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Original grade range ewes used in the investigation reported in this bulletin, photographed after they had produced five crops of lambs. Yearling ewes of the 1923 crop are shown in the background.

Fitting Sheep Into Plains Farming Practices

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SUMMARY

SHEEP may be grazed to keep down weed growth during the early summer period, thus eliminating weed-control cultivations from those usually necessary to maintain clean fallow. Sheep in this experiment proved very effective in controlling weed growth on their respective miniature farms, but the experience gained here indicates clearly that unless sheep husbandry is taken up as a community project there is no hope that their grazing will result in a diminished weed crop on the individual farms.

Pasturing sheep on weeds on fallow land during the early summer saved approximately two weed-eliminating cultivations but resulted in a 30-percent lower yield of winter wheat the following year. Pasturing the rye instead of plowing it under for green manure saved one or two weed-eliminating cultivations and two plowings every four years, and in addition resulted in a 15½-percent higher yield of winter wheat the following year. The pastured rye, however, did not yield as well as the pastured fallow by 15 percent.

The test of a successful pasture succession is the amount of the overlapping dates of availability and exhaustion of the different kinds of pasture. The rye became available at an average date of May 13, which was 22 days before the next earliest unit, the sod grasses, and held out for a yearly average of 60 days. There was only one year, 1925, when the rye failed to furnish pasture up to the available date of the grasses of the sod supplemental plot. The sod grasses became available at an average date of June 5, much in advance of the average date of the exhaustion of the pasture on the rye plot, and held out for a yearly average of 36 days. The weeds on the fallow became available at an average date of June 15, just 10 days later, and held out for a yearly average of 36 days. The sod and supplemental pastures easily furnished the 22 and 25 days of pasture annually necessary to bridge the rye, and the weeds on fallow, respectively, over to August 3, when the stubble plots became available. Barley was harvested at an average date of July 13, or 4 days earlier than the winter wheat. The stubble plots furnished continuous pasture until exhausted, which usually was just after the first hard, killing fall frost.

The weeds on the 2 acres of fallow, with an average available date of June 15, furnished the average of 7.7 ewes and 6.4 lambs a yearly average of 36 days of pasture. These weeds were the starting pasture unit on the fallow rotation 4 years out of the 11 years.

The 2-acre rye plot, with the rye available at an average date of May 13, furnished the average of 7.7 ewes and 6.5 lambs a yearly average of 60 days of pasture. The rye was the starting pasture unit on that rotation each and every year. The pasture from the rye plot after about June 20 was likely to be largely weeds which the sheep apparently grazed with equal relish.

The weeds and waste grain of the 4 acres of stubble, available at an average date of August 3, furnished the average of 7.7 ewes

and 6.5 lambs a yearly average of 63 days of pasture. There were 37 days from the winter-wheat stubble plots and 29 days and 22 days from the barley-stubble plots of rotations 28 and 51, respectively.

The 2 acres of native sod of the supplemental plots, available at an average date of June 5, furnished the average of 7.7 ewes and 6.5 lambs a yearly average of 36 days of pasture. The pasture obtained from these small supplemental plots was almost exactly the same as that obtained from the 10-acre native-sod pasture. This probably means that these small areas were not grazed as closely as was the 10-acre sod pasture, for the deferred grazing, especially during the last 6 years of the experiment, should have resulted in increased pasturage. The sod pasture supplemental to the fallow rotation was the starting pasture unit in 7 of the 11 years. The 10-acre native-sod pasture furnished the average of 10 ewes and 9.5 lambs a yearly average of 131 pasture days.

The relative carrying capacities of the different pastures for sheep, as determined by this experiment and expressed as percentages of winter rye for 60 days are as follows: winter rye, 100; sod grass, 60; weeds on fallow, 60; and weeds and waste grain on stubble land, 52.5. The 2 acres of standing cornstalks furnished winter grazing for an average of 8 bred ewes for a yearly average of 94 days.

The average gains of the ewes and lambs on lot 1, on the 10-acre native-sod pasture, were 9.5 and 33.8 pounds, respectively. The average gains of the ewes and lambs of lot 2, on the grazing rye rotation 51, were 19.8 and 44.9 pounds, respectively. The average gains of the ewes and lambs of lot 3, on the grazing fallow rotation 28, were 19.7 and 35.3 pounds, respectively.

The data indicate that 160 ewes and their lambs can be carried on each quarter-section of native short-grass sod, with an average annual grazing season of 131 days. The length of the pasture season on sod land could undoubtedly be increased proportionately by decreasing the number of ewes and lambs per 10-acre unit.

The data indicate that 96 ewes and their lambs can be carried on each quarter-section of land devoted to a cropping lay-out as exemplified by grazing rotation 51 (wheat on pastured rye, corn, barley, pastured rye, and supplementary sod pasture), with an average annual grazing season of 157 days. The data indicate that 96 ewes and their lambs can be carried on each quarter-section of land devoted to a cropping lay-out as exemplified by grazing rotation 28 (wheat on fallow, corn, barley, pastured fallow, and supplementary sod), with an average annual grazing season of 136 days.

The data indicate that 72 ewes and their lambs can be carried on each quarter-section of land devoted to a lay-out outlined as follows, with a carefully estimated average annual grazing season of 195 days: 37½ acres in native sod, with five other fields of 24½ acres each cropped to a rotation of winter rye followed by corn, barley, fallow, and winter wheat, respectively, in the order indicated.

Fitting Sheep Into Plains Farming Practices¹

George E. Morton², E. J. Maynard³, J. F. Brandon⁴

THIS BULLETIN reports the 11 years' results of pasturing three lots of ewes and their lambs on three differently managed but identically sized areas at the U. S. Dry-land Field Station at Akron, Colo. Two of the primary objects were to discover whether grazing by sheep might replace cultivation of summer fallow on farms in the plains area and to determine approximately the carrying capacity of native short-grass sod.

Fallow land is land that is allowed to be without crop one season, the surface being kept free from weeds and in a condition sufficiently open to receive and absorb hard, beating rains.

A year of fallow every 2 to 5 years is generally recommended as good farming practice upon non-irrigated plains farms. Farmers producing only grain generally fallow their land every second or third year. Farmers producing diversified crops will find that fallowing each unit area of their farms every 4 or 5 years, if on hard land, will aid in eliminating noxious annual weeds and will make more certain a satisfactory yield of the important cash crop.

Cultivation is needed to keep the ground free of weeds. These cultivations also keep the ground open and in suitable condition for absorbing rains. The number of cultivations required will vary from season to season, depending upon the distribution and the amount of rainfall, but will average about 3 to 4.

Sheep might be used to keep down weed growth and so reduce the number of cultivations, provided such grazing would not result in too greatly reduced yields of subsequent crops. Sheep kept for this purpose could also be used to graze the grain stubble fields, as these usually become very weedy after harvest unless the fields were fallow the previous year, and sometimes even then. This late summer growth of weeds in stubble on the hard lands is chiefly Russian thistles and pigweeds. Also there is some waste grain that may be gleaned by sheep.

The United States Dry-land Field Station is located on the plains of Northeastern Colorado, near Akron. The land on which

¹This bulletin gives the results of experiments carried on by the Animal Investigations Section of the Colorado Experiment Station, operated in connection with the Colorado State College of Agriculture and Mechanic Arts at Fort Collins, cooperating with the U. S. Dry-land Field Station at Akron, Colo., operated by the Division of Dry-land Agriculture of the U. S. Department of Agriculture, Washington, D. C. The experiment was planned in 1918 by George E. Morton, head of the Animal Investigations Section of the Colorado Experiment Station, and O. J. Grace, then superintendent of the U. S. Dry-land Field Station near Akron, Colo. Dr. W. W. Robbins, then botanist of the Colorado Experiment Station, planned the botanical phases of the work which were carried on by E. C. McCarty and Dr. H. C. Hanson of the Colorado Experiment Station from 1920 to 1930. Mr. Grace had charge of the agronomic phases of the work in 1918 and 1919, and J. F. Brandon from 1920 to 1930.

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the experiment was located is typical hard land of this region, the soil being classified as a light brown to brown loam. The sod in the native state is typical short-grass sod, being made up largely of buffalo grass (*Bulbilis dactyloides*) and grama grass (*Bouteloa gracilis*).

The monthly, seasonal, and annual precipitation for each of the years from 1920 to 1930, inclusive; the averages for the 11 years; and the averages for the 23 years from 1908 to 1930 are given in table 1.

This experiment was started in the spring of 1920 as a co-operative experiment between the Colorado Experiment Station and the Bureau of Plant Industry, U. S. Department of Agriculture. This bulletin presents the pasturing results from 1920 to 1930 and the cropping results from 1921 to 1931.

OBJECTS OF EXPERIMENT

1. To study the possibility of replacing fallow cultivations by the grazing of sheep.
2. To determine the value of sheep in keeping down weed growth and their possible value in reducing the percentage of weeds on cultivated farms in Eastern Colorado.
3. To study the effect on the following winter-wheat crop (*a*) of pasturing weeds on fallow land and (*b*) of pasturing fall-sown winter rye.
4. To study the ability of certain crops in definite rotations to provide continuous pasturage.
5. To study the carrying capacity of (*a*) weed growth on fallow, (*b*) fall-sown winter rye, (*c*) weed growth and waste grain on small-grain stubble land, and (*d*) native sod.
6. To determine in terms of bred ewes per acre the carrying capacity of standing cornstalks as pasturage after the corn is husked.
7. To determine the summer gains in live weight of ewes and lambs when pastured on non-irrigated Eastern Colorado farms devoted to certain definite cropping systems.
8. To study the results of this experiment with a view of arriving at an optimum sheep-carrying capacity for plains farms when devoted to certain definite cropping systems.

