronomy (1952) have found the following:

> Good clipping techniques may give more precise yield data than computed yields based on animal productivity and maintenance due to animal variability. The following principles may be used as a guide in sampling for herbage yields by clipping or other techniques: (1) Divide a pasture into four or more strata. (2) Take 2 to 8 samples at random within each stratum. The larger the number of samples, the lower the variance between pastures. North Carolina data (51) show that 5 cages 4 feet by 4 feet in size per pasture were insufficient to measure total herbage yields or botanical composition. More recent tests show that more than 9 cages per pasture will be needed to obtain reliable results. (3) Use long narrow areas for clipping, 1.5 feet by 12 feet or areas of larger size and similar shape. Larger samples, if the number is kept constant, will decrease the variance. (4) It is desirable to sample herbage on a growth stage basis rather than on a date basis. (5) Except where botanical analyses are made from the samples, they should be dried to an oven-dry basis within 24 hours to keep fermentation and respiration losses at a minimum. Yields should be reported on an oven-dry basis.

Ahlgren and others (1938), Brown (1937), Gardner and others (1935), Hodgson and others (1933), and Jones and others (1937), have all reported higher yields from clipping or mowing experiments than from actual grazing, however, Brandt and Ewalt (1939) and Linehan and Lowe (1946) have pointed out that total digestable nutrients from both clipping tests and grazing tests are essentially the same.

Clippingsin this experiment were taken at the end of the grazing season. Each cage was moved after the clippings had been taken to give more accurate results the following year. The grass was clipped at a height approximating close grazing or about one to one and one half inches both inside and outside the cage. An area of 4.36 sq.ft. was sampled.

The samples outside the cages were taken from areas in which the species composition of the vegetation approximated that under the cage. An attempt was made in each case to select a representative area, representative being an area of like vegetation and, visually, neither over nor under grazed.

It was intended that at least ten cages be placed on each site in each pasture. However, due to the destruction of some cages by livestock, some sites had fewer than ten. From each clipping were taken three types of vegetation samples; forage, weeds, and mulch. The forage included all grasses and palatable forbs. The weeds were unpalatable forbs, and the mulch was the dead fallen vegetative material upon the ground. Each type of material was placed in a paper bag at the time of sampling and properly labeled. The bags were strung on heavy twine and hung in the greenhouses to dry. The contents of each bag was then weighed and the air dry weight recorded.

Yield and utilization were calculated for all three vegetation types in all but the burned pastures. No mulch was present in these pastures as it had been destroyed the previous spring by fire; therefore, only forage and weeds were measured.

Yield was measured by weighing the entire sample of forage, weeds, or mulch from under the cage and using the calculated conversion factor to figure pounds per acre. Total yield was the sum of all three vegetative types.

Utilization was measured by weighing the sample of a like vegetation type from both caged and uncaged areas and subtracting the uncaged weight from the caged. This figure was in turn converted into pounds per acre.

EXPERIMENTAL RESULTS

Statistical Procedure

The results of this experiment have been placed in an r x c (row x column) table, and analyzed according to procedures prescribed by Goulden (1952) in Methods of Statistical Analysis. This method was necessary due to unequal sample numbers in the various sites and to the presence of different sites in different pastures. The nine pastures were divided into three separate groupings. The groups were designated 3 x 6, 2 x 9, and 3 x 3. Pastures one through six contained three common sites of such size as to permit adequate sampling. They made up the 3 x 6 group. Pastures one through six and nine through eleven contained two common sites large enough to provide adequate sampling. They are designated as the 2 x 9 group. Pastures nine through eleven included three common sites and made up the 3 x 3 group.

Within each of these groups the following comparisons were made: (1) total pasture yields, (2) total yields of forage, mulch, and weeds by pasture, and (3) total forage, mulch, and weed yields by site.

Clipping Data

The clippings from which these data were obtained were taken in the fall of 1956 and 1957. Data of both years were used in preparation of the results of this investigation. Both yield and utilization from the variously stocked pastures and the burned pastures were tabulated. The first comparisons were made among yields of total vegetation of pastures 1 through 6. Pasture 1 was moderately stocked (5.0 acres per animal unit), 2 was heavily stocked (3.5 acres per animal unit), 3 was lightly stocked (7.5 acres per animal unit) and 4, 5 and 6 were moderately stocked under a system of deferred rotation grazing. The three sites used for sampling, which were common to all six pastures, included ordinary upland, limestone breaks, and clay upland.

Table 2 contains the analysis of variance for the total vegetative yield in 1956 relating to these six pastures.

The F value in this table indicates significance in yield among pastures at the .05 level. Also included in this table is

Table 2. Analysis of variance and Duncan's New Multiple Range Test[a] of total 1956 vegetative yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pastures)	5	38112.24	7622.45	2.756*
Obs: Subclasses	510	1410452.47	2765.59	

Duncan's Test

n[1]	87	93	105	81	51	99
$\bar{x}$[2]	62.44	74.55	75.86	78.26	81.88	90.34
Pasture	2	1	5	6	4	3

[a] Any two means not underscored by the same line are significantly different (P.05). Any two means underscored by the same line are not significantly different.

*Indicates significance at the .05 level.

[1] n indicates number of observations.

[2] $\bar{x}$ indicates mean of plot observations.

Duncan's New Multiple Range Test and it indicates which pastures differ significantly. According to this test pasture 3 yields significantly more vegetation than pasture 2, but it is not significantly greater than any of the other pastures. This situation indicates that there is a relationship between stocking rate and total yield. Heavy stocking appears to reduce the total yield of vegetation on pasture 2.

In 1957 data from additional clippings were recorded. To enable comparisons with the 1956 data the analysis of variance and Duncan's test are presented in Table 3.

The F value is significant at the .05 level indicating a significant difference among the six pastures. To determine more

Table 3. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pastures)	5	63450.00	12690.00	2.885*
Obs: Subclasses	591	2599351.64	4398.23	

Duncan's Test

n :	99	99	99	102	99	99
$\bar{x}$:	73.33	79.33	85.97	89.43	98.50	99.98
Pasture :	1	2	5	4	6	3

fully which pastures are significantly better Duncan's test was included. Pasture 3 yielded more than pastures 1 and 2. This indicates that heavy stocking does reduce total yield. Pasture 1 is also more heavily stocked than pasture 3. Pasture 6 yielded significantly more than pasture 1. The remaining pastures did not differ significantly from one another. In both 1956 and 1957 the pasture with the light stocking rate yielded significantly more than the pasture with the heavy rate of stocking.

As mentioned earlier, both yield and utilization were meas-used and recorded on these six pastures. The analysis of variance and the multiple range test of the 1956 pasture utilization data are given in Table 4.

There is an indication from the data that significant differences did exist in amount of utilization among pastures. Duncan's test reveals that the pastures which yielded most were utilized

Table 4. Analysis of variance and Duncan's New Multiple Range Test of total 1956 vegetative utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture)	5	39235.50	7847.10	4.251**
Obs.: Subclasses	510	941345.50	1845.78	

Duncan's Test

n :	99	81	105	93	87	51
$\bar{\bar{x}}$:	246.91	251.51	259.44	266.38	266.90	272.98
Pasture :	3	6	5	1	2	4

**Indicates significance at the .01 level.

significantly less than those which were lowest in total yield.

Similar data were recorded and tabulated for 1957 utilization in Table 5. The analysis of variance indicated significant differences in utilization among pastures. Duncan's test reveals the same general trend. Highly utilized pastures appeared to be

Table 5. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pastures)	5	23798.85	4759.77	2.390*
Obs: Subclasses	591	1176864.15	1991.31	

Duncan's Test

n :	99	99	99	102	99	99
$\bar{\bar{x}}$:	168.40	178.44	181.67	183.28	184.91	188.36
Pasture :	1	6	5	4	3	2

low in total yield.

In order to compare pastures 1 through 6 with the burned pastures 9 through 11, two sites common to all nine pastures were sampled. These two sites were ordinary upland and limestone breaks. The three burned pastures were all grazed at the moderate stocking rate.

The 1956 yield of total vegetation on these two sites in each pasture was compared in Table 6.

Table 6. Analysis of variance and Duncan's New Multiple Range Test of total 1956 vegetative yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture)	8	84036.43	10504.55	3.194**
Obs: Subclasses	465	1529194.82	3288.59	

Duncan's Test

n	36	34	63	32	75	36	75	54	69
$\bar{x}$	64.36	65.15	67.51	72.59	76.71	81.78	83.15	89.89	106.77
Pasture	11	10	2	9	1	4	5	6	3

There is indication from the F value in Table 6 that significant differences among pastures do exist. Duncan's test shows that a significant difference in yield exists between pasture 3 and pastures 1, 2 and the three burned pastures; three yielded signicantly more than the others.

The results obtained from the 1957 yield data concerning pastures 1 through 6 and 9 through 11 are shown in Table 7.

Table 7. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture)	8	107566.05	13445.76	2.770**
Obs: Subclasses	539	2615550.90	4852.60	

Duncan's Test

n	72	72	44	46	69	72	69	44	60
$\bar{x}$	68.80	80.49	84.54	84.67	87.93	91.78	102.80	102.91	118.07
Pasture	1	2	9	10	5	4	6	11	3

The analysis of variance reveals significant differences among yields of pastures. According to Duncan's test pasture 3 yields significantly more than all pastures except 4, 6, and 11. Pastures 6 and 11 yield significantly more than pasture 1. Pasture 3 was stocked at the light stocking rate and its yield was high while the pastures yielding lower than 3 were all grazed at heavier stocking rates. In addition pastures 9 and 10 were burned annually, in early spring and in mid spring respectively. Pastures 1, 6 and 11 were each stocked at the moderate stocking rate, but 6 and 11 are significantly different from 1. This may be explained by the fact that 6 was one of the three deferred-rotation pastures. Theoretically this should give it a slight advantage over pasture 1 (stocked season long with no deferrment). It is difficult to say why pasture 11 was significantly different. The late burned pasture treatment may or may not be the explanation for significantly different yields in this case.

The utilization comparisons for 1956 are presented in Table 8.

The F value from the analysis of variance is significant for utilization among pastures at the .01 level. The trend, as indicated by Duncan's test, was generally the same as that for pastures 1 through 6. Pastures in the high utilization group generally rank low in yield, while those low in utilization usually rank high in yield. Examples of this are pastures 3 and 6 in Table 8 which are significantly lower in utilization than any other pastures and which are significantly higher than all others except 4 and 11 in yield (Table 7).

The utilization data for 1957 gave results shown in Table 9

Table 8. Analysis of variance and Duncan's New Multiple Range Test of total 1956 vegetative utilization in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture	8	53422.75	6677.84	3.339**
Obs: Subclasses	465	93018.95	2000.04	

<u>Duncan's Test</u>

n :	69	54	75	75	63	34	36	36	32
$\bar{x}$:	243.55	250.80	263.07	265.16	267.22	268.29	269.97	270.53	283.28
Pasture :	3	6	5	1	2	10	11	4	9

Table 9. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative utilization in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S..	F
Subclasses (pastures)	8	71058.22	8885.65	4.430**
Obs: Subclasses	539	1080988.73	2005.54	

Duncan's Test

n :	72	46	69	69	72	44	44	72	60
$\bar{\bar{x}}$:	158.06	162.26	173.72	174.96	178.96	180.70	188.70	189.70	193.07
Pasture :	1	10	6	5	4	9	11	2	3

which also show highly significant differences among pastures.

Duncan's test indicates that, contrary to the general trend, pasture 3 ranks significantly higher in utilization than 1, 5, 6 and 10 which were all grazed at heavier rates. Pasture 2, however, follows the previous trend. It is usually low in yield (Tables 2, 3, 6, and 7) and in the above analyses it is higher in utilization as it was in Tables 3 and 5.

In burned pastures, 9 through 11, three common sites were sampled. They consisted of ordinary upland, limestone breaks, and claypan. Observations for total yield and utilization were made and the tabulated results are given in Table 10.

Table 10. Analysis of variance and Duncan's New Multiple Range Test of total 1956 vegetative yields in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pastures)	2	1771.20	885.60	0.224 n.s.
Obs: Subclasses	117	463225.30	3959.19	

Duncan's Test

n :	42	44	34
$\bar{\bar{x}}$:	60.31	63.61	69.94
Pasture (b) :	10	11	9

n.s. Indicates non-significance at the .05 level.

(b) 9 (Burned in early spring), 10 (burned in mid spring), and 11 (burned in late spring).

Neither the analysis of variance nor Duncan's test revealed significant differences among pasture yields in 1956. Similar results were obtained from the 1957 yield data as shown in Table 11.

Table 11. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative yields in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture)	2	15284.28	7642.14	$0.621^{n.s.}$
Obs: Subclasses	173	2130124.72	12312.86	

Duncan's Test

n :	64	52	60
$\bar{\bar{x}}$:	84.26	86.63	104.88
Pasture[(a)] :	9	10	11

The tendency for total vegetativs production to remain constant among pastures with respect to burning dates is shown. This, however, implies nothing about the species of vegetation present in the total production.

The utilization data collected from these pastures in 1956 suggest that significant differences are not present.

It could be concluded that there would be no significant differences among these pastures because the stocking rate is the same in each case. This may be true but it does not rule out the possibility of some other factor affecting the degree of utilization. An example of such a factor is the more abundant production of desirable species in one pasture than in another.

Table 12. Analysis of variance and Duncan's New Multiple Range test of total 1956 vegetative utilization in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pasture)	2	4758.16	2379.08	$1.310^{n.s.}$
Obs: Subclasses	117	212536.77	1816.55	

Duncan's Test

n :	42	44	34
$\bar{x}$:	265.38	272.57	281.29
Pasture :	10	11	9

Significant differences among pastures may exist as shown by the utilization data for 1957, Table 13.

Table 13. Analysis of variance and Duncan's New Multiple Range Test of total 1957 vegetative utilization in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Subclasses (pastures)	2	17727.17	8863.58	4.520^{*}
Obs: Subclasses	173	339222.83	1960.82	

Duncan's Test

n :	52	64	60
$\bar{x}$:	164.73	184.42	188.52
Pasture[a] :	10	9	11

The explanation for the differences among pastures in the analyses above and the differences between the 1956 and 1957 results are not clear. Burning dates, amounts and yearly distribution of precipitation, or some other unknown factor may be responsible.

In Figs. 1, 2 and 3 total vegetative yield and utilization are shown.

Presented in Table 14 is the record of annual precipitation for 1956 and 1957.

In addition to the data on yield and utilization of total vegetation, influence on specific types of vegetation were also studied. Total vegetation was separated into three specific types which are:: (1) forage, (2) mulch, and (3) weeds. Forage consisted of all species of grasses and forbs which were known to be palatable to livestock. Mulch was the loose, dried, fallen plant material on the surface of the soil. Weeds were designated as those grass and forb species which were not palatable. In the following discussion of each type of vegetation among pastures 1 through 6 are compared. The sites and samples used in making these comparisons were the same as those used for total vegetative yield. The analysis of variance for forage yield and Duncan's test for 1956 are in Table 15.

Yield differences among pastures and the pasture by sites interaction were not significant, however, the differences among sites were significant at the .001 level. This suggests that there were highly significant differences in forage yield among different sites when identical treatments were applied. This may be explained by soil variations and different soil moisture

Table 14. Precipitation amounts and monthly distribution for 1956 and 1957[c].

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1956	0.51	0.33	0.16	1.40	2.05	3.84	5.07	3.61	0.12	1.74	1.04	0.58	20.45
1957	0.66	0.40	3.02	3.63	3.74	7.07	3.32	2.02	5.25	3.55	2.40	0.88	35.94

[c] Data obtained from records of the Kansas State College Agronomy Farm.

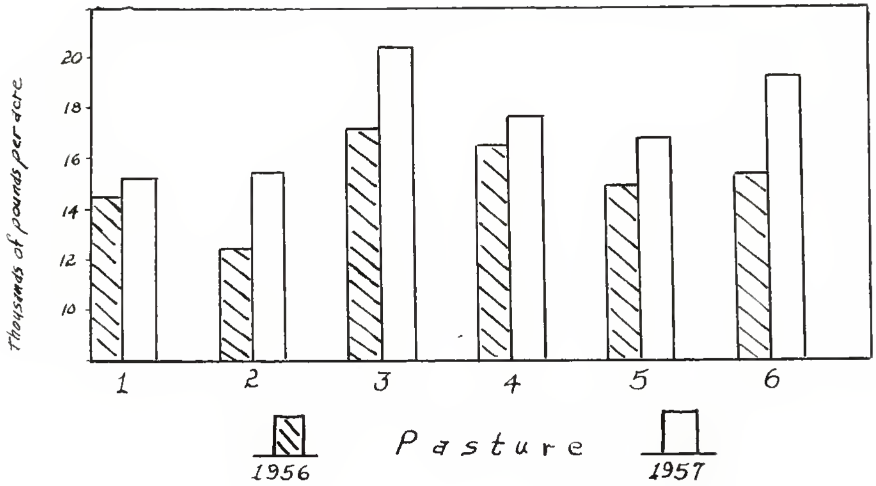

Fig. 1. Total vegetative yield on ordinary upland, limestone breaks, and clay upland in pastures 1 through 6 (Donaldson Pastures).

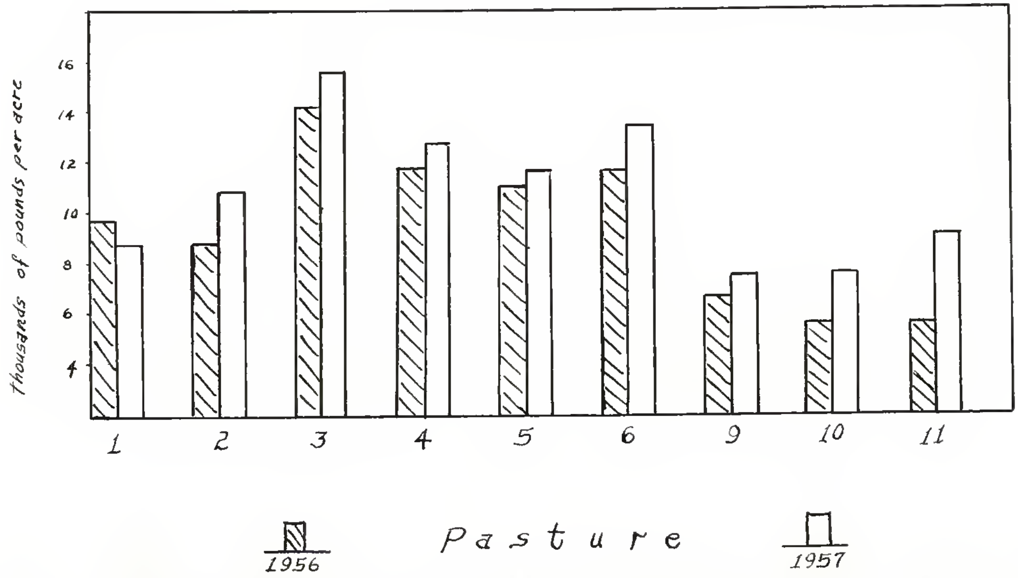

Fig. 2. Total vegetative yield on ordinary upland and limestone breaks in pastures 1 through 6 and 9 through 11 (Donaldson Pastures).

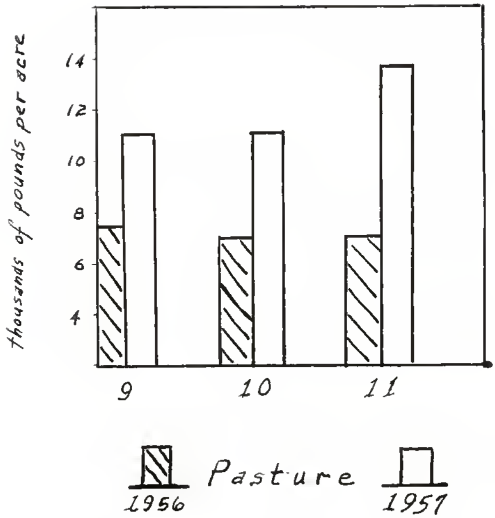

Fig. 3. Total vegetative yield on ordinary upland, limestone breaks, and claypan in pastures 9 through 11 (Donaldson Pastures).

Table 15. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	10166.488	2033.298	1.620 n.s.
Sites	2	17539.027	8769.514	6.985***
Pastures x sites (p x s)	10	22126.115	2212.612	1.762 n.s.
Error	154	193347.580	1255.504	

Duncan's Test

n	17	31	29	35	27	33
$\bar{x}$	85.70	92.10	93.83	103.11	105.00	105.54
Pasture	4	1	2	5	6	3

***Indicates significance at the .001 level.

relationships from site to site. Duncan's test was applied only to pastures and agrees with the analysis of variance in that no significant differences in forage yield due to treatment were found.

The results of 1957 forage data are shown in Table 16.

Table 16. Analysis of variance of 1957 forage yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	42180.826	8436.165	5.29***
Sites	2	3611.821	1805.910	1.13 n.s.
Pastures x sites (p x s)	10	41803.369	4108.369	2.58**
Error	181	288688.93	1594.966	

Significant differences in yield among pastures and a significant pastures x sites interaction are revealed by the analysis of variance. Sites are non-significant in Table 16. This shows that in 1957 sites were not an important source of variation in forage production. The reason for this is not clear, however, it may be explained in part by the greater amount of precipitation in 1957 than in 1956, especially during the growing season. Although a significant difference among pastures does exist Duncan's test has been omitted for the following reason. Since there is a significant pasture x site interaction there will be a best or optimum stocking rate for a given site, but a given stocking rate probably would not be best for all sites. For that reason, even though there are significant differences among stocking rates, it may be difficult or impossible to find the ideal treatment, unless one particular site is considered. No general statement concerning any ideal treatment for all sites is possible.

Forage utilization information from 1956 is recorded in Table 17.

Table 17. Analysis of variance of 1956 forage utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	35668.872	7133.774	5.58***
Sites	2	13347.907	6687.454	5.23**
Pastures x sites (p x s)	10	30086.848	3008.685	2.35
Error	154	196789.760	1277.856	

There are significant differences in amounts of use among pastures due to the pasture treatment. Sites also differ significantly in amount of use. This may be due to livestock preference for specific areas which include a certain site. It may be due to preference for a certain grass or forb species which grow primarily on a given site. Due to the significant p x s interaction a general statement cannot be made regarding best treatment.

The same type of situation existed in the 1957 utilization data as seen in Table 18.

Table 18. Analysis of variance of 1957 forage utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	33092.936	6618.587	2.45*
Sites	2	43407.313	21703.656	8.05***
Pastures x sites (p x s)	10	55121.816	5512.182	2.04*
Error	181	488178.520	2697.119	

Significant differences are present among pastures and among sites, but, again, because there was a significant p x s interaction, no general statement can be made with respect to a most desirable treatment. Apparently forage utilization was a contributing factor to the significant differences observed among pastures in total vegetative utilization for 1956 and 1957.