PLAN OF EXPERIMENT

Three adjacent 10-acre areas were selected which were identical in soil type and vegetation cover insofar as those in charge were able to determine identity of these factors. These areas, however, were not uniform in topography. The lack of uniformity in topography prevented grouping the units to the best advantage from a pasture-management standpoint. However, the grouping as selected gave a fair distribution of the units over the two soil levels (fig. 1).

The rotations chosen for this experiment were identical in all but one respect with two rotations, numbers 28 and 51, that had been carried since 1908 on the main rotation field. Oats in rotation 28 in the main field was replaced by barley in the grazing experiment. The rotations were continued on the main rotation fields during the period of this experiment, so that direct comparisons can be made between crop yields on the main plots and upon the plots used in this sheep-grazing experiment.

Because of the need for proper utilization of pasturage upon the plots in the sheep-grazing experiment, and because pasturing affected the cultivation required, it was impossible with either the fallow land or the rye plots to keep cultural practices absolutely uniform between the main rotation plots and these sheep-grazing



Figure 2.—View of the sheep-grazing rotation plots, looking northwest.

plots of like nature. This, however, does not prevent a comparison of yields, because in this experiment the most efficient management of sheep in connection with the rotations is of paramount importance, and any loss or gain in subsequent crop must be considered in connection with returns from the flock.

It was decided to allot 10 ewes and their lambs to each 10-acre area. The layout of the pastures in the field is shown in figure 1.

Area 1, 10 acres in native short-grass sod pastured by ewe-and-lamb lot 1. One 20-by-20 foot quadrat was fenced out of the pasture each year, and another of the same size was fenced in.

Area 2, sheep-grazing rotation 51: Ten acres were divided into five 2-acre plots and pastured by ewe-and-lamb lot 2: One 2-acre plot was left permanently in native sod, and the other four 2-acre plots were in rotation 51, which is winter rye, winter wheat, corn, and barley.

Area 3, sheep-grazing rotation 28: Ten acres were divided into five 2-acre plots and pastured by ewe-and-lamb lot 3. One 2-acre plot was left permanently in native sod, and the other four 2-acre plots were in rotation 28, which is fallow, winter wheat, corn, and barley.

Area 2, sheep-grazing rotation 51, differs from area 3, sheep-grazing rotation 28, in only one respect: namely, that winter rye takes the place of fallow in sheep-grazing rotation 28.

MANAGEMENT OF GRAZING AREAS

Area 1, the 10-acre native-sod area: This area was grazed by lot 1, consisting of 10 ewes and their lambs, from as early in the spring to as late in the fall as pasture was available.

Area 2, sheep-grazing rotation 51, and area 3, sheep-grazing rotation 28: These areas are similar except in one crop in the rotation; hence the details of the management are discussed jointly.

These areas were grazed by ewe-and-lamb lots 2 and 3, respectively, consisting usually of 10 ewes and their lambs during the first 5 years and of 6 ewes and their lambs during the last 6 years of the experiment. They were grazed usually from as early in the spring to as late in the fall as pasture was available. Any deviation from this rule is explained in the text.

The winter rye was early fall-seeded on the barley stubble land. During the early years of the experiment the barley stubble was plowed; but later, when it was observed that it was largely devoid of weeds due to the pasturing, the land was duckfoot or field cultivated in preparation for the seeding of the winter rye. This rye occasionally provided some pasture in the fall, but its principal pasture season was from as early the following spring to as late as pasture was available, or until the small-grain stubble plots became available, after which the land was made ready for seeding to winter wheat. In the early years the remaining crop of rye was plowed under in bloom stage, whereas later it was allowed to stand in order to furnish pasture up to the time the stubble plots became available. Some changes such as this were found necessary, after the experiment had progressed a few years, in order to adjust properly livestock and crop management. The pasture period on the winter rye was usually broken by a period on the native sod.

The fallow plot was very early spring-plowed and packed, and weeds thereon were grazed from the earliest date up to the time the small-grain stubble plots became available, after which the land was made ready for seeding to winter wheat. This early spring-plowing of the fallow plot was not consistently followed the first 4 years of the experiment, during which time valuable experience was being gained on the effect of the time of plowing on the resulting weed crop.

The winter wheat was early fall-seeded at the rate of 3 pecks per acre on the pastured rye and on the pastured fallow plots. The common drill was used during the early years and the furrow drill during the later years of the experiment. The variety used was Kanred, C. I. 5146. The sheep pasturing on these fields during the first half of the summer left the soil tight and hard but largely

devoid of weeds. The seed bed for the wheat was prepared during the early years of the experiment by plowing, and later by duck-foot cultivating. The winter-wheat stubble was grazed after the threshing date to as late in the fall as pasture was available. During the first 5 years of the experiment the winter-wheat straw was available to the ewes and lambs on the stubble plot. The sheep ate some of this straw but largely wasted it. The remaining straw was hauled off the plots during the winter to leave the land clear for the following crop. The straw was not available to the sheep during the summer pasture seasons of the last 6 years of the experiment.

The corn was seeded with a corn planter, equipped during the latter part of the experiment with furrow openers, on early spring-plowed winter-wheat stubble land. A locally adapted strain of corn was used, common with the variety used on the main rotation plots. It was spaced about 30 inches between the plants in the rows, the rows being 42 inches apart; these factors were common with those of the corn in the main rotation block. The corn was clean cultivated. The standing cornstalks were grazed during the winter months by the bred ewes of the respective lots.

The barley was early spring-seeded, 5 pecks per acre about April 1, on the pastured corn-stover land. The variety was an adapted strain common with the variety used on the rotation plots. The corn ground was disked or duckfoot cultivated in preparation for the barley. The barley stubble was grazed from the threshing date to the date of seeding the rye in the one rotation, and to as late in the fall as pasture was available in the other. The barley straw of sheep-grazing rotation 51 was threshed on the winter-wheat stubble plot, so that the barley-stubble plot would be open for seeding to the winter rye. During the first 5 years of the experiment this barley straw was available to the ewes and lambs. They ate some but largely wasted it. The remaining barley straw of both plots was hauled off during the winter so as to have the land open for preparing for the spring crops. This straw was not available to the ewes and lambs during the summer-grazing periods of the last 6 years of the experiment.

The 2 acres of sod of the two 10-acre cropped rotations were heavily grazed during the first 5 years of the experiment, because the allotment was at the rate of 10 ewes and their lambs per 10-acre area, and also because they were forced to carry a heavy portion of the pasture burden up to the time the small-grain stubble plots became available. During the last 6 years of the experiment the allotment was reduced to 6 ewes and their lambs per 10 acres, and owing to the changed cultural methods previously mentioned these sod areas were not so heavily grazed. They were used insofar as possible to extend the pasture season at the beginning or close and were used only during the summer when pasture could not

possibly be made available elsewhere. Fearing the original 2-acre sod plots might have been injured by the close grazing during the first 5 years, new 2-acre sod plots adjoining the old ones on the west were fenced out for use with the reduced allotment during the last 6 years of the experiment (fig. 1).

GRAZING MANAGEMENT OF EWES

Thirty 2-year-old range ewes showing Rambouillet and Shropshire blood were purchased during the spring of 1920. They were of medium grade and quality and in fair condition. These ewes dropped lambs after they were received at the station.

During the first 2 years of the experiment no extra ewes were kept. Because of early spring deaths there was a shortage of ewes in 1921. There were more early spring death losses in 1922, and



Figure 3.—Yearling ewes of the 1923 crop; these grade Hampshires had been grown out properly. Compare with cover illustration.

extra ewe lambs were purchased to build up the flock to the requirements of the experiment. Thereafter a few extra ewes were kept on hand for replacements.

The ewes were bred in the fall to a registered Hampshire ram. The ewe lambs saved for replacements were not bred during the first winter and usually were not added to the flock until the second fall after their birth, when they were coming 2-year-olds.

New allotments were made up each year, observing such factors as age, weight, quality, type, grade of wool, and numbers and ages of lambs.

A ewe was not used in the grazing experiments after 5 years of age except in rare instances, and then it was made certain that her teeth were sound. Ewes were usually bred to lamb in March and early April, in advance of the opening of the grazing season.

Allotments were made when the first pasture became available, which was usually the rye pasture of area 2. The other two lots were kept in dry lot until pasture became available on their respective areas.

The ewes were sheared late in May or early June, when permanently warm weather seemed assured. This was after the early spring allotment and quite often after the initial weights were obtained. The allotment weight when corrected by the weight of the wool clip and the parturition loss, if necessary, is considered the initial weight.

Salt was present in the grazing plots at all times. Water was provided in open tanks. Summer shelter was portable sheds with sloping roofs, boarded up on three sides. These, with the salt block and water tank, were moved as the sheep were changed from plot to plot.

Weights of ewes and lambs were taken at the beginning and at the end of the summer grazing period and at approximately monthly intervals during the grazing season.

ANNUAL CONDITIONS AND RESULTS

The details of the experimental conditions and results for the summer pasturing periods from 1920 to 1930, inclusive, are given in the pages immediately following.