The analyses of mulch yields for both 1956 and 1957 are shown in Tables 19 and 20 and resulted in nearly identical results.

Table 19. Analysis of variance of 1956 mulch yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	104582.491	20916.498	9.21***
Sites	2	122341.730	61170.865	26.94***
Pastures x sites (p x s)	10	78048.867	7804.887	3.44***
Error	154	349693.500	2270.737	

Table 20. Analysis of variance of 1957 mulch yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	99011.705	19802.341	11.26***
Sites	2	159483.600	78741.800	45.32***
Pasture x sites (p x s)	10	62589.534	6258.953	3.56***
Error	181	318444.10	1759.360	

There were highly significant differences due to treatments among pastures in mulch production. This indicated that there were treatments which produced significantly more mulch than others. Site differences also were highly significant in both instances. This indicated that soil differences upon which sites themselves are in part differentiated, plus the treatment, may have had significant effects upon the mulch yield. Again, a specific ideal treatment cannot be recommended because of the interaction present.

Utilization of mulch for 1956 and 1957 was similar. Data recorded during this period are included in Tables 21 and 22.

Table 21. Analysis of variance and Duncan's New Multiple Range Test of total 1956 mulch utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	16770.764	3354.153	$1.09^{n.s.}$
Sites	2	248.443	124.221	$0.04^{n.s.}$
Pastures x sites (p x s)	10	37307.619	3730.762	$1.22^{n.s.}$
Error	154	472282.960	3066.772	

Duncan's Test

n :	33	35	27	29	31	17
$\bar{x}$:	233.30	242.82	245.78	249.83	261.29	262.65
Pasture :	3	5	6	2	1	4

Table 22. Analysis of variance and Duncan's New Multiple Range Test of total 1957 mulch utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	12959.148	2591.830	$1.37^{n.s.}$
Sites	2	5592.396	2796.198	$1.48^{n.s.}$
Pastures x sites (p x s)	10	23598.558	2359.856	$1.25^{n.s.}$
Error	181	341806.070	1888.431	

Duncan's Test

n :	33	33	33	33	33	34
$\bar{x}$:	154.52	166.10	170.61	172.10	174.70	177.53
Pasture :	1	5	2	6	3	4

There were no significant differences among pastures or sites for 1956 or 1957. Neither were significant interactions present. Apparently mulch is not a contributing factor to the significant differences found among pastures for total vegetative utilization during 1956 and 1957. The non-significance among pastures might be explained in part by the fact that forage generally is the first choice utilization product of livestock and consequently if sufficient forage exists then mulch would only be utilized slightly. That mulch utilization was not significantly different from pasture to pasture may be an indication that forage was sufficiently abundant to absorb the major amounts of utilization.

The yield of weeds in pastures 1 through 6 as measured and recorded in this experiment are tabulated in Table 23 for 1956.

Table 23. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weeds yields from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	5333.499	1066.700	2.12 n.s.
Sites	2	4448.770	2224.385	4.43*
Pastures x sites (p x s)	10	2643.098	264.310	.53 n.s.
Error	154	77375.670	502.439	

Duncan's Test

n	27	35	31	33	29	17
$\bar{x}$:	24.96	30.54	34.42	36.09	39.66	44.76
Pasture :	6	5	1	3	2	4

(Underlines in the original: pastures 5, 1, 3, 2, 4 joined; pastures 6, 5, 1, 3 joined.)

The F value derivsd from the analysis of variance indicates that no significant differences in yield is present among pastures. However, based on values in the F distribution table it approaches significance at the .05 level. According to the F value for sites there is a significant difference due to stocking rate. Since there is no significant p x s interaction Duncan's test can be used in determining whsre the significant differencss among pastures is to be found if any exist. It indicates that pastures 2 and 4 yield significantly more weeds than pasture 6. Since pasture 2 is stocked more heavily than pasture 6 it points out that forage is utilized more fully. This would result in less competition for weed growth in pasture 2. Pastures 4 and 6 are both in the deferred-rotation system. The explanation of 4 yielding significantly more weeds than six is not clear. In 1956 pasture 4 was deferred; this would mean that in 1955 and again in 1954 it had been slightly overgrazed for a portion of each summer. This may account for the weed yield produced in 1956.

Weed yield data for 1957 is recorded in Table 24.

F values from analyses in Table 24 indicate significant differences in yield among all pastures and sites. Site differences may be expected due to different soil conditions and soil-moisture relationships. Duncan's test shows wesd yields of pastures 1 and 4 to be significantly greater than those of pasture 6, as was true in 1956. Pasture 2 was stocked more heavily than 6, thus giving the weeds in pasture 2 a better opportunity to utilize existing water, soil, nutrients, and light which ordinarily would be used by the forage plants. The reason for the significant difference between pasture 4 and 6 is not clear. It may be related to the deferred-rotation grazing system of which both pastures are a part.

Table 24. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed yield from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pasture	5	6021.679	1204.336	2.37^{*}
Sites	2	16091.833	8045.916	15.84^{***}
Pastures x sites (p x s)	10	6386.946	638.694	$1.26^{n.s.}$
Error	181	91925.47	507.876	

Duncan's Test

n	33	33	33	33	34	33
$\overline{x}$	23.61	30.12	30.54	32.97	36.03	40.09
Pasture	6	3	5	1	4	2

Weed utilization data for 1956 from the three sites sampled in pastures 1 through 6 is recorded in Table 25.

The F value for utilization indicates significant differences among pastures. There are not significantly different degrees of utilization among sites nor is there a significant p x s interaction. Duncan's test disclosed that pastures 2 and 4 are used significantly more than pastures 5 and 3. This is to be expected in the case of pasture 2 since it was stocked at a heavy rate. The trend observed previously in total vegetation yields is again evident. It suggests that pastures which were utilized heavily, generally yielded low, and pastures high in yield, generally were lightly utilized.

Table 25. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pasture	5	9408.277	1881.655	4.02^{**}
Sites	2	1210.209	605.104	$1.29^{n.s.}$
Pastures x sites (p x s)	10	2576.962	257.696	$0.55^{n.s.}$
Error	154	72039.000	467.786	

Duncan's Test

n	33	33	27	31	29	17
$\bar{x}$	244.20	247.97	250.52	253.00	260.28	268.76
Pasture	5	3	6	1	2	4

The F value in Table 26 indicates that for 1957 there were no significant yield differences among pastures.

The F value among sites suggests that there are significant differences which may be expected due to preferential grazing by the livestock and varying soil characteristics. The significant interaction indicates that Duncan's test will be meaningless due to the fact that more than one specific site is being used.

Table 26. Analysis of variance of 1957 weed utilization from Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	2552.606	510.521	$1.18^{n.s.}$
Sites	2	3860.370	1930.185	4.48^{*}
Pastures x sites (p x s)	10	9717.408	971.741	2.25^{*}
Error	181	78052.900	431.231	

Significant interaction suggests a best treatment for a specific site, but the treatment will not necessarily be best for all sites.

In an effort to compare burned pasture with non-burning two common sites were selected from pastures 1 through 6 and 9 through 11. They included ordinary upland and limestone breaks. The analysis of variance and Duncan's test for the results of forage yields for 1956 and 1957 are given in Tables 27 and 28 respectively.

The F value in Table 27 indicates that among pastures there is a significant difference in the yield of forage produced. There is no significant difference among sites with respect to yield nor is there a significant interaction. Similar trends are found with respect to pastures, sites, and interaction in Table 28. Pastures 3, 6, and 11 were high in production. In 1957 they were significantly higher in yield than any of the others. Pasture 9 was the highest yielding unit in 1956 but even though arrayed in a higher position than 3, 6 or 11 it did not yield significantly

Table 27. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	29857.485	3732.186	2.56^{**}
Sites	1	838.967	838.967	$0.58^{n.s.}$
Pastures x sites (p x s)	8	19890.603	2486.325	$1.71^{n.s.}$
Error	157	228594.480	1456.016	

Duncan's Test

n :	12	25	21	25	18	23	17	18	16
$\bar{x}$:	85.83	95.72	96.81	110.00	115.22	116.13	123.00	123.94	128.69
Pasture :	4	1	2	5	6	3	10	11	9

Table 28. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variance	d.f.	S.S.	M.S.	F
Pasture	8	109153.895	13644.237	8.28***
Sites	1	5837.675	5837.675	3.54 n.s.
Pasture x sites (p x s)	8	13405.583	1675.698	1.02 n.s.
Error	187	308141.14	1647.814	

Duncan's Test

n :	24	23	22	24	24	23	23	22	20
$\bar{x}$:	132.42	136.83	138.59	141.00	142.75	147.30	177.00	192.72	193.80
Pasture :	1	5	9	4	2	10	6	11	3

more. The treatments of these pastures seem to be plausible explanations for these results. Pasture 3 was lightly stocked, pasture 6 was deferred one month every third year, and pasture 11 was moderately stocked and burned annually in late spring. The reason for the high forage production of pasture 11 is not entirely clear since burning is generally detrimental to good soil-moisture relationships, and consequently it inhibits full vegetative development. A partial explanation may be that nearly one-half the annual precipitation came in July and August of 1956 which would provide moisture during a period that normally is quite dry.

In Table 29 results for 1956 forage utilization have been tabulated and the analysis of variance and Duncan's test recorded.

Utilization is shown to differ significantly among pastures and among sites. Duncan's test indicates that utilization is significantly greater on 9, the early burned pasture, than on pastures 1, 3, or 6. Pastures 3 and 6 are significantly lower in degree of utilization than any of the others. They are generally high in yield. Pasture 9 may be utilized most heavily due to the increased length of grazing time brought about by early burning. Utilization of sites may vary significantly due to preferential grazing and an increased length of the grazing period on burned sites.

Utilization data for 1957 are presented in Table 30.

There are significant differences among pastures with respect to forage utilization. Duncan's test shows that pasture 2 was utilized significantly more than pastures 1 and 10. This

Table 29. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage utilization from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	71168.331	8896.041	6.15^{***}
Sites	1	10045.076	10045.076	6.95^{**}
Pastures x sites (p x s)	8	22621.854	2827.732	$1.96^{n.s.}$
Error	157	226968.450	1445.659	

Duncan's Test

n :	23	18	25	12	21	17	25	18	16
$\bar{x}$:	248.04	257.94	283.94	285.08	286.76	294.12	294.40	301.72	316.44
Pasture :	3	6	1	4	2	10	5	11	9

Table 30. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage utilization from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	98122.203	12265.275	4.11^{***}
Sites	1	361.841	361.841	$0.12^{n.s.}$
Pastures x sites (p x s)	8	24103.546	3012.943	$1.01^{n.s.}$
Error	187	558053.49	2984.243	

Duncan's Test

n :	24	23	23	23	24	22	22	20	24
$\bar{x}$:	155.79	157.09	181.22	184.09	187.42	192.91	214.41	216.15	216.58
Pasture :	1	10	5	6	4	9	11	3	2

seems plausible since it was stocked at the heaviest rate. It is difficult to account for the indication that there are no significant differences among sites with respect to utilization. The increased moisture received in 1957 may have had some effect upon the sites with respect to kinds and amounts of forage produced.

The weed yield in these nine pastures for 1956 has been recorded in Table 31.