Summer Grazing Test, 1920

The allotment of ewes and lambs for the first summer grazing test was made May 23, and the summer pasturing of the three lots started on that date. This was before the ewes had been clipped but after they had lambed. The three lots for 1920 were made up of 10 ewes and 9 lambs each. The station had no equipment for shearing sheep, and it was not until July 1 that a commercial shearer could be secured. One lamb was lost from lot 3 only 4 days after the start of the summer grazing.

The season was favorable. The rainfall was well distributed, and both the annual and the seasonal were well above the averages. The average pasture season of the three lots was the second longest, 151 days; and the ewes made the second greatest gain, 28 pounds, of the 11-year period. The lambs made the fourth greatest gain, 43.3 pounds, of the 11-year period. The pasture season was the same length on the three areas. Both the ewes and the lambs of lot 3 made the greatest average gains of the three lots. This lot, however, contained one less lamb than the others.

Detailed data of the pasture periods, and the weights and gains of the ewes and lambs for 1920, are given in table 2.

Lot 1, on 10-Acre Native-Sod Pasture

The grasses of this area greened up comparatively early and

were pastured by the 10 ewes and 9 lambs from May 23 to October 21. The first vegetation was the slender fescue (*Festuca octoflora*).

One lamb was killed on this area on October 10, probably by a coyote.

Lot 2, on Sheep-Grazing Rotation 51

The 10 ewes and 9 lambs pastured on this area from May 23 to October 21.

The winter rye seeded on October 6, 1919 did not emerge until early in the spring of 1920. It came on slowly and was not ready to pasture until May 23. The 10 ewes and 9 lambs pastured on this rye in conjunction with the 51A^s ½-acre sod plot from May 23 to June 23, a period of 31 days, when the remaining rye, then in milk stage, was plowed under. Weeds on this plowed-under rye ground were grazed in conjunction with the 51A ½-acre sod plot from July 7 to 15, a period of 8 days, and alone from July 31 to August 12, a period of 12 days. This plot was thereafter plowed and packed on August 12 and 13 and seeded to winter wheat on September 16. It was observed that, while the sheep had the run of both the sod and the rye pasture, they grazed practically all the time on the latter; the rye pasture is credited with the entire time spent jointly on the two areas. It is especially significant that the sheep cleaned up the young, succulent weed growth on the rye plot between July 7 and 15, when they were also on the 51A sod plot.

The 51A ½-acre sod plot was pastured in conjunction with the rye plot from May 23 to June 23, a period of 31 days, and from July 7 to 15, a period of 8 days. The 51B 1½-acre sod plot was grazed from June 23 to July 7, a period of 14 days, and from July 15 to 31, an additional period of 16 days.

Wheat and barley on both pasture rotations were threshed on August 12. Threshing marks the date when the stubble plots became available as pasture for the sheep. The barley stubble was pastured from August 12 to September 22, a period of 41 days, after which the land was made ready for seeding to winter rye by plowing and packing. The winter-wheat stubble was grazed from September 22 to October 21, a period of 29 days. The straw from these two stubble plots, 346 pounds of winter wheat and an undetermined amount of barley, was left on the winter-wheat plot.

Lot 3, on Sheep-Grazing Rotation 28

The 10 ewes and 8 lambs pastured on this area from May 23 to October 21. This lot started with 9 lambs, but one died of mother neglect 4 days after the beginning of the summer grazing.

The fallow plot was not plowed until August 13, when the stubble plots of this area became available for pasture. The 10 ewes

^sThe 2 acres of sod of this cropped grazing rotation were divided into two separate plots during the first 5 years of the experiment. One plot contained ½ acre and will hereafter be referred to as the 51A sod plot. The other contained 1½ acres and will hereafter be referred to as the 51B sod plot.

and 8 lambs grazed on the fallow plot in conjunction with the 28A⁶ 1-acre sod plot from May 23 to June 22, a period of 30 days. There was practically no weed growth on the fallow plot before June 14, so the pasture burden up to this date rested on the 1-acre sod plot. The fallow plot therefore is given credit for only eight of these pasture days. Weeds did not reappear on the fallow plot until July 7, when they were pastured to August 13, a period of 37 days. This land was then plowed and packed on August 13 and 15 and seeded to winter wheat on September 16.

The 28A 1-acre sod plot was grazed in conjunction with the fallow plot from May 23 to June 22, a period of 30 days, during which the sod grasses carried the pasture burden. The 28A sod plot is therefore credited with 22 of these 30 pasture days. The 28B 1-acre sod plot was grazed from June 22 to July 7, a period of 15 days.

The barley-stubble plot was grazed from September 15 to October 21, a period of 36 days. The winter-wheat stubble plot was pastured from August 13 to September 15, a period of 33 days. The straw was left on the respective stubble plots. The ewes and lambs ate some straw but largely wasted the bulk of 205 pounds of wheat straw and an undetermined amount of barley straw.

Summer Grazing Test, 1921

The allotment of ewes and lambs for the second summer grazing test was made on June 20, and the summer pasturing of the three lots was started on that date. This was after the ewes had been clipped and after they had lambed. Two ewes died from disease early in the spring at lambing time, and these were not replaced. The lamb crop was small due to losses at lambing time. The three lots for 1921 were made up as follows: lot 1, 10 ewes and 10 lambs; lot 2, 9 ewes and 5 lambs; lot 3, 9 ewes and 4 lambs.

The ewes were clipped the day before the opening of the pasture season, resulting in general confusion among the ewes and lambs. It was not until June 27, a week after the beginning of the pasture season, that mothers and lambs became reunited so that initial lamb weights could be secured.

Lambs were removed from the lots on September 22 because of anticipated shortage of pasture, and because the lambs were already a good weight for feeder lambs.

The season was unfavorable. The total rainfall was one-fourth and the seasonal rainfall one-third less than the 11-year average. This resulted in a short pasture season and in decidedly less than average gains among the ewes and lambs.

The pasture season was the same length on the three areas. Both ewes and lambs of lot 2 produced the heaviest gains, 17.2 and

⁶The 2 acres of sod of this cropped grazing rotation were divided into two separate plots during the first 5 years of this experiment. These plots contained 1 acre each and will hereafter be referred to as 28A and 28B sod plots.

23.5 pounds, respectively. However, neither lot 2 nor lot 3 contained as many ewes or lambs as did lot 1.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1921 are given in table 3.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was cold and backward, and grasses on this area did not green up until June 20. The 10 ewes pastured on this area from June 20 to October 20 and the 9 lambs from June 20 to September 22. Lambs were taken from this lot on September 22 to be sold as feeder lambs.

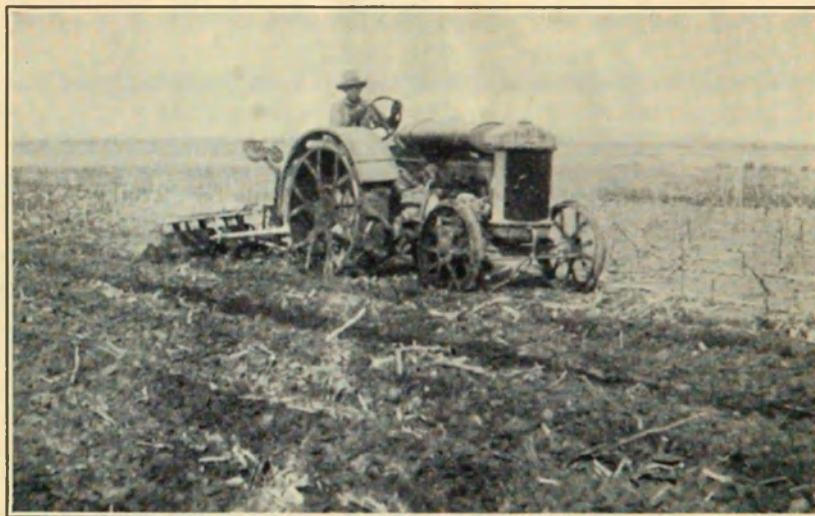


Figure 4.—Double-disking one of the corn-stover plots of the sheep-grazing rotations in the early spring of 1921, preparatory to seeding barley.

Lot 2, on Sheep-Grazing Rotation 51

The 9 ewes pastured on this area from June 20 to October 20 and the 5 lambs from June 20 to September 22. This area was not pastured as early, but was grazed as late, as pasture was available. Lambs were taken from the lot on September 22 to be sold as feeder lambs.

The rye plot, seeded September 22, 1920, did not emerge until spring, when the stand was estimated at not more than 65 percent. This rye came on slowly and was not ready to pasture until May 20. It was not pastured then, because pasture was not available on the other two areas, and it was thought all three lots should start the summer grazing period on the same date. This rye was plowed under in bloom stage on June 17, which was 3 days before the beginning of the summer grazing period. The exposed heads and

weeds along the fence rows were grazed from June 20 to 22, a period of 2 days. Weeds did not appear on this plowed-under rye ground until August 8, when they were cultivated off because the two 2-acre stubble plots were then available, with ample pasture for all near-future needs. Weeds reappeared and were grazed off from August 22 to 27, a period of 5 days. This plot was thereafter harrowed on August 29 and seeded to winter wheat on the same date.

The 51B 1½-acre sod plot was closely grazed from June 22 to July 24, a period of 32 days. The 51A ½-acre sod plot was not grazed, partly because of its inaccessibility, and partly because it was not actually needed.