Table 31. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	27510.280	3428.785	8.78^{***}
Sites	1	4571.114	4571.114	11.67^{***}
Pastures x sites (p x s)	8	1698.356	212.294	$0.54^{n.s.}$
Error	157	61483.390	391.614	

<u>Duncan's Test</u>

n	18	17	16	18	25	23	21	12	15
$\bar{x}$	4.78	7.29	16.50	25.78	28.36	38.35	41.14	42.58	58.13
Pasture	11	10	9	6	5	3	2	4	1

The F value obtained from the analysis of variance indicates that among pastures there are significant differences in yield. There are, in addition, significant differences in yield among sites, which is generally to be expected. Duncan's test reveals that pasture 1 yields significantly more weeds than any of the other pastures. The reasons for the high yield of weeds in pasture 1 are not known. The fact that it is stocked season long at a moderate rate without deferrment may influence this yield. Pastures 2 and 4 yield signicantly more weeds than pastures 6, 9, 10 or 11. Pasture 2 has generally yielded more weeds due to heavy stocking. Pasture 4 has yielded high for reasons not clearly known. Pastures 9, 10, and 11 were significantly lower in weed production than any of the other pastures.

The analysis of variance for 1957 data is shown in Table 32.

Table 32. Analysis of variance of 1957 weed yields from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variance	d.f.	S.S.	M.S.	F
Pastures	8	9916.349	1239.544	2.62**
Sites	1	702.394	702.394	1.49n.s.
Pasture x sites (p x s)	8	116893.724	14611.716	30.93***
Error	187	88330.61	472.356	

The F value discloses that in yield of weeds significant differences exist among pastures. Due to significant p x s interaction reliable information cannot be obtained from this experiment with respect to individual pastures which may differ significantly. A general statement cannot be made with regard to a best treatment for all sites in any one pasture.

In Table 33 the analysis of variance for 1956 weed utilization indicates a significant difference among pastures in weed utilization.

Table 33. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	11483.973	1436.122	3.55^{***}
Sites	1	631.052	631.052	$1.56^{n.s.}$
Pastures x sites (p x s)	8	566.967	70.870	$0.18^{n.s.}$
Error	157	63544.740	404.744	

Duncan's Test

n	18	17	25	18	16	23	25	21	12
$\bar{x}$	238.22	242.47	242.92	249.61	250.12	252.78	254.36	262.05	266.58
Pastures	11	10	5	6	9	3	1	2	4

It is suggested that among sites there is not a significant difference in utilization. As previously indicated, the explanation for this is not entirely clear. Duncan's test indicates that in pasture 4 weeds were most highly utilized. Utilization with respect to weeds was signicantly more than pastures 5, 6, 10 and 11. According to the 1956 and 1957 yield results, pasture 4 was one of the highest producers of weeds. This being true it is only logical to assume that there was a good possibility for weed utilization to be high. Weed utilization is also high in pasture 2. It, however, is not significantly different from pasture 4 in this respect. The heavy-stocking rate would suggest an explanation for this fact. The burned pastures were utilized significantly less than all other pastures with the exception of 5 and 6. Reasons for this are not clear. Burning may have made the pastures less desirable in some way.

The analysis of variance for weed utilization in 1957 as given in Table 34, indicates that among pastures and among sites no significant differences existed.

Table 34. Analysis of variance of 1957 weed utilization from Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	3124.677	390.585	$0.83^{n.s.}$
Sites	1	693.681	693.681	$1.48^{n.s.}$
Pastures x sites (p x s)	8	1317.599	164.700	$0.35^{n.s.}$
Error	187	87480.580	476.810	

Although no significant differences actually exist when arrayed in Duncan's test pastures 2 and 4 are highest in weed utilization. There seems to be no clear cut explanation for the non-significant differences in utilization among pastures and sites.

Within the three burned pastures (9, 10 and 11), the three sites, ordinary upland, limestone breaks, and claypan were sampled and studied. Table 35 includes the analysis of variance for forage yields from these sites for 1956.

Table 35. Analysis of variance and Duncan's New Multiple Range Test for total 1956 forage yields from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	556.168	278.084	$0.19^{n.s.}$
Sites	2	9880.004	4940.002	3.45^{*}
Pasture x sites (p x s)	4	4404.180	1101.045	$0.77^{n.s.}$
Error	51	73005.200	1431.474	

Duncan's Test

n :	21	22	17
$\bar{x}$:	114.48	121.36	124.24
Pasture :	10	11	9

No significant difference exists for forage yields among burned pastures. This may be the effect of summer rains in 1956, which supplimented moisture normally lost in the springs through excessive runoff. Among sites there were significant differences due to preferential grazing of specific areas and the utilization of more desirable species of vegetation. Although no significant difference in yield was evident among pastures, pasture 9 ranked highest in production of forage.

Table 36 includes the analysis of variance and Duncan's test for 1957 forage yield data.

Table 36. Analysis of variance and Duncan's New Multiple Range Test for total 1957 forage yields from Donaldson Pastures 9 through 11 (burned).

Source of variance	d.f.	S.S.	M.S.	F
Pasture	2	43979.763	21989.882	9.53***
Sites	2	4247.382	2123.691	.92 n.s.
Pastures x sites (p x s)	4	10663.677	2665.919	1.16 n.s.
Error	79	181417.35	2296.422	

Duncan's Test

n :	32	26	30
$\bar{x}$:	141.09	151.85	192.30
Pasture :	9	10	11

According to the F value there is a significant difference among pastures with respect to yield. Pasture 11 yielded significantly more than either of the other two. This is probably due to the presence of water holding mulch during the period of spring rains. Burning the mulch from pastures 9 and 10 permitted excessive water runoff and reduced water infiltration. The nonsignificant differences among sites with respect to yield indicates that sites were not an important source of variation in the final analysis of forage production.

The 1956 forage utilization data for burned pastures are presented in Table 37.

Table 37. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage utilization from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	5886.953	2943.476	$1.74^{n.s.}$
Sites	2	889.263	444.632	$0.26^{n.s.}$
Pastures x sites (p x s)	4	9389.963	2347.491	$1.39^{n.s.}$
Error	51	86035.06	1686.962	

Duncan's Test

n :	21	22	17
$\bar{x}$:	288.71	307.00	313.00
Pasture :	10	11	9

The F value suggests that among pastures as well as among sites there are no significant differences in utilization. As indicated previously, the explanation for results such as this are not clearly defined. The highest ranking pasture in terms of utilization in 1956 was number 9. Since this pasture was burned in early spring it resulted in earlier vegetative growth. This would indicate that more utilization might be possible from that pasture.

Table 38 presents analysis of variance and Duncan's test data for 1957 utilization of the burned pastures.

Table 38. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage utilization from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	30778.204	15389.102	5.73^{**}
Sites	2	15418.671	7709.336	$2.87^{n.s.}$
Pasture x sites (p x s)	4	11947.628	2986.907	$1.11^{n.s.}$
Error	79	212354.490	2688.032	

Duncan's Test

n	26	32	30
$\bar{x}$	162.77	203.03	209.60
Pasture	10	9	11

The F value in this table is significant at the .01 level for differences in utilization among pastures. Pasture 11 is highest in terms of utilization. Pastures 11 and 9 are significantly more productive than pasture 10. Pasture 11 was treated by late spring burning which permitted greater water infiltration and provided necessary soil-moisture for summer growth of forage. Increased growth made greater utilization possible. Sites apparently did not prove to be an important source of variation in utilization.

Data of 1956 weed yields have been tabulated in Table 39.

The analysis of variance and F value suggest that there may be significant differences in weed yields among pastures. Pasture 9 yielded significantly more weeds than 10 or 11. This may

Table 39. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed yields from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	1145.640	572.820	5.96^{**}
Sites	2	401.152	200.576	$2.09^{n.s.}$
Pastures x sites (p x s)	4	438.769	109.692	$1.14^{n.s.}$
Error	51	4901.120	96.100	

Duncan's Test

n :	22	21	17
$\bar{x}$:	5.86	6.14	15.65
Pasture :	11	10	9

be explained in part by the fact that early burning permits close grazing of the new young vegetation, thus reducing competition for weeds. Early burning causes a droughty soil condition later on in the summer and many weed species can thrive on less water than forage species. Sites do not appear to be of great importance in affecting differences of weed production in this particular situation. Presumably, sampling error may have been a contributing factor in producing non-significant results among sites.

The analysis of variance and multiple range test for 1957 weed yield data are given in Table 40.

Even though no significant differences among pastures or sites are indicated with respect to yield when using Duncan's test, pasture 9 ranks highest in weed yield as it did in 1956.

The same explanations and reasons are applicable here.

Table 40. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed yields from Donaldson Pastures 9 through 11 (burned).

Source of variance	d.f.	S.S.	M.S.	F
Pasture	2	1535.889	767.944	1.36$^{n.s.}$
Sites	2	402.505	201.253	.36$^{n.s.}$
Pasture x sites (p x s)	4	2557.094	639.273	1.13$^{n.s.}$
Error	79	44538.09	563.773	

Duncan's Test

n :	30	26	32
$\bar{x}$:	17.47	21.42	27.44
Pasture :	11	10	9

Tables 41 and 42 present the results of the 1956 and 1957 weed utilization data respectively.

The only difference between these two years data is that in 1956 (Table 41) the pastures showed significantly different yields while in 1957 (Table 42) this is not true. In 1956 weed utilization in pastures 9 and 10 are significantly more than in pasture 11. This may be due to a longer grazing season caused by early burning and to the fact that weeds were, shown in Tables 39 and 40, to be more abundant in those pastures. Sites for both years are not significantly different in weed utilization and p x s interaction is not significant in either case.

In addition to comparison by pasture of total vegetative

Table 41. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	1181.194	590.597	4.37*
Sites	2	42.447	21.223	$0.16^{n.s.}$
Pastures x sites (p x s)	4	81.464	20.366	0.15
Error	51	6888.750	135.074	

Duncan's Test

n :	22	21	17
$\bar{x}$:	238.14	242.05	249.59
Pasture :	11	10	9

Table 42. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed utilization from Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	46.884	23.442	$0.04^{n.s.}$
Sites	2	443.749	221.875	$0.37^{n.s.}$
Pastures x sites (p x s)	4	2706.336	676.584	$1.13^{n.s}$
Error	79	47317.700	598.958	

Duncan's Test

n :	32	26	30
$\bar{x}$:	165.81	166.69	167.43
Pasture :	9	10	11

yields and forage, mulch, and weed yields the latter three were compared by site. The data of all like sites from the pastures concerned were combined and treated as one unit. Different treatments were applied within each unit. These treatments were represented by various stocking rates for each pasture found in the site concerned. In pastures 1 through 6 the ordinary upland, limestone breaks, and clay upland sites were combined into three separato units.

Table 43 presents the analysis of variance and Dunoan's Test for 1956 forage yields from combined sites.

The analysis of variance indicated that there were no significant differences in yield among pastures within sites. Duncan's test indicates that within ordinary upland, pasture 3 and 5 yield significantly more than any other pastures except 6. This may be explained in the light of the stocking rates and management practices. Ordinary upland significance was apparently masked in the analysis of variance by the faot that neither limestone breaks or olay upland had significant differences in yield. The behavior of limestone breaks may be explained through the fact that it is generally on a slope that is sufficiently steep to render it undesirable for grazing and the livestock tend to avoid it. Clay upland tends to be grazed harder than any other site regardless of pasture treatment so it is plausible that there were no significant differences in yields among pastures within these two sites.

Data gathered in 1957 have been recorded in Table 44.