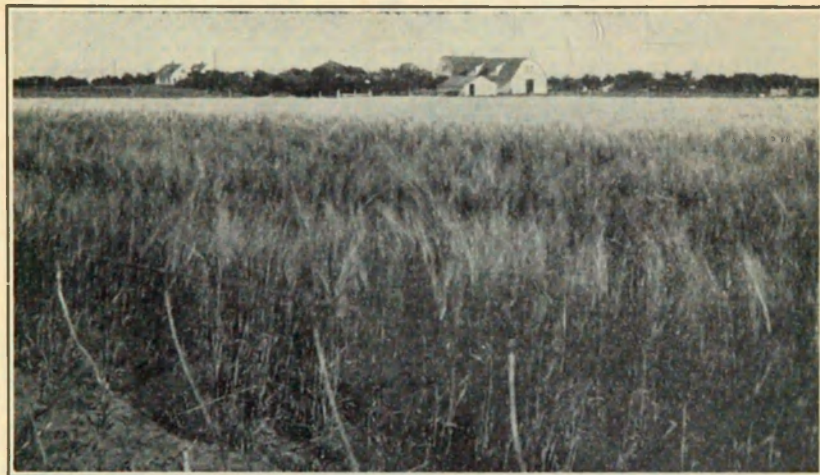


Figure 5.—Winter wheat on the pastured rye plot in 1921, yielding 31.6 bushels per acre; station buildings in the background.

Wheat and barley were threshed on July 24. The barley-stubble plot was pastured from July 24 to August 22, a period of 29 days, after which the land was plowed and packed and seeded to winter rye on August 29. The winter-wheat stubble was grazed from August 27 to September 22, a period of 26 days. The rye emerged promptly. The 9 ewes pastured on it from September 22 to October 20, a period of 28 days.

The straw from the two stubble plots was left on the winter-wheat plot. There were 2,038 pounds of barley straw and 6,225 pounds of winter-wheat straw. The sheep of lot 2 ate some straw but wasted the bulk of it.

The yield of winter wheat from the pastured rye plot was 31.6 bushels per acre. The yield of winter wheat from the plowed-under rye plot of rotation 51 in the main field was 14.8 bushels per acre. A full crop of rye was plowed under on this plot in bloom stage

on June 7, 1920. The plot was cultivated on July 7 and 20, August 4, and September 18, and seeded to winter wheat on the latter date.

Lot 3, on Sheep-Grazing Rotation 28

The 9 ewes pastured on this area from June 20 to October 20 and the 4 lambs from June 20 to September 22. Lambs were taken from this lot on September 22 to be sold as feeder lambs.

Half of the fallow plot was plowed and packed on May 16, at the time the first weeds appeared, and the remainder on June 28. Weeds on the unplowed portion were grazed from June 20 to 28, a period of 8 days. Weeds did not appear on the plowed land until August 8, when they were cultivated off because the two 2-acre



Figure 6.—One of the wheat fields in 1921; station buildings in the background.

stubble plots were then available, with ample pasture for all near-future needs. Weeds reappeared, and a thin crop was grazed off from August 22 to 27, a period of 5 days, after which the land was harrowed and seeded to winter wheat on August 29.

The 28A 1-acre sod plot was not grazed because not actually needed during the summer, and because it was not deemed advisable to use it to extend the pasture season any later into the fall. The 28B 1-acre sod plot was closely grazed from June 28 to July 24, a period of 26 days.

The barley stubble was grazed from July 24 to August 22, a period of 29 days, and by the ewes alone from September 22 to October 20, an additional period of 28 days. This later pasture was largely volunteer barley. The winter-wheat stubble was grazed from August 27 to September 22, a period of 26 days.

The straw was left on the respective stubble plots. The ewes and lambs ate some of it but wasted the bulk of the 1,306 pounds of barley straw and 3,610 pounds of winter-wheat straw.

The yield of winter wheat from the pastured fallow plot was 21.3 bushels per acre. The yield from the cultivated fallow plot of main rotation 28 was 28.5 bushels per acre. This plot was plowed and packed on June 15, 1920. It was cultivated on July 7 and 20, August 4, and September 18, and seeded to winter wheat on the latter date.

Summer Grazing Test, 1922

The allotment of ewes and lambs for the third summer grazing test was made on June 20, and the summer pasturing of the three lots started on that date. This was after the ewes had been clipped and after they had lambed.

Five ewes died during the early spring of 1922: four from a disease similar to that encountered in the early spring of 1921 and one from accident. This necessitated the purchase of ewes from a fattening-lamb lot near Brush, Colo. Ewes with lambs could not be located. The lamb crop also was small due to losses at lambing time.

Each of the three lots for 1922 was made up of 10 ewes and 5 lambs. The lamb crop was too small, even in lot 1, to maintain the standard allotment.

Dr. I. E. Newsom, head of the Pathology and Bacteriology Section, Colorado Experiment Station, diagnosed the disease as preparturient paralysis. He prescribed as the quickest, most effective control a complete change of feed, to include if at all possible a succulent green pasture. The only early spring pasture on the station was the 2-acre rye plot of sheep-grazing rotation 51. It was decided that the exigencies of the situation warranted the use of this rye pasture by the entire lot of ewes, which grazed the rye cleanly to the ground from May 19 to June 20, a period of 32 days. There were no more ewe losses after May 19.

Regular monthly weighings were interfered with by the installation of new scales which arrived piecemeal.

The season was about average. Total and seasonal rainfall were slightly below the averages. Upon rotation 51 the rye pasture was utilized by the entire flock from May 19 to June 20; the pasture seasons on the other two areas were of equal length. Lot 3 produced the heaviest gains, 28.2 and 37.3 pounds, respectively, on sheep-grazing rotation 28.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1922 are given in table 4.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was cold and backward, and grass on the sod area did not green up until June 20. The 10 ewes and 5 lambs grazed on this area from June 20 to October 21.

Lot 2, on Sheep-Grazing Rotation 51

The 10 ewes and 5 lambs pastured on this area from June 20 to October 21. This area was not pastured as early in the spring as pasture was available. One ewe was lost from this lot; hence the pasturing results are based on the 9 ewes to begin and to end the summer grazing period.

The rye came on slowly in the spring of 1922 but was ready to pasture by May 19. This rye was disposed of by the entire flock of 23 ewes as mentioned previously. Weeds and rye on this plot were cultivated off on July 5, because the sheep were then on the 51B 1½-acre sod plot, with ample pasture for immediate needs. Weeds came on again and were cultivated off on August 11, because the two 2-acre stubble plots were then available, with ample pasture for all near-future needs. The plot was plowed on August 23 and 24 and thereafter seeded to winter wheat on September 27.

The 51A ½-acre sod plot was grazed from October 11 to 21, a period of 10 days. The 51B 1½-acre sod plot was closely grazed from June 20 to August 5, a period of 46 days. May rainfall was abundant, and pasture was ample on this sod plot to about July 25, when it became extremely short and remained so until the sheep were removed on August 5.

Wheat and barley were threshed on August 5. The barley stubble was grazed from August 5 to 18, a period of 13 days, after which the land was plowed and packed and then seeded to winter rye on August 22. The winter-wheat plot was grazed from August 18 to October 1, a period of 44 days.

A ewe was found dead on the winter-wheat stubble plot on September 23. Her summer weights had indicated a progressive lack of condition pointing to some constitutional ailment as the ultimate cause of death. Another ewe was immediately added to the lot.

The rye on this land emerged promptly and was fall grazed from October 1 to 11, a period of 10 days.

The straw from these two stubble plots was left on the winter-wheat plot. The sheep ate some straw but largely damaged the bulk of 2,280 pounds of barley straw and 1,442 pounds of wheat straw.

The yield of winter wheat from the pastured rye was 5.0 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 2.0 bushels per acre. A full crop of rye was plowed under on this plot on June 10, 1921. It was cul-

tivated on August 9 and September 9 and 12 and seeded to winter wheat on September 13.

Lot 3, on Sheep-Grazing Rotation 28

The 10 ewes and 5 lambs pastured on this area from June 20 to October 21.

The fallow plot was plowed April 4 and 5. Weeds, however, did not become established until July 5, when they were cultivated off because the sheep were then on the 28A 1-acre sod plot, with ample pasture for immediate needs. Weeds came on again and were again cultivated off on August 5, because the two 2-acre stubble plots were then available, with ample pasture for all near-future needs. This plot was again cultivated on August 24 to eliminate weeds and to prepare a seedbed for the winter wheat, which was seeded on September 27.

The 28A 1-acre sod plot was closely grazed from June 20 to August 5, a period of 46 days. Ample May rainfall produced abundant pasture on this sod up to about July 20, after which the grazing was extremely short until the sheep were removed on August 5. The 28B 1-acre sod plot was grazed from October 11 to 21, a period of 10 days.

The barley stubble was grazed from August 5 to 18, a period of 13 days, and from October 1 to 11, an additional period of 10 days. The winter-wheat stubble was grazed from August 18 to October 1, a period of 44 days.

The straw was left on the respective stubble plots. The sheep ate some but wasted the bulk of 2,155 pounds of barley straw and 2,617 pounds of winter-wheat straw.

The yield of winter wheat from the pastured fallow plot was 11.2 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 1.7 bushels per acre. This plot was plowed on June 3, 1921 and cultivated on August 9 and September 9 and 13, and seeded to winter wheat on the latter date.