Significant differences in yield are indicated among pastures within sites. This may be explained either by the different stocking rate in each pasture or by the system of deferred-

Table 43. Analysis of variance and Duncan's New Multiple Range test of total 1956 forage yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	10166.488	2033.298	$1.62^{n.s.}$
Sites	2	17539.027	8769.514	6.985^{***}
Pastures x sites (p x s)	10	22126.115	2212.612	$1.762^{n.s.}$
Error	154	193347.580	1255.504	

Duncan's Test

Ordinary Upland

n :	7	8	17	7	12	12
$\bar{x}$:	69.57	85.25	93.12	121.57	128.17	129.33
Pasture :	4	2	1	6	5	3

Limestone Breaks

n :	13	8	11	13	5	11
$\bar{x}$:	93.23	101.25	101.73	103.92	108.60	111.18
Pasture :	5	1	3	2	4	6

Clay Upland

n :	6	10	9	5	8	10
$\bar{x}$:	77.00	81.20	84.56	85.40	85.87	85.90
Pasture :	1	3	6	4	2	5

rotation grazing. A significant interaction will indicate that there is an ideal treatment for a given site. Since comparisons are now being made by sites Duncan's test will indicate which stocking rate will produce best. In ordinary upland and limestone breaks pasture 3 yielded significantly more than all other

Table 44. Analysis of variance and Duncan's New Multiple Range test of total 1957 forage yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	42180.826	8436.165	5.29^{***}
Sites	2	3611.821	1805.910	$1.13^{n.s.}$
Pastures x sites (p x s)	10	41803.691	4108.369	2.58^{**}
Error	181	288688.930	1594.966	

Duncan's Test

Ordinary Upland

n :	10	15	13	10	12	9
$\bar{x}$:	138.60	139.33	142.80	155.60	178.20	198.20
Pasture :	2	1	4	5	6	3

Limestone Breaks

n :	9	13	11	14	11	11
$\bar{x}$:	120.90	122.40	138.80	145.70	175.60	190.10
Pasture::	1	5	4	2	6	3

Clay Upland

n :	13	10	9	10	9	10
$\bar{x}$:	144.60	149.20	162.20	163.20	170.90	175.30
Pasture :	3	5	2	4	1	6

pastures except 6. The clay upland pasture 6 was the top ranked pasture while it is second only to 3 in ordinary upland and limestone breaks. This high yield may in part be accredited to the stocking rate and the deferred-rotation grazing system.

Forage utilization for 1956 has been analyzed and the results may be seen in Table 45.

Table 45. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	35668.872	7133.774	5.58^{***}
Sites	2	13347.907	6687.454	5.23^{**}
Pastures x sites (p x s)	10	30086.848	3008.685	2.35
Error	154	196789.760	1277.836	

Duncan's Test

Ordinary Upland

$\underline{n}$:	12	7	17	8	7	12
$\bar{x}$:	263.33	269.00	278.00	284.25	290.57	325.00
Pasture :	3	6	1	2	4	5

Limestone Breaks

$\underline{n}$:	11	11	13	5	13	8
$\bar{x}$:	231.36	250.91	266.15	277.40	288.31	294.62
Pasture :	3	6	5	4	2	1

Clay Upland

$\underline{n}$:	9	10	10	6	5	8
$\bar{x}$:	258.78	283.50	285.90	291.17	293.40	300.62
Pasture :	6	5	3	1	4	2

Pastures are significantly different in relation to forage utilization within each site. The significant interaction suggests ideal treatments for individual sites. In ordinary upland, pasture 5 was used significantly more than any of the other pastures.

The total grazing pressure of pastures 4, 5 and 6 was placed upon it about August 1 that summer which may account for its high utilization rate. In limestone breaks and clay upland, pastures 1, 2 and 4 were used hardest. Pasture 1 was grazed season long with no deferment. This fact may influence the degree to which it is used. Pasture 2 was stocked heavy season long which could explain its high utilization. Pasture 4 generally yielded least and appeared to be utilized the most of the three deferred-rotation pastures. The explanation of this is not clear. Pasture 6 which seemed to yield relatively high was comparatively low in utilization.

The results of the 1957 forage utilization data are presented in Table 46.

The F value points out significant differences in utilization among pastures within given sites. Duncan's test revealed that there is little difference among treatments. Pastures 2 and 3 were used significantly more than pastures 1 and 4 in ordinary upland and limestone breaks. Significant utilization differences did not exist in clay upland. In this particular case several options are available for an ideal stocking rate or management practice. This may be due to additional moisture in 1957 or to some other unknown factor.

In Tables 47 and 48 the analyses of mulch yields for 1956 and 1957, respectively, are disclosed.

Significant differences in mulch yields among pastures within a given site are shown here. This may be accredited to the different pasture treatments. According to Duncan's test in two sites,

Table 46. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	33092.936	6618.587	2.45*
Sites	2	43407.313	21703.656	8.05***
Pastures x sites (p x s)	10	55121.816	5512.182	2.04
Error	181	488178.520	2697.119	

Duncan's Test

Ordinary Upland

n	15	10	12	13	9	10
x	155.67	176.60	190.83	206.54	212.44	222.20
Pasture	1	5	6	4	3	2

Limestone Breaks

n	9	11	11	13	14	11
x	156.00	164.82	176.73	184.77	212.57	219.18
Pasture	1	4	6	5	2	3

Clay Upland

n	13	10	9	10	9	10
x	195.85	216.60	224.11	227.70	230.89	242.90
Pasture	3	6	2	4	1	5

Table 47. Analysis of variance and Duncan's New Multiple Range Test of total 1956 mulch yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	104582.491	20916.498	9.21***
Sites	2	122341.730	61170.865	26.94***
Pastures x sites (p x s)	10	78048.867	7804.887	3.44***
Error	154	349693.500	2270.737	

Duncan's Test

Ordinary Upland

n	8	7	12	17	7	12
$\bar{x}$	75.25	81.43	98.17	107.60	121.57	154.92
Pasture	2	4	5	1	6	3

Limestone Breaks

n	13	8	13	11	5	11
$\bar{x}$	58.00	82.25	123.00	133.18	166.60	177.73
Pasture	2	1	5	6	4	3

Clay Upland

n	8	10	10	9	6	5
$\bar{x}$	25.75	45.60	51.00	57.11	87.17	111.00
Pasture	2	3	5	6	1	4

Table 48. Analysis of variance and Duncan's New Multiple Range Test of total 1957 mulch yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	99011.704	19802.341	11.26***
Sites	2	159483.600	79741.800	45.32***
Pastures x sites (p x s)	10	62589.534	6258.953	3.56***
Error	181	318444.100	1759.360	

Duncan's Test

Ordinary Upland

n	15	10	13	12	9	10
$\bar{x}$	57.66	63.60	70.90	98.30	108.80	112.20
Pasture	1	2	4	6	3	5

Limestone Breaks

n	9	14	13	11	11	11
$\bar{x}$	38.90	58.70	101.80	124.10	141.90	158.30
Pasture	1	2	5	6	4	3

Clay Upland

n	9	9	13	10	10	10
$\bar{x}$	20.80	26.80	32.80	39.80	41.80	60.40
Pasture	2	1	3	4	5	6

ordinary upland and limestone breaks, pasture 3 (light stocking) either yielded most or was not significantly different in yield from the best pasture. It was significantly greater than all pastures except 6 and 4 in limestone breaks. In all, pasture 3 was best and second best, respectively, in 1956 and 1957. In the clay upland, pasture 4 yielded the most mulch in 1956 and was not significantly different from the best pasture in 1957. In all three sites, pasture 2 (heavy stocking) or 1 (moderate season-long stocking) produced the least mulch. This was probably due to overgrazing which resulted in the use of forage that otherwise might become mulch. This was especially true with respect to pasture 2.

The 1956 and 1957 mulch utilization data results were obtained and are presented in that order in Tables 49 and 50.

According to the analyses little need be said with respect to the utilization of mulch in either 1956 or 1957. The only site which had any differences great enough to be significant was limestone breaks each year. No pasture stocking rates could be selected which would consistently provide for the most mulch utilization. Adequate forage production for the necessary maintenance and fattening rations of the livestock may have been obtained. If so, then use of mulch was probably minimized. This may or may not explain the non-significant utilization results.

Presented in Table 51 are the 1956 weed yield comparisons.

The F values in the analyses shown in Table 51 suggest that significant differences did not exist in yields among pastures within sites. Neither was there any apparent stocking rate that was ideal for weed production on a given site, with the exception of ordinary upland where pasture 2 yielded significantly more than 6. Proper range management is the best control of pasture weeds. The only pasture that was overstocked produced a yield of weeds

Table 49. Analysis of variance and Duncan's New Multiple Range Test of total 1956 mulch utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	16770.764	3354.153	$1.09^{n.s.}$
Sites	2	248.443	124.221	$0.04^{n.s.}$
Pastures x sites (p x s)	10	37307.619	3730.762	$1.22^{n.s.}$
Error	154	472282.960	3066.772	

Duncan's Test

Ordinary Upland

n	7	12	7	12	17	8
$\bar{x}$	239.00	241.58	248.29	252.17	253.65	269.25
Pasture	4	5	6	3	1	2

Limestone Breaks

n	11	11	13	13	8	5
$\bar{x}$	205.45	242.64	242.77	261.38	266.62	289.20
Pasture	3	6	2	5	1	4

Clay Upland

n	10	10	8	9	5	6
$\bar{x}$	220.20	241.30	241.87	247.67	269.20	275.83
Pasture	5	3	2	6	4	1

Table 50. Analysis of variance and Duncan's New Multiple Range Test of total 1957 mulch utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	12959.148	2591.830	$1.37^{n.s.}$
Sites	2	5592.396	2796.198	$1.48^{n.s.}$
Pastures x sites (p x s)	10	23598.558	2359.856	$1.25^{n.s.}$
Error	181	341806.070	1888.431	

Duncan's Test

Ordinary Upland

n	15	12	13	9	10	10
$\bar{x}$	157.33	167.08	175.46	179.78	186.00	188.40
Pasture	1	6	4	3	2	5

Limestone Breaks

n	9	13	14	11	11	11
$\bar{x}$	143.44	162.46	169.93	171.73	176.64	201.45
Pasture	1	5	2	6	4	3

Clay Upland

n	10	13	9	9	10	10
$\bar{x}$	148.50	153.62	154.56	160.89	178.50	181.29
Pasture	5	3	2	1	6	4

Table 51. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	5333.499	1066.700	$2.12^{n.s.}$
Sites	2	4448.770	2224.385	4.43^{*}
Pastures x sites (p x s)	10	2643.098	264.310	$0.53^{n.s.}$
Error	154	502.439		

Duncan's Test

Ordinary Upland

n	7	12	17	12	7	8
$\bar{x}$	26.86	36.67	39.06	40.92	50.86	53.63
Pasture	6	5	1	3	4	2

Limestone Breaks

n	13	11	8	5	13	11
$\bar{x}$	20.69	25.09	26.00	31.00	33.46	35.55
Pasture	5	6	1	4	2	3

Clay Upland

n	9	10	6	8	10	5
$\bar{x}$	23.33	30.90	32.50	35.75	36.00	50.00
Pasture	6	3	1	2	5	4

significantly greater than one of the deferred-rotation pastures. It may be possible that proper use of the pastures has in some way balanced weed production in this particular case.

The results of 1957 weed yield data are not greatly different from those of 1956 as shown in Table 52.

Table 52. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed yields from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	6021.679	1204.336	2.37^{*}
Sites	2	16091.833	8045.917	15.84^{***}
Pastures x sites (p x s)	10	6386.946	638.694	$1.26^{n.s.}$
Error	181	91925.470	507.876	

Duncan's Test

Ordinary Upland

n :	10	15	12	13	9	10
$\bar{x}$:	18.80	23.66	24.20	28.00	32.40	42.30
Pasture :	5	1	6	4	3	2

Limestone Breaks

n :	11	11	13	9	11	14
$\bar{x}$:	16.90	17.80	22.00	22.90	34.30	34.80
Pasture :	6	3	5	1	4	2

Clay Upland

n :	10	13	9	10	10	9
$\bar{x}$:	30.20	39.00	45.80	48.40	53.40	58.60
Pasture :	6	3	2	4	5	1

However, significant differences in yield among pastures within a given site did exist. In ordinary upland, pasture 2 produced a significantly higher yield than did pasture 5. In clay upland, both pastures 5 and 1 produced significantly more weeds than pasture 6. The differences were not great and with non-significant p x s interaction it would be difficult to recommend one treatment over another.

Analyses of 1956 weed utilization as given in Table 53 suggest a non-significant interaction and a significant difference in utilization among pastures within sites.

Table 53. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	9408.277	1881.655	4.02**
Sites	2	1210.209	605.104	1.29n.s.
Pastures x sites (p x s)	10	2576.962	257.696	0.55n.s.
Error	154	72039.000	467.786	

Duncan's Test

Ordinary Upland

n	12	7	17	12	8	7
$\bar{x}$	245.50	253.86	255.41	257.25	261.75	270.43
Pasture	5	6	1	3	2	4

Limestone Breaks

n	13	11	11	8	5	13
$\bar{x}$	240.54	246.91	247.91	252.12	261.20	262.23
Pasture	5	6	3	1	4	2

Clay Upland

n	10	6	10	9	8	5
$\bar{x}$	236.90	247.33	247.40	252.33	255.62	274.00
Pasture	3	1	5	6	2	4

Although Duncan's test showed pastures that differed significantly from each other in utilization, there was only one pasture in each site which actually differed to that extent. This left five pastures in each site which did not differ significantly from each other. From this fact and the non-significant p x s interaction it may be observed that there is no best treatment for a given site. In this instance, out of six possible stocking rates, five are left as best treatments. There is no clear cut reason for this, although presumably weeds are not utilized to any great extent except in cases of necessity regardless of stocking rate.

In Table 54 the results of the 1957 weed utilization data are presented.

The significant differences indicated for clay upland seem to be masked by the non-significance of the other two sites. However, the interaction F value suggested that there was an ideal treatment for at least one site. Duncan's test showed that in clay upland site, both pastures 1 and 5 produced significantly higher utilization results. It may be well to note the array of pastures in the other sites. Generally, those pastures with the heaviest grazing pressure are at the high end of the array.

As previously done, in order to compare the effects of stocking rates and management practices among all nine pastures, two common sites were used for sampling. Ordinary upland and limestone breaks were the two sites.

Table 54. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed utilization from combined like sites in Donaldson Pastures 1 through 6.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	5	2552.606	510.521	1.18 n.s.
Sites	2	3860.370	1930.185	4.48*
Pastures x sites (p x s)	10	9717.408	971.741	2.25*
Error	181	78052.900	431.231	

Duncan's Test

Ordinary Upland

n	15	10	12	13	9	10
$\bar{x}$	166.73	168.70	170.83	171.77	176.67	180.80
Pasture	1	5	6	4	3	2

Limestone Breaks

n	11	9	11	13	14	11
$\bar{x}$	166.73	168.70	170.83	171.77	176.67	180.80
Pasture	1	5	6	4	3	2

Clay Upland

n	13	10	10	9	9	10
$\bar{x}$	167.62	172.70	172.80	174.00	196.22	199.90
Pasture	3	4	6	2	1	5

According to the analyses presented in Table 55, significant differences in 1956 forage yields were found among pastures within sites. These differences were all in ordinary upland.

The p x s interaction is not significant and, again, there is a wide choice of ideal treatments for a given site. The

Table 55. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage yields from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	29857.486	3732.186	2.56**
Sites	1	838.967	838.967	0.58n.s.
Pastures x sites (p x s)	8	19890.603	2486.325	1.71n.s.
Error	157	228594.480	1456.016	

Duncan's Test

Ordinary Upland

n :	7	8	17	7	9	7	12	12	6
$\bar{\bar{x}}$:	69.57	85.25	93.12	113.45	119.11	121.57	128.17	129.33	133.67
Pastures :	4	2	1	10	11	6	5	3	9

Limestone Breaks

n :	13	8	11	13	5	11	10	10	9
$\bar{\bar{x}}$:	93.23	101.25	101.73	103.92	108.60	111.18	125.70	129.70	128.78
Pasture :	5	1	3	2	4	6	9	10	11

significant differences in yield in ordinary upland are found at the low end of the array. Pasture 4 was significantly lower in yield than six of the other pastures. Because limestone breaks usually is not heavily grazed under any of these stocking rates or management practices it would tend to exhibit yields which are not significantly different.

The non-significant p x s interactions of 1957 forage yields, as shown in Table 56, suggests a range of alternatives with regard to a best stocking rate for individual sites.

Indication of significant differences in yield among pastures within sites is given. Duncan's test revealed that these differences are there, but in limestone breaks there are three choices for an ideal treatment and four in ordinary upland. In both sites, pastures 3, 11, and 6 are included in the best options. In the case of pasture 3 this may be explained in part by the light stocking rate. In the instance of pasture 6, the fact that it is one of the deferred-rotation pastures could be a partial explanation for its high yield. Pasture 11 was the late-burned pasture. Burning late retains a mulch cover long enough to materially aid in better soil moisture relationships for summer growth. Burning may also cut down competition from other vegetation by causing partial or total destruction.

Presented in Tables 57 and 58 are the results of data pertinent to forage utilization of 1956 and 1957, respectively.

The F values each year pointed to significant differences in utilization among pastures within given sites. The p x s interaction was not significant. The significant differences among

Table 56. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage yields from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	109153.895	13644.237	8.28***
Sites	1	5837.675	5837.675	3.54n.s.
Pastures x sites (p x s)	8	13405.583	1675.698	1.02n.s.
Error	187	308141.140	1647.814	

Duncan's Test

Ordinary Upland

n	11	10	15	13	10	11	12	9	11
$\bar{x}$	130.80	138.60	139.33	142.80	155.60	166.10	178.20	198.20	201.20
Pasture	9	2	1	4	5	10	6	3	11

Limestone Breaks

n	9	13	12	11	14	11	11	11	11
$\bar{x}$	120.90	122.40	130.10	138.80	145.70	146.40	175.60	184.30	190.10
Pasture	1	5	10	4	2	9	6	11	3

Table 57. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage utilization from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	71168.331	8896.041	6.15^{***}
Sites	1	10045.076	10045.076	6.95^{**}
Pastures x sites (p x s)	8	22621.854	2827.732	$1.96^{n.s.}$
Error	157	226968.450	1445.659	

Duncan's Test

Ordinary Upland

n	12	7	17	8	7	7	9	12	2
$\bar{x}$	263.33	269.00	278.00	284.25	290.57	295.14	302.44	325.00	329.27
Pasture	3	6	1	2	4	10	11	5	9

Limestone Breaks

n	11	11	13	5	13	10	8	9	10
$\bar{x}$	231.36	250.91	266.15	277.40	288.31	293.40	294.62	301.00	308.50
Pasture	3	6	5	4	2	10	1	11	9

Table 58. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage utilization from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	98122.203	12265.275	4.11***
Sites	1	361.841	361.841	0.12 n.s.
Pastures x sites (p x s)	8	24103.546	3012.943	1.01 n.s.
Error	187	558053.49	2984.243	

Duncan's Test

Ordinary Upland

n	11	15	10	11	12	11	13	9	10
$\bar{x}$	146.18	155.67	176.60	179.09	190.83	199.18	206.54	212.44	222.20
Pasture	10	1	5	9	6	11	4	3	2

Limestone Breaks

n	9	11	12	11	13	11	14	11	11
$\bar{x}$	156.00	164.82	167.08	176.73	184.77	206.73	212.57	219.18	229.64
Pasture	1	4	10	6	5	9	2	3	11

pastures is evident from Duncan's test. However, out of 9 possible choices there is a range of 5 to 7 which will give an ideal stocking rate so any alternative may or may not prove to be the best for a particular site.

The analysis of variance and Duncan's test, as shown in Table 59, suggest that in weed yields there were significant differences present among the pastures within a given site.

The interaction F value was not significant; therefore, a range of alternatives for an optimum stocking rate may be present. The multiple range test shows this to be true. The burned pastures were all three significantly lower in weed yield than the other pastures with the exception of pasture 6 in ordinary upland. This may be due to stunting or destruction of weeds at the time of burning or it could be due partially to the soil-moisture conditions which vary from those of non-burned pastures.

The F value for pastures within sites and for p x s interaction are significant, as given in Table 60, with respect to 1957 weed yield.

Due to the heavy stocking rate, pasture 2 yielded significantly more weeds than pastures 5 or 11 in ordinary upland. In limestone breaks, pasture 2 was also the pasture which yielded most. In either site, pasture 11, the late-burned treatment, yielded the least.

Significant differences among pastures within sites were indicated by the F value, as shown in Table 61 for 1956 weed utilization results.

Table 59. Analysis of variance and Duncan's New Multiple Range Test of Total 1956 weed yields from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	27510.280	3430.785	8.78***
Sites	1	4571.114	4571.114	11.67***
Pastures x sites (p x s)	8	1698.356	212.294	0.54 n.s.
Error	157	61483.390	391.614	

Duncan's Test

Ordinary Upland

n	9	7	6	7	12	17	12	7	8
$\bar{x}$	7.67	10.71	20.00	26.86	36.67	39.06	40.92	50.86	53.63
Pasture	11	10	9	6	5	1	3	4	2

Limestone Breaks

n	9	10	10	13	11	8	5	13	11
$\bar{x}$	1.89	4.90	14.40	20.69	25.09	26.00	31.00	33.46	35.55
Pasture	11	10	9	5	6	1	4	2	3

Table 60. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed yields from combined like sites in Donaldson Pastures 1 through 6 and 8 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	9916.349	1239.544	2.62^{**}
Sites	1	702.394	702.394	$1.49^{n.s.}$
Pastures x sites (p x s)	8	116893.724	14611.716	30.93^{***}
Error	187	88330.610	472.356	

Duncan's Test

Ordinary Upland

n :	11	10	15	12	11	13	11	9	10
$\bar{x}$:	14.20	18.80	23.66	24.20	27.40	28.00	31.50	32.40	42.30
Pasture :	11	5	1	6	10	4	9	3	2

Limestone Breaks

n :	11	11	12	11	13	9	11	11	14
$\bar{x}$:	12.00	16.80	17.20	17.80	22.00	22.90	29.50	34.30	34.80
Pasture :	11	6	10	3	5	1	9	4	2

Table 61. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	11488.973	1436.122	3.55***
Sites	1	631.052	631.052	1.56 n.s.
Pastures x sites (p x s)	8	566.967	70.870	1.18 n.s.
Error	157	63544.740	404.744	

Duncan's Test

Ordinary Upland

n	9	7	12	6	7	17	12	8	7
$\bar{x}$	237.67	243.86	245.50	250.33	253.86	255.41	257.25	261.75	270.43
Pasture	11	10	5	9	6	1	3	2	4

Limestone Breaks

n	9	13	10	11	11	10	8	5	13
$\bar{x}$	238.78	240.54	241.50	246.91	247.91	250.00	252.12	261.20	262.23
Pasture	11	10	5	6	3	9	1	4	2

Aleo present is a non-significant p x s interaction. Duncan'e test indicated that both were correct. There was a significant difference among pastures end there was also a wide scope of stocking ratee which could be classed as best. This made it impossible to choose any one treatment and state that it was coneistently the optimum. In both sites, pastures 2 and 4 are ranked highest in weed utilization which is probably due to the stocking rate and management practice. The burned pastures were again low in the array.