Summer Grazing Test, 1923

The allotment of ewes and lambs for the fourth summer grazing test was made on May 19, and the summer pasturing of the three lots started on May 26. This was after the ewes had been clipped and after they had lambed. The delay from May 19 to May 26 was occasioned by a series of cold, drenching rains which it was feared would prove detrimental to the health of the newly clipped ewes and to the newly born lambs.

Early spring ewe losses, though not as heavy as in 1921 and 1922, occurred again, apparently from the same disease. However, extra ewe lambs from the 1922 lamb crop were available, so the death losses did not affect the allotment of ewes. The lamb crop, however, was light owing to losses at lambing time, and

again there were not as many lambs as ewes in the lots. Each of the three lots for 1923 was made up of 10 ewes and 6 lambs. A ewe possessing a lamb was lost in lot 2 during the summer, and it was necessary to replace her with a ewe possessing a lamb too young to wean. Lot 2 then contained 7 lambs during the latter half of the season. Lambs were removed from the lots on September 22 to be sold as feeder lambs.

The season was favorable. The annual rainfall was slightly heavier than average, while the seasonal rainfall was about average. This rainfall resulted in a pasture season of average length, with about average gains. The pasture seasons were the same length on the three different areas. The ewes and lambs of lot 1 produced the heaviest gains.

Detailed data of the pasture periods and the gains of ewes and lambs in 1923 are given in table 5.

Lot 1, on 10-Acre Native-Sod Pasture

The season was early, and the grasses on this sod area provided pasture by May 19, the date the rye pasture was ready. The first vegetation was the slender fescue (*Festuca octoflora*). The 10 ewes pastured on this area from May 26 to October 15, and the 6 lambs from May 26 to September 22.

Lot 2, on Sheep-Grazing Rotation 51

The 10 ewes pastured on this area from May 26 to October 15, and the 6 lambs from May 26 to September 22. A seventh lamb was added on July 21. The pasturing results for this lot are based on the weights of the 9 ewes to begin and to end the summer grazing period.

The rye, which was grazed from October 1 to 11, 1922, came on slowly in the spring of 1923 but was grazed from May 26 to June 14, a period of 19 days. Then the remaining rye, at that time in bloom stage, was plowed under and the land packed. Weeds appeared and were grazed from July 15 to August 10, a period of 26 days. This land was thereafter duckfoot cultivated on September 7 and seeded to winter wheat on September 18.

The ewe lost from this lot became entangled in the woven-wire fencing surrounding the rye field and was found dead on July 21.

The 51A $\frac{1}{2}$ -acre sod plot was grazed by the ewes alone from October 5 to 15, a period of 10 days. The 51B $1\frac{1}{2}$ -acre sod plot was closely grazed from June 14 to July 15, a period of 31 days.

A test was made of the practicability of pasturing weeds from among winter wheat in head. Winter-wheat stands on the sheep-rotation plots were spotted, and the blank areas were populated with weeds, largely rough pigweeds (*Amaranthus retroflexus*) and lamb's-quarters (*Chenopodium album*). Unfortunately, these weeds were quite large and woody by the time the wheat broke into head.

The ewes and lambs were given the run of the wheat plot in conjunction with the 51B 1½-acre sod plot from June 14 to 19, a period of 5 days. It was observed that the sheep were grazing the weeds, but not exclusively, so they were barred from the wheat.

Wheat and barley were threshed on August 10. The barley-stubble plot was grazed from August 15 to September 17, a period of 33 days, after which the land was plowed and packed and seeded to winter rye on September 18. The winter-wheat stubble was grazed from August 10 to 15, a period of 5 days, and from September 17 to 22, a period of 5 days, and by the ewes alone from September 22 to October 5, a period of 13 days. The straw from these stubble plots was left on the winter-wheat plot, where it was largely



Figure 7.—The Hampshire characteristics soon were noticeable. Compare with cover illustration.

wasted by the sheep. There were 3,825 pounds of barley straw and 4,080 pounds of winter-wheat straw.

The yield of winter wheat from the pastured rye plot was 7.1 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 3.2 bushels per acre. A full crop of rye was plowed under in bloom stage on June 17, 1922. The land was thereafter cultivated on July 12 and August 8 to eliminate weeds and to create a seedbed for the winter wheat, which was seeded on September 18.

Lot 3, on Sheep-Grazing Rotation 28

The 10 ewes pastured on this area from May 26 to October 15 and the 6 lambs from May 26 to September 22. Lambs were taken from the lot on September 22 to sell as feeder lambs.

The fallow plot was plowed on May 6 and 7 and was immediately packed. The rainfall was ample during May and June, and a weed

crop emerged promptly. The weeds were grazed from June 18 to July 12, a period of 24 days. This plot furnished no more pasture; it was duckfoot cultivated on September 7 to eliminate stray weeds and to create a seed bed for the winter wheat, which was seeded on September 18.

The 28A 1-acre sod plot was grazed from July 12 to August 10 a period of 29 days. The 28B 1-acre sod plot was grazed from May 26 to June 18, a period of 23 days. The ewes and lambs were given the run of the winter-wheat plot in conjunction with the 28A sod plot from June 11 to 18, with results similar to those reported under discussion of lot 2.

The barley-stubble plot was grazed by the ewes alone from September 22 to October 15, a period of 23 days. The winter-wheat stubble was grazed from August 10 to September 22, a period of 43 days. The straw was left on the respective stubble plots, where it was largely wasted by the sheep. There were 3,629 pounds of barley straw and 2,905 pounds of wheat straw.

The yield of winter wheat from the pastured fallow plot was 8.2 bushels per acre. The yield of winter wheat from the cultivated fallow of main rotation 28 was 7.3 bushels per acre. This plot was plowed and packed on June 8, 1922; it was subsequently cultivated on July 12 and August 8 and seeded to winter wheat on September 18.

Summer Grazing Test, 1924

The allotment of ewes and lambs for the fifth grazing test was made on April 22, at the time the rye pasture on rotation 51 became available. This was before the ewes had been clipped and before they had lambed.

This marked a departure from the procedure of the four preceding years, which was to start grazing on the three areas on the same date. It was now obvious that a uniform starting date would not permit early and full utilization of the rye pasture. It was therefore decided to start each lot when pasture became available on its respective unit.

The lamb crop was good, and it was possible to allot nearly one lamb to each ewe. The three lots for 1924 were made up as follows: lot 1, 10 ewes and 10 lambs; lots 2 and 3, 10 ewes and 9 lambs each. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas. Lot 2 lambed on the rye pasture. Lots 1 and 3 lambed in the dry lot.

One ewe was lost on the rye plot soon after the pasture season opened, and another was lost from the same lot on the winter-wheat stubble plot just before the close of the summer grazing period. An orphaned lamb died on the 51A sod plot of area 2 on August 2.

The season was unfavorable. Both the annual and the seasonal rainfall was appreciably below the 11-year averages. The pasture

season was short, and the gains were well below the averages. The pasture season was longest, 167 days, for lot 2, owing to the early date at which the rye pasture became available. The heaviest gains of ewes and lambs, 29.7 and 49.2 pounds, respectively, were made by this lot, probably owing to the longer pasture season.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1924 are given in table 6.

Lot 1, on 10-Acre Native-Sod Pasture

Rainfall was light in April and early May, and the grasses of this area did not green up until June 14. The 10 ewes and 10 lambs grazed on this pasture from June 14 to October 6.

Lot 2, on Sheep-Grazing Rotation 51

The 10 ewes and 9 lambs grazed on this area from April 22 to October 6. The pasture results for this lot are based on the 8 ewes to begin and to end the summer grazing period.

The winter rye came on rapidly and was pastured completely to the ground between April 22 and May 22, a period of 30 days. The rye recovered slowly and was pastured in conjunction with the 51A ½-acre sod plot from June 6 to 16, a period of 10 days, and alone from June 16 to 23, a period of 7 days. The rye plot is given credit for 5 days, one-half the time spent jointly with the sod plot. The rye plot was again grazed from July 12 to 18, a period of 6 days, after which the land was duckfoot cultivated on September 18 in preparation for seeding the winter wheat on September 23.

A ewe was lost on the rye plot 4 days after the opening of the pasture season. Her death was believed to be due to a carry-over of preparturient paralysis.

The 51A ½-acre sod plot was grazed from May 22 to June 6, a period of 15 days, and in conjunction with the rye plot from June 6 to 16, a period of 10 days, and alone from July 18 to August 2, a period of 15 days. This sod plot is credited with half the time spent jointly with the rye plot, 5 days. This sod plot contained considerable bunch grass (*Aristida longiseta*) which the sheep had heretofore refused to graze. However, because of shortage of other feed this bunch grass was closely cropped during the period from July 18 to August 2. The ewes held up in appearance, indicating that the bunch grass, though unpalatable, was nourishing. The orphaned lamb of this lot died on this pasture on August 2. The 51B 1½-acre sod plot was grazed from June 23 to July 12, a period of 19 days.

Winter wheat and barley were threshed on July 31. The barley stubble was grazed from August 2 to 18, a period of 16 days, after which the land was plowed and packed on August 16 and 18 and seeded to winter rye on September 9. The winter-wheat stubble was grazed from August 18 to October 6, a period of 49 days.

A ewe was found dead on this stubble plot on October 6. Her death was thought to have been caused by constitutional ills, since her monthly summer weights and her appearance had indicated low condition throughout the latter half of the pasture season.