The analyses of 1957 weed utilization are presented in Table 62.

Duncan's test and the analysis of variance give evidence that significant differencesin utilization are not preeent in either pastures within sites or p x s interaction for ordinary upland or limestone breaks. When arrayed the pastures rank, in general, as before. The ones with heavier grazing pressure are high and the burned pastures low.

In comparing by site, yield, and utilization of forage, mulch, and weede, the burned pastures were separeted into three common eites. They were ordinary upland, limestone breaks, and claypan.

In Table 63 the analysis of variance and multiple range teet for 1956 forage yields are reported.

Significant differences among paetures are not indicated nor is a significant p x s interaction shown in either the analysis of variance or Duncan's test. Since there were no significant differences in yield of total vegetation on the burned paetures for 1956 it could reaeonably follow that there would be no differences

Table 62. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed utilization from combined like sites in Donaldson Pastures 1 through 6 and 9 through 11.

Source of variation	d.f.	S.S.	M.S.	F
Pastures	8	3124.677	390.585	$0.83^{n.s.}$
Sites	1	693.681	693.681	$1.48^{n.s.}$
Pastures x sites (p x s)	8	1317.599	164.700	$0.35^{n.s.}$
Error	187	87480.580	476.810	

Duncan's Test

Ordinary Upland

n	11	15	10	11	12	13	11	9	10
$\bar{\bar{x}}$	162.73	166.73	168.70	170.00	170.83	171.77	173.82	176.67	180.80
Pasture	11	1	5	9	6	4	10	3	2

Limestone Breaks

n	12	11	11	9	11	13	14	11
$\bar{\bar{x}}$	161.58	163.27	164.45	165.44	167.00	170.85	173.50	174.91
Pasture	10	11	6	1	3 and 9	5	2	4

Table 63. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage yields from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	556.168	278.084	$0.19^{n.s.}$
Sites	2	9880.004	4940.002	3.45^{*}
Pasture x sites (p x s)	4	4404.180	1101.045	$0.77^{n.s.}$
Error	51	73005.200	1431.474	

Duncan's Test

Ordinary Upland

n :	7	9	6
$\bar{x}$:	113.43	119.11	133.67
Pasture :	10	11	9

Limestone Breaks

n :	10	9	10
$\bar{x}$:	125.70	128.78	129.70
Pasture :	9	11	10

Claypan

n :	1	4	4
$\bar{x}$:	53.00	78.20	87.80
Pasture :	9	10	11

of significance on the combined like sites. Stocking rates were the same in each of these pastures so apparently the different burning dates, representing different treatments, did not significantly affect the yield of forage within sites. A clear, concise explanation for this is not offered.

Shown in Table 64 are the analyses of 1957 forage yields which suggested significant differences among pastures within given sites.

Table 64. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage yields from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	43979.763	21989.882	9.58^{***}
Sites	2	4247.382	2123.691	$0.92^{n.s.}$
Pastures x sites (p x s)	4	10663.677	2665.919	$1.16^{n.s.}$
Error	79	181417.35	2296.422	

Duncan's Test

Ordinary Upland

n :	11	11	11
$\bar{x}$:	130.80	166.10	201.20
Pasture :	9	10	11

Limestone Breaks

n :	12	11	11
$\bar{x}$:	130.10	146.40	184.30
Pasture :	10	9	11

Claypan

n :	10	3	8
$\bar{x}$:	146.60	186.70	191.10
Pasture :	9	10	11

A non-significant p x s interaction was revealed. Duncan's test indicated that in ordinary upland and limestone breaks there were significant differences between the pastures with the highest and the lowest yields. The pasture with a yield falling in between these two was not significantly different from either one. This indicated that there were two out of three pastures which could be chosen as a best treatment. In the claypan, differences of significance did not exist.

Revealed in Table 65 are the analysis of variance and multiple range test for the 1956 forage utilization data.

The analyses in Table 65 indicate that significant differences did not exist among paatures within sites or in the p x s interaction. This would point to evidence that dates of burning did not significantly affect the amount of use in the pastures. The reasons for this are not all clear aince presumably the earlier the burning, the quicker utilization can begin. The summer rains may have been, in part, responsible.

The results of the 1957 forage utilization data were similar to those for 1956 although significant differences among pastures within a given site were shown to be present in the 1957 results.

The analysis of variance and multiple range test for the 1957 forage utilization data are presented in Table 66.

The interaction was not significant. In clay upland there were no significant differences in degree of use. However, in ordinary upland and limestone breaks, pasture 11 was used significantly more than 10 in each site. It was arrayed above pasture 9 but it did not differ significantly from it. Pastures 10 and 9 were not significantly different.

Table 65. Analysis of variance and Duncan's New Multiple Range Test of total 1956 forage utilization from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	6886.953	2943.476	1.74 n.s.
Sites	2	889.263	444.632	0.26 n.s.
Pastures x sites (p x s)	4	9389.963	2347.491	1.39 n.s.
Error		86035.06	1686.962	

Duncan's Test

Ordinary Upland

n	7	9	6
$\bar{x}$	295.14	302.44	329.67
Pasture	10	11	9

Limestone Breaks

n	10	9	10
$\bar{x}$	293.40	301.00	308.50
Pasture	10	11	9

Claypan

n	1	4	4
$\bar{x}$	258.00	265.75	330.75
Pasture	9	10	11

Table 66. Analysis of variance and Duncan's New Multiple Range Test of total 1957 forage utilization from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	30778.204	15389.102	5.73^{**}
Sites	2	15418.671	7709.336	$2.87^{n.s.}$
Pastures x sites (p x s)	4	11947.628	2986.907	$1.11^{n.s.}$
Error	79	212354.490	2688.032	

Duncan's Test

Ordinary Upland

n	11	11	11
$\overline{x}$	146.18	179.09	199.18
Pasture	10	9	11

Limestone Breaks

n	12	11	11
$\overline{x}$	167.08	206.73	229.64
Pasture	10	9	11

Claypan

n	8	3	10
$\overline{x}$	196.37	206.33	225.30
Pasture	11	10	9

Table 67 discloses the tabulated results of 1956 weed yields. The F value from the analysis of variance shows pastures within sites to have yields giving significant differences. The p x s interaction is not significant. Apparently due to early spring burning, pasture 9 yielded significantly more weeds than

Table 67. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed yields from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	1145.640	572.820	5.96^{**}
Sites	2	401.152	200.576	$2.09^{n.s.}$
Pastures x sites (p x s)	4	438.769	109.692	$1.14^{n.s.}$
Error	51	4901.120	96.100	

Duncan's Test

Ordinary Upland

n :	9	7	6
$\bar{x}$:	7.67	10.71	20.00
Pasture :	11	10	9

Limestone Breaks

n :	9	10	10
$\bar{x}$:	1.89	4.90	14.40
Pasture :	11	10	9

Claypan

n :	4	1	4
$\bar{x}$:	1.25	2.00	8.60
Pasture :	10	9	11

pasture 11 in both ordinary upland and limestone breaks. There were no significant differences in the claypan site.

The 1957 weed yield was analyzed and the results are presented in Table 68.

Table 68. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed yields from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	1535.889	767.944	$1.36^{n.s.}$
Sites	2	402.205	201.253	$0.36^{n.s.}$
Pastures x sites (p x s)	4	2557.094	639.273	$1.13^{n.s.}$
Error	79	44538.090	563.773	

Duncan's Test

Ordinary Upland

n	11	11	11
$\bar{x}$	14.20	27.40	31.50
Pasture	11	10	9

Limestone Breaks

n	11	12	11
$\bar{x}$	12.00	17.20	29.50
Pasture	11	10	9

Claypan

n	3	10	8
$\bar{x}$	16.60	20.70	29.50
Pasture	10	9	11

The presence of significant differences is not indicated by either the analysis of variance or Duncan's test. As arrayed for the multiple range test, pasture 9 produced more weeds than 10 or 11 in limestone breaks and ordinary upland. Observations of this pasture indicated that this is true but there were no significant differences present as indicated in 1956. In claypan the yield of pasture 11 was ranked as highest. Presumably the better soil-moisture relationships on the late-burned pastures may assist weed production as well as other vegetative growth.

Recorded in Table 69 are the analyses for the 1956 weed utilization. Duncan's test and the analysis of variance pointed out significant differences among pastures within a specific site.

Claypan had no significant differences in degree of utilization, but limestone breaks and ordinary upland were identical with respect to differences. Pasture 9 was utilized to a significantly higher degree than 11 but not significantly more than 10. This could follow from the evidence in Table 67 indicating that pasture 9 was the highest producer of weeds and as indicated in Table 63 in limestone breaks where it was the lowest in yield of forage.

Significant differences were nonexistent in the 1957 weed utilization results as shown in Table 70.

Both the analysis of variance and the multiple range test gave evidence of this. The additional moisture of 1957 may have produced enough forage to keep utilization of weeds at a minimum, thus balancing their use among pastures within given sites.

Table 69. Analysis of variance and Duncan's New Multiple Range Test of total 1956 weed utilization from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	1181.194	590.597	4.37^{*}
Sites	2	42.447	21.223	$0.16^{n.s.}$
Pastures x sites (p x s)	4	81.464	20.366	$0.15^{n.s.}$
Error	51	6888.750	135.074	

<u>Duncan's Test</u>

<u>Ordinary Upland</u>

n :	9	7	6
$\overline{x}$:	237.67	243.86	250.33
Pasture :	11	10	9

<u>Limestone Breaks</u>

n :	9	10	10
$\overline{x}$:	238.78	241.50	250.00
Pasture :	11	10	9

<u>Claypan</u>

n :	4	4	1
$\overline{x}$:	237.75	240.25	241.00
Pasture :	11	10	9

Table 70. Analysis of variance and Duncan's New Multiple Range Test of total 1957 weed utilization from combined like sites in Donaldson Pastures 9 through 11 (burned).

Source of variation	d.f.	S.S.	M.S.	F
Pastures	2	46.884	23.442	0.04$^{n.s.}$
Sites	2	443.749	221.875	0.37$^{n.s.}$
Pastures x sites (p x s)	4	2706.336	676.584	1.13$^{n.s.}$
Error	79	47317.700	598.958	

Duncan's Test

Ordinary Upland

n :	11	11	11
$\bar{x}$:	162.73	170.00	173.82
Pasture :	11	9	10

Limestone Breaks

n :	12	11	11
$\bar{x}$:	161.58	163.27	167.00
Pasture :	10	11	9

Claypan

n :	10	3	8
$\bar{x}$:	159.90	161.00	179.62
Pasture :	9	10	11

DISCUSSION AND CONCLUSIONS

Total Vegetation by Pastures

From the results of the preceding data comes evidence to support the following conclusions.