The straw of these two stubble plots was left on the winter-wheat plot. The sheep ate some straw but largely wasted the bulk of 755 pounds of barley straw and 2,025 pounds of winter-wheat straw.

The yield of winter wheat from the pastured rye plot was 8.3 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 2.8 bushels per acre. A full crop of rye in bloom stage was plowed under on this plot on June 14, 1923 and the ground cultivated on July 3, 10, and 19 and then seeded to winter wheat on September 20.



Figure 8.—Some of the lambs in dry lot at the close of the 1924 summer grazing season. This illustration gives an idea of the growth of the lambs on the summer pastures.

Lot 3, on Sheep-Grazing Rotation 28

The 10 ewes pastured on this area on the barley-stubble plot, before it was plowed for corn, from April 23 to 25 and from April 28 to 30, a total period of 4 days. They pastured on the extreme end of the 28A 1-acre sod plot, where there was .24 of an acre of almost pure western wheatgrass (*Agropyron smithii*), from May 8 to 16, a period of 8 days. This grass was in an early stage of growth, and the ewes grazed it readily. It had been noticed in previous years that the sheep did not graze this patch of wheatgrass. Both these pasture periods were without the main summer grazing period for this lot, which did not begin until June 14. The break in the pasture period from April 23 to 30 was occasioned by foul weather, which it was feared would interfere with successful lambing.

The 10 ewes pastured on this area from June 14 to October 23 and the 9 lambs from June 14 to October 6. The lambs were removed from this lot on October 6 to combine with the lambs of the other two lots to be sold as feeder lambs.

The fallow plot was not plowed until after the stubble plots became available as pasture. It was grazed from June 24 to August 2, a period of 39 days, after which the land was plowed on August 1 and 2 in preparation for the winter wheat, which was seeded on September 23.

The 28A 1-acre sod plot was not grazed this year. It had been closely grazed the year before and produced no pasture on the light rainfall. The 28B 1-acre sod plot was grazed by the ewes alone from May 8 to 16, a period of 8 days, and by the ewes and lambs from June 14 to 24, a period of 10 days.

The barley stubble was grazed from August 2 to 15, a period of 13 days, and by the ewes alone from October 6 to 23, an additional period of 17 days. The 4 days of grazing in early spring make the total days on this pasture 34 for this year. The winter-wheat stubble was grazed from August 15 to October 6, a period of 52 days. The straw was left on the respective stubble plots, where it was largely wasted by the ewes and lambs. There were 800 pounds of barley straw and 2,005 pounds of winter-wheat straw.

The yield of winter wheat from the pastured fallow plot was 11.3 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 11.2 bushels per acre. This plot was plowed and packed on June 6, 1923, cultivated July 3, 10, and 19, and September 19, and seeded to winter wheat on September 20.

Observation on First Five Years' Problems

Ten-Acre Native-Sod Pasture

This plot was grazed bare each year, but there was no marked evidence that the vegetative cover had been greatly injured. It seemed that the chief effect of the close grazing was to shorten the length of the grazing season. Two courses seemed open: (1) to continue the allotment at 10 ewes and their lambs to see whether the sod cover would be damaged by the pasturing of the sheep; or (2) to reduce the allotment and have a longer grazing period each season. A desire to determine how long the native-sod grasses could continue to stand such close grazing led to a decision to continue the allotment.

Sheep-Grazing Rotation 51

There was a severe shortage of pasture during the early summer months up to the date of threshing of the small-grain plots of this rotation. A full test of the intensity of this shortage was not obtained because of the faulty management of the rye pasture from the livestock standpoint.

Two facts stood out: (1) that the sod-supplement areas were not large enough to carry a preponderance of the pasture burden during the early summer; and (2) that the rye had not been fully used as pasture. Two things contributed to the faulty pasture usage of the rye during the first 5 years: (1) the plan to begin the pasture seasons of all three lots on the same date in order to keep all factors uniform; and (2) the plan to make the cultural practices on the pastured rye rotation conform as nearly as possible to the practices used on the plowed-under rye plot of the main rotation 51. In only 2 of the 5 years was the rye late enough and certain pastures of the other two rotations early enough to make a uniform starting date practical. In 1921, 1922, and 1924 the rye was much earlier than any pasture on either of the other two areas.

It was found impractical to pasture the rye up to the heading stage and then plow the remainder under in simulation of the practice followed on main rotation 51. This plowing under of the remaining rye not only destroyed existing feed needed by the sheep but rendered the land unsuitable for an immediate crop of weeds. From 1908 to 1920 rye plowed under for green manure on the main rotation field at an average date of June 10 was not cultivated to eliminate the first crop of weeds until an average date of July 10. So it is seen that land plowed about June 10 will not ordinarily produce a weed crop until one month later. It was decided for the future not to plow under any remaining rye for green manure, but to harvest the remaining rye to prevent contamination of the soil with rye seed, thus leaving the soil intact for weed growth following rains of consequence.

When the experiment was started it was not known what the carrying capacity of the various areas would be, hence 10 ewes and their lambs was chosen as an arbitrary number. This allotment proved to be so dangerously high during the first 5 years of the experiment that, even with better management of the rye from the pasture-production and -utilization standpoint, it was deemed expedient to reduce the allotment. This reduction was from 10 ewes and their lambs upon 10 acres to 6 ewes and their lambs upon the same number of acres.

Sheep-Grazing Rotation 28

The same early summer shortage of pasture was experienced on this area as on the rye rotation, particularly when an attempt was made to correlate the date of plowing the pastured fallow plot with the date upon which the similar rotation on the main field was plowed. In 1920 and 1924 the pastured fallow plot was not plowed until late summer, when the small grain stubble plots had become available. In those 2 years satisfactory early summer pasture was obtained from the fallow plot, but the plowing date was far out of line with good cultural practice. In 1921 one-half the plot was

plowed on May 16, when the first weeds appeared. The other half was grazed up to June 28, when it also was plowed. No more pasture was available on this plot until after the threshing date of the small grains. In 1922 the fallow plot was plowed on April 4 and 5. The April and May rainfall was 70 and 50 percent, respectively, above normal, but with a June rainfall 15 percent below normal it was July 10 before this plot had weed growth enough to warrant pasturing. This was early enough to be of value but 30 to 40 days later than a desirable date.

In 1923 the fallow plot was plowed on May 5. With heavy rainfall in May, 4.94 inches, this plot furnished pasture by June 18, but this was more than 40 days after the plowing date. There seemed to be a definite relationship between the firmness of the

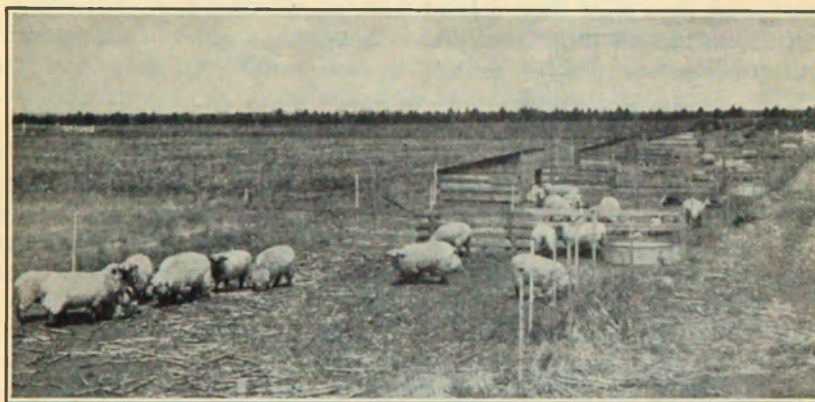


Figure 9.—General view of the dry lot, winter quarters of the ewes.

surface soil and the early weed growth. It was quite evident, then, that the pastured fallow plot either must be plowed extremely early in the spring or not until after the early summer pasture-stringency period was passed. The choice was with the former, and a definite policy was established of plowing the fallow plot as early in the spring as the work could be accomplished and immediately packing so as to firm the soil.

It was decided not to allow the ewes and lambs access to the straw of the stubble plots, since experience showed that they wasted most of it. Although the straw is a by-product of the pastured rotations, it was decided not to thresh on the stubble plots but to control-feed the straw to the sheep if and as they needed it.

With the reduction in allotment it seemed desirable to provide the two pastured rotations with new and undamaged sod supplements. Undisturbed sod immediately to the west of the old sod plots made this possible. These new sod areas were used throughout the final 6 years of the experiment. These sod plots were each

2 acres in area; hence it will be unnecessary to designate the sod plots in any other way (fig. 1).

Summer Grazing Test, 1925

The allotment of ewes and lambs for the sixth summer grazing test was made on April 25, at the time the rye pasture became available. This was before the ewes had been clipped, but after they had lambed. The three lots for 1925 were made up as follows: lot 1, 10 ewes and 10 lambs; lots 2 and 3, 6 ewes and 6 lambs each. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas.

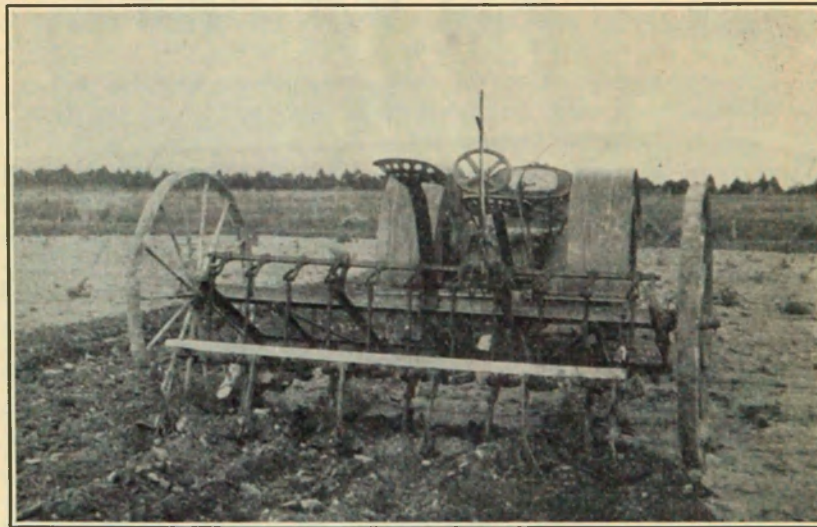


Figure 10.—Duckfoot cultivator being used to break an undesirable crust on rather clean land. This implement was used for practically all the seedbed preparation work after 1922.

The rainfall was the most deficient of any year thus far experienced in the course of this experiment. Even with the reduced allotments the grazing season was especially short, and the pasture was barely sufficient for the short period. The pasture season was the longest, 86 days, and the gains of ewes and lambs the heaviest, 24.2 and 33.5 pounds, respectively, on the rye rotation.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1925 are shown in table 7.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was late, and it was not until June 15 that the sod grasses greened up and offered pasture. The 10 ewes and 10 lambs grazed on this area from June 15 to September 8. These ewes and lambs lost weight sharply between August 19 and September 8,

causing the ewes to show a loss and the lambs to show 5.5 pounds less gain for the summer period as a whole. It is evident the season should have been closed about August 19.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 5 lambs grazed on this area from April 25 to May 9 and from June 11 to August 22. This lot started with 6 lambs, but one was lost on the rye plot 4 days after the beginning of the pasture season.

The rye came on rapidly in the spring and was grazed from April 25 to May 9, a period of 14 days, during which the ground was made bare. No other pasture being available for this lot, they were returned to dry lot until the rye was again grazed from June 11 to

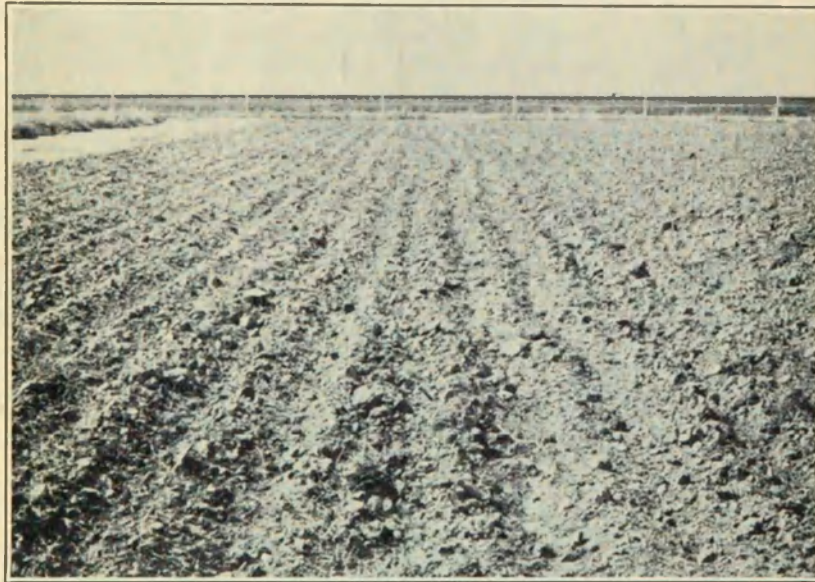


Figure 11.—Seedbed created by the duckfoot cultivator. The seedbed is receptive of rainfall, resistant to soil blowing, and nicely pulverized for good seed germination.

July 3, a period of 22 days. The rye plot was again grazed from July 20 to 25, a period of 5 days, after which the land was double-disked on August 18 in preparation for seeding to winter wheat on September 16.

There was a very severe outbreak of army cutworms in the spring of 1925, and it was estimated that these insects damaged this rye plot fully 50 percent. An inspection on April 25 revealed the surface soil completely infested and the rye straggly and lacking in color. The month of May was exceedingly deficient in rainfall. These

two factors caused the rye pasture to fail to support the 6 ewes and 5 lambs up to heading stage.

The sod land from which the new sod supplements were taken had been early spring grazed by the entire flock of ewes and had been denuded of the vegetable cover of former years. This early spring sod grazing was for the purpose of encouraging the bred ewes to take plenty of exercise as a prophylaxis against the lambing-time disease experienced among the ewes in former years. The new sod plot was grazed from July 3 to 20, a period of 17 days.

The winter wheat and barley were threshed on July 22. The barley stubble was grazed from July 25 to August 8, a period of 14 days, after which the land was made ready by means of the duckfoot cultivator for seeding to winter rye. The winter-wheat stubble plot was grazed from August 8 to 22, a period of 14 days.

The yield of winter wheat from the pastured rye plot was 4.7 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 1.7 bushels per acre. A full crop of rye in bloom stage was plowed under on this plot on June 23, 1924, and the land thereafter was cultivated on July 16 and seeded to winter wheat on September 22.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 6 lambs grazed on this area from June 15 to August 22.

The fallow plot was plowed on March 10 and 11 and immediately packed. Weeds on this plot were grazed from June 15 to 30, a period of 15 days; from July 14 to 20, a period of 6 days; and from August 19 to 22, a period of 3 days. This last grazing was to clean up the weeds along the fence rows after the land had been duckfoot cultivated on August 19, in preparation for seeding winter wheat on September 16.

The new 2-acre sod plot had been early spring grazed, as was the one under sheep-grazing rotation 51. It was grazed from June 30 to July 14, a period of 14 days, and from July 20 to 22, a period of 2 days.

The barley stubble was grazed from July 22 to August 8, a period of 17 days. The winter-wheat stubble plot was pastured from August 8 to 19, a period of 11 days.

The yield of winter wheat from the pastured fallow plot was 5.5 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 15.8 bushels per acre. This plot was plowed and packed on June 7, 1924 and cultivated on July 16 and September 18, after which it was seeded to winter wheat on September 22.

Summer Grazing Test, 1926

The allotment of ewes and lambs for the seventh summer grazing test was made on April 1. This was before the ewes had been clipped and before they had lambed. The three lots were kept in dry lot until pasture became available on their respective areas. The allotment was as follows: lot 1, 10 ewes and 9 lambs; lots 2 and 3, 6 ewes and 5 lambs each.

The season was particularly favorable, and all wether lambs were removed from the three lots on September 6 and sold as grass-and-milk-fat lambs. Both the seasonal and the total rainfall were well above the average. The pasture season was long, and the gain of the ewes and lambs was well above the average.

The removal of the wether lambs on September 6, before the end of the pasture season, necessitates some weighted average lamb pasture days. Lot 2 had 5 lambs, 4 of which were wethers which were removed on September 6. There were, then, 5 lambs on the winter-wheat stubble plot of sheep-grazing rotation 51 from August 21 to September 6, a period of 16 days, and 1 lamb on this same stubble plot from September 6 to October 6, a period of 30 days. This winter-wheat stubble plot then bore the burden of 5 lambs, an average of 22 *weighted* pasture days.

The longest pasture season was on sheep-grazing rotation 51, 203 days, where the heaviest gains of lambs were made, 78 pounds. The ewes of lot 1 on the 10-acre native-sod plot made the heaviest gains, 33.5 pounds.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs for 1926 are given in table 8.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was backward, and it was not until June 11 that this area promised grazing for the sheep. The 10 ewes and 9 lambs pastured on this area from June 11 to September 6. The 10 ewes and 5 remaining ewe lambs grazed on it from September 6 to October 9. The 4 wether lambs of this lot were removed September 6 and sold as grass-and-milk-fat lambs. They averaged 76.7 pounds each.

Cacti were removed from two diagonally opposite quarters of the 10-acre native-sod plot in the fall of 1926. A four-tined fork was used to push the cacti from their surprisingly insecure moorings, after which they were loaded and hauled from the area.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 5 lambs pastured on this area from April 16 to September 6. The 6 ewes and 1 remaining ewe lamb grazed on the area from September 6 to October 6 and the ewes alone to November 5. The 4 wether lambs, averaging 90 pounds each, were removed from this lot on September 6 and sold as grass-and-milk-fat lambs.

The rye came on rapidly and was grazed from April 16 to May 24, a period of 38 days, and from June 11 to July 18, an additional period of 37 days. This plot was then duckfoot cultivated on August 15 and seeded to winter wheat on September 7.

The 2-acre sod plot was grazed from May 24 to June 11, a period of 18 days, and from October 6 to November 5, an additional period of 30 days. This later grazing was by the 6 ewes alone.

Winter wheat and barley were threshed on July 16. The barley stubble was grazed from July 18 to August 21, a period of 34 days, after which the land was duckfoot cultivated on August 23 and seeded to winter rye on August 25. The winter-wheat stubble plot was pastured from August 21 to October 6, a period of 46 days.



Figure 12.—This view, looking north over the sheep-grazing rotation project, gives a good idea of the lay of the land comprising the five lots located on the high table-land.