Pastures 1 through 6. These pastures were affected by grazing and range site conditions. The pastures which were heavily grazed yielded less than those which were lightly grazed. Pastures which were lightly grazed produced high yields. Pastures high in yield tend to be low in utilization and those pastures low in yield are high in utilization. Deferred-rotation pastures were generally ranked between pastures which yielded highest and lowest, generally being nearer the high ones in yield and the low ones in utilization. The moderately stocked pasture grazed season long tended to be nearer the low yielding pastures in yield and nearer the highly utilized pastures in utilization.

Pastures 1 through 6, and 9 through 11. With the inclusion of the burned pastures, sampling was limited to ordinary upland and limestone breaks sites. Pasture 3, grazed lightly, yielded most with the deferred-rotation pastures remaining near the top. The remaining pastures tended to intermix; however, pasture 2 was consistent in being near the bottom in yield. The burned pastures were nearer the bottom than the top. Pasture 9, which was early spring burned, yielded slightly more than 2 but it was not significantly so. While some variation was present, generally those pastures which yielded high showed low utilization and the pastures yielded low exhibited high utilization.

Pastures 9 through 11. The treatment on these pastures consisted of burning at different dates. No effect was made upon total vegetative yield. With respect to utilization it is hard to make a definite conclusion. It appears that pastures 9 and 11 were most utilized, especially during 1957.

Forage, Mulch, and Weeds by Pasture

Pastures 1 through 6. Forage. The production of forage seems to be quite variable from year to year. If more than 2 years' data were available more accurate results could be observed. Differences due to pasture treatments do occur in the utilization of forage. The production of forage is least when utilization is most, and the production of forage is most when utilization is least.

Mulch. The yield of mulch is quite highly affected by the different pasture treatments; however, best treatments cannot be recommended for an overall pasture unless the complete pasture consists of only one site. Mulch utilization is not influenced by different pasture treatments.

Weeds. The weed yield in these pastures is variable from year to year. Range sites are an important source of variation in weed yields, not only due to different treatments but also due to differences in soil and soil-moisture conditions. Pastures 4 and 2 produced the greatest amount of weeds. Variation is such in weed utilization that significant differences among pastures exist one year, and the next year those differences will be gone.

Pastures 1 through 6, and 9 through 11. Forage. The yield of forage is affected by various pasture treatments. The late spring burned pasture ranked high in yield. Pastures 3 and 6, lightly grazed and deferred-rotation grazed respectively, also ranked among the top forage producers. Pasture 1 ranked low in forage yield as did pastures 2 and 4. The different stocking rates and grazing systems affected the utilization of forage in these nine pastures. Pastures 9 and 11, the early and late spring burned pastures respectively, were utilized most. The heavily stocked pasture was also utilized heavily.

Weeds. There were differences in yields of weeds due to pasture treatment, but these differences were not consistent for the two years in which the experiment was evaluated. Pastures 2 and 4 were both in the highest yielding class each year. The utilization from year to year was not consistent at all as far as effects which were caused by pasture treatments were concerned. Pastures 2 and 4 were both highly utilized each year but in 1957 they were not significantly different from any of the other pastures.

Pastures 9 through 11. Forage. There was no consistency in the variations in yield among pastures. In 1956 they were non-significant while the following year they were significant at the .001 level. No definite conclusions can be drawn. Pasture 9 was utilized hardest each year.

Weeds. Too much variation was found in differences among pastures with respect to weed yield to draw accurate conclusions. More information needs to be gathered on both yield and utilization.

Forsge, Mulch, and Weeds by Site

Pastures 1 through 6. Forage; Ordinary Upland, Limestone Breaks, and Clay Upland. Little can be said with respect to forage yield on these sites when only two years of data are compared, especially when they are inconsistent. The only definite evidence observed is that in both ordinary upland and limestone breaks, psstures 6 and 3 are in the top yielding group. With respect to utilization, pasture treatments were affecting the degrees of use among pastures. In ordinary upland, pasture 5 is found in the group utilized most. In limestone breaks, pastures 2 and 5 were consistently used the most. All that can be said of clay uplsnd is that pasture 6 was consistently low in utilization.

Mulch; Ordinary Upland, Limestone Breaks, and Clay Upland. Regardless of the differences in precipitation amount between 1956 and 1957, pasture treatments did affect the yield of mulch. Pasture 3 was a consistently high yielder in ordinary upland and limestone breaks. Pasture 2 was consistently low in limestone breaks. In clay upland, 4 and 6 were high and 2 was low. Utilization was not affected by the pasture treatments throughout the two years.

Weeds; Ordinary Upland, Limestone Breaks, and Clay Upland. The yield of weeds was not affected greatly by the different pasture treatments. Pasture 2 was consistently high in weed yields in ordinary upland and limestone breaks. In clay upland, pasture 6 was low in yield of weeds. The difference in rainfall between the two years evaluated is offered as an explanation for the inconsistencies in utilization of weeds.

Pastures 1 through 6, and 9 through 11. Forage; Ordinary Upland and Limestone Breaks. The yield of forage among these pastures was affected by the pasture treatments. The best treatments were not too consistent, however. Pasture 3 was in the top yielding group while in the limestone breaks, 1 and 5 were low yielding. The various pasture treatments have affected the use of forage. The forage on the burned pastures has been consistently used heavily although within those three pastures, 1 was not used consistently more than another. In limestone breaks, pasture 2 was used heavily also.

Weeds; Ordinary Upland and Limestone Breaks. In this group of pastures the weeds were consistently high in yield in pasture 2 and consistently low in the late burned pasture 11. The pasture treatment did affect the yields of the pastures within the sites. The large pastures mean square indicated that in 1956, weeds must have been used to a greater extent than in 1957. The precipitation difference will account for much of the inconsistencies here. As ranked, pastures 2 and 4 were fairly well utilized while the burned pasture 11 consistently ranked low.

Pastures 9 through 11. Forage; Ordinary Upland, Limestone Breaks, and Claypan. The forage yield was not consistent enough to safely say that pasture treatments were causing the results indicated by this study. In claypan, pastures 9, 10, and 11 were low, medium, and high in forage yield, respectively, as far as rank was concerned. Again, with respect to forage utilization there were no consistencies between the two years.

Weeds; Ordinary Upland, Limestone Breaks, and Claypan. In the burned pastures there was some factor which caused a high degree of variability in the 1957 weed yield, resulting in inconsistencies to be reported and indicating that pasture treatments are not always affecting the weed yields in the same way. When means were ranked, however, they fell exactly in the same places each year so if it weren't for the large error mean square, one would say that the pasture treatments were consistently affecting the weed yields. Concerning the utilization of weeds in these pastures the conclusions are also confused so no definite statement can be made regarding pasture treatment effects except that they do not appear to be affecting the use of the weeds.

SUMMARY

This study has been conducted in an effort to determine the effects of grazing and range site condition upon the yield and utilization of true prairie vegetation. The experiment was conducted in the Donaldson Pastures, 6 miles northwest of Manhattan. Three comparisons were made: (1) comparisons of total vegetative yield and utilization by pasture, (2) comparisons of forage, mulch, and weed yield and utilization by pasture, and (3) comparisons of forage, mulch, and weed yield and utilization by site. Treatments applied to the pastures consisted of different stocking rates, deferred-rotation grazing, and different dates of burning.

Total vegetative yield and utilization were found to vary with different pasture treatments. In pastures 1 through 6, and 9 through 11 the same general trend was found. The burned pastures

(9 through 11) tended to yield more nearly like pastures that had been grazed hard. The utilization pattern was the same as that for pastures 1 through 6. In pastures 9 through 11 the burning did not affect the yields. Neither was utilization affected significantly.

Yield and utilization of forage, mulch, and weeds were quite varied and inconsistent from year to year. Definite conclusions as to best yielding pasture treatments cannot often be made with certainty. Generally when conditions for a good combination of each year's data existed, definite pasture treatments could be recommended. This did not occur frequently enough to establish any kind of trend or pattern. The following observations were made from the data, however. Pastures which were stocked heavily generally yielded least in forage and mulch; often they yielded high with respect to weeds.

A partial explanation for all of the inconsistencies is the difference in amount of precipitation during 1956 and 1957. The former year was dry while the latter one was above normal in rainfall. This presented conditions which were, in part, quite dissimilar upon which the comparisons were based. Additional data from succeeding years would be desirable in obtaining more accurate results.

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THE EFFECTS OF GRAZING AND RANGE SITE CONDITION UPON YIELD AND UTILIZATION OF TRUE PRAIRIE VEGETATION

by

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Ranges have been overgrazed for many years. Not until recently has the seriousness of this exploitation been realized when research workers and ranchers have joined together in an attempt to improve the range as it exists today. The purpose of this study is to increase understanding and knowledge of the effects of grazing and range site condition upon true prairie vegetation.

The experiment was performed on the Donaldson Pastures, 6 miles northwest of Manhattan, Kansas, and data were collected during 1956 and 1957. Nine different pastures were used. The various pasture treatments were begun about 1950. All were typical Flint Hill rangeland. Treatments on six of the pastures consisted of light (7.5 acres per animal unit), moderate (5.0 acres per animal unit, and heavy (3.5 acres per animal unit) stocking rates and a system of deferred rotation grazing. On the other three pastures, different dates of annual burning were used as treatments. The pastures were burned in early spring, mid spring, and late spring.

Upon each of these pastures a measurement of yield and utilization was taken. This was done by the use of heavy woven-wire cages. The cages were 4 feet x 4 feet. These were placed randomly over four major sites. Six pastures had ordinary upland, limestone breaks, and clay upland throughout, while the other three had ordinary upland, limestone breaks, and claypan. In the fall of the year after the growing season had been completed, an area 25.04 inches square (1/10,000 of an acre) was clipped from under the cage at a height of one inch. Another sample of the same size was taken outside the cage from a representative area. Forage, mulch, and weeds were separated at the time of clipping. These samples were bagged and labeled in the pasture and taken to the greenhouses for drying. The weight of the material from under the cage represented yield for that year. The weight of the sample outside the cage subtracted from the weight of that under the cage gave the utilization measurement.

Three comparisons were made from the data obtained, (1) comparisons of total vegetative yield and utilization by pastures, (2) comparisons of forage, mulch, and weed yield and utilization by sites. Treatments applied to the pastures consisted of different stocking rates, deferred-rotation grazing, and different dates of burning.

Total vegetative yield and utilization were found to vary with different pasture treatments. In pastures 1 through 6 the highest yielding pastures were those grazed lightest. The lowest yielding pastures were those grazed heaviest. As vegetative yield increased, utilization decreased. In pastures 1 through 6, and 9 through 11 the same general trend was found. The burned pastures (9 through 11) tended to yield more nearly like those that had been grazed hard. The utilization pattern was the same as that for pastures 1 through 6. In pastures 9 through 11 the burning did not affect the yields. Neither was utilization affected significantly.

Yield and utilization of forage, mulch, and weeds were quite varied and inconsistent between years. Definite conclusions as to best yielding pasture treatments cannot often be made with any degree of certainty. Generally, when conditions for a good combination of each year's data existed, definite pasture treatments could be recommended. This did not occur frequently enough to establiah any kind of a reliable trend or pattern except in the following case. Pastures which were stocked heavily generally yielded less forage and mulch than did those stocked lighter. Often the heavily stocked pastures yielded high with respect to weeds.

A partial explanation for all of the inconaistencies is the difference in amount of rainfall during 1956 and 1957. The former year waa dry while the latter one was above normal in precipitation. This presented conditions which were, in part, quite dissimilar upon which the comparisons were based. Additional data from succeeding years would be desirable in obtaining more accurate and enlightening results.