From September 6 to October 6 this grazing was by the 6 ewes and 1 ewe lamb.

The yield of winter wheat from the pastured rye plot was .9 of a bushel per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 2.7 bushels per acre. A full crop of rye was plowed under on June 16, 1925 while in bloom stage, and the land thereafter was cultivated on July 1 and September 1 and seeded to winter wheat on September 14.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 5 lambs pastured on this area from June 5 to September 6. The 6 ewes and 4 lambs grazed on from September 6 to October 6 and the ewes alone to November 5. The one wether

lamb weighing 81 pounds was removed from this lot on September 6 and sold as a grass-and-milk-fat lamb.

The fallow plot was plowed and packed on March 5 and 6. This plot was located this year near the south end of the project, on the higher land where some evidence of a diminished weed supply had been noted in previous years. A feed crop was badly needed on the fallow plot to prevent over-grazing of the sod plot of this rotation. It was decided, therefore, to spring seed one-half the fallow plot to winter rye. This rye was seeded on the south half on April 13. It emerged promptly and was ready to graze by June 5, not however in advance of the weeds on the unseeded portion. The entire 2-acre plot was grazed from June 5 to 10, a period of 5 days, when it was observed that the sheep preferred the rye and were allowing the weeds to develop. A fence was constructed between the weed and rye portions. The weed one-half was grazed from June 10 to July 10, a period of 30 days, and the rye one-half from July 10 to August 11, a period of 32 days. The entire plot was grazed free of weeds and rye. A few lamb's-quarters weeds became established in open spots among the rye, which the sheep did not graze as long as the rye remained available. About July 25 the rye became so scarce that the grazing of the lamb's-quarters was forced. By that time the weeds were in bloom and the stems standing about 30 inches tall and practically devoid of leaves.

On August 2 one ewe was found dead on this area, lying on her back with all four feet in the air. This was a dry ewe, and she was very fat and plump. It is believed that she got on her back in a slight depression and could not regain her feet. Another possible cause of her death may have been bloat, but the ewes were continued on this area among the nearly mature lamb's-quarters to August 11 without any further losses. This dead ewe's place was taken by another ewe to keep up the allotment to this area. This land was thereafter duckfoot cultivated on August 15 and seeded to winter wheat on September 7.

The 2-acre sod plot was grazed from October 6 to November 5, a period of 30 days. This grazing was by the 6 ewes alone.

The barley-stubble plot was grazed from August 11 to 21, a period of 10 days. The winter-wheat stubble was grazed from August 21 to October 6, a period of 46 days. The grazing from September 6 to October 6 was by the 6 ewes and the 4 ewe lambs.

The yield of winter wheat from the pastured fallow was 4.5 bushels per acre. The yield of winter wheat from the cultivated fallow of main rotation 28 was 2.5 bushels per acre. This plot was disked in April and May, plowed and packed on June 5, 1925, and cultivated July 1 and 10, then seeded to winter wheat on September 14.

Summer Grazing Test, 1927

The allotment of ewes and lambs for the eighth summer grazing test was made April 29, at the time the rye pasture became available. This was before the ewes had been clipped but after they had lambled. The three lots for 1927 were made up as follows: lot 1, 10 ewes and 10 lambs; lots 2 and 3, 6 ewes and 6 lambs each. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas.

One ewe was lost from lot 2 on August 25. Therefore the pasture results for the lot are based on the weights of the 5 ewes to begin and to end the summer grazing period.

The season was again especially favorable. The wether lambs were removed on September 21 and sold as heavy feeder lambs. The seasonal rainfall was well above the average, but the total rainfall for the year was approximately 1 inch below the average. The pasture season was long and the gain of the lambs well above the average; however, the gain of the ewes was less than average. The pasture season was longest, 199 days, for lot 2. The heaviest gains of ewes and lambs were also made by this lot, 13.5 and 52.8 pounds, respectively.

Weighted average lamb pasture days were calculated as illustrated in the discussion of the 1926 pasture results.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1927 are given in table 9.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was early and the grasses were ready to pasture by May 31. The slender fescue (*Festuca octoflora*) was the first vegetation on this area. The 10 ewes and 10 lambs grazed on this area from May 31 to September 21. The 10 ewes and the 3 remaining ewe lambs grazed on from September 21 to November 10. The 7 wether lambs, averaging 74.3 pounds each, were removed on September 21 and sold as heavy feeder lambs.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 6 lambs pastured on this area from April 29 to September 21. The 6 ewes and the 4 ewe lambs grazed on from September 21 to November 14. The 2 wether lambs, averaging 68 pounds each, were removed on September 21 and sold as heavy feeder lambs.

The rye plot came on slowly but was pastured from April 29 to July 16, a period of 78 days, and from August 1 to 8, an additional period of 7 days. This land was thereafter duckfoot cultivated on August 30 and seeded to winter wheat that same day.

The 2-acre sod plot was grazed from July 16 to August 1, a period of 16 days, and from October 3 to November 14, an additional

period of 42 days. This later grazing was by the 6 ewes and the 4 ewe lambs.

Winter wheat and barley were threshed on August 1. The barley stubble was pastured from August 8 to 29, a period of 21 days, after which the land was cross duckfoot cultivated on August 22 and seeded to winter rye on August 29.

A ewe was found dead on this stubble plot on August 25. She had carried a badly infected shoulder since July 1, which had been drained but to no avail. A rattlesnake was suspected of having caused the sore, which would not heal, and which ultimately caused the death of the ewe. The dead ewe's place was immediately taken by another ewe in order to keep up the allotment to this area.

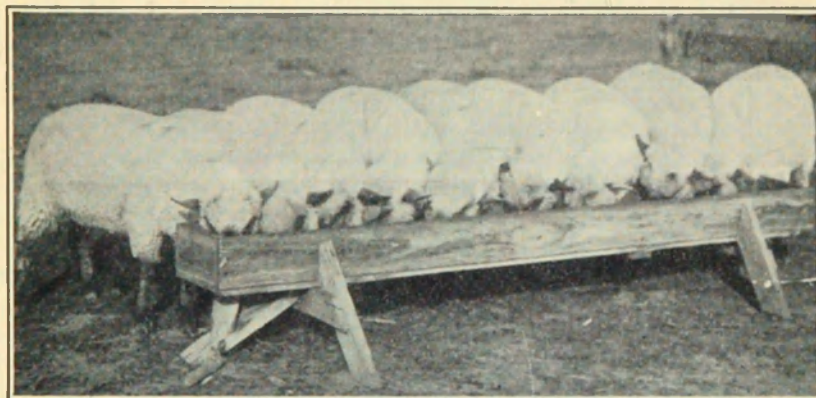


Figure 13.—Offspring of original ewes and a pure-bred, registered Hampshire ram.

The winter-wheat stubble plot was grazed from August 29 to October 3, a period of 35 days. From September 21 to October 3 this pasturing was by the 6 ewes and the 4 ewe lambs.

The yield of winter wheat from the pastured rye plot was 8.9 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 11.7 bushels per acre. A full crop of rye in bloom stage was plowed under on this plot on June 6, 1926, and the plot was subsequently cultivated on June 24, July 13, and August 25 and seeded to winter wheat on September 23.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 6 lambs pastured on this area from May 31 to September 21. The 6 ewes and the remaining 2 ewe lambs pastured on from September 21 to November 14. The 4 wether lambs of this lot, averaging 77.5 pounds, were removed on September 21 and sold as heavy feeder lambs.

The fallow plot was plowed and packed on April 2 and 4. Weeds emerged and were grazed from May 31 to August 8, a period of 69 days. The sheep did not control the weed growth, so the north

and east one-half of this plot was duckfoot cultivated on July 23. This cultivation eliminated the weeds on the northeast quarter and thinned them on the southeast and northwest quarters. The remainder of the plot was duckfoot cultivated on August 12 and the land seeded to winter wheat on August 30.

Something of the comparative value of weeds and rye as pasture for sheep was brought out this year. Lot 2 pastured on the rye 2 acres from April 29 to July 16, a period of 78 days. The ewes lost an average of 9.2 pounds, and the lambs gained an average of 29.1 pounds. Lot 3 pastured on the 2 acres of weeds on the fallow plot from May 31 to August 8, a period of 69 days. The weight of the ewes remained stationary, while the lambs gained an average of 37.5 pounds.

The 2-acre sod plot was grazed from October 3 to November 14, a period of 42 days. This grazing was by the 6 ewes and the remaining 2 ewe lambs.

The barley-stubble plot was pastured from August 8 to 31, a period of 23 days. The winter-wheat stubble was pastured from August 31 to October 3, a period of 33 days. From September 21 to October 3 this grazing was by the 6 ewes and the remaining 2 ewe lambs.

The yield of winter wheat from the pastured fallow plot was 10.6 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 20.8 bushels per acre. This plot was spring disked, plowed, and packed on June 8, 1926 and thereafter cultivated on June 10, July 13, and August 13 and seeded to winter wheat on September 23.

Summer Grazing Test, 1928

The allotment of ewes and lambs for the ninth summer grazing test was made on May 19, at the time the rye pasture became available. This was before the ewes had been clipped, but after they had lambed. The three lots for 1928 were made up as follows: lot 1, 10 ewes and 15 lambs; and lots 2 and 3, 6 ewes and 9 lambs each. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas.

Lambs were removed from lots 2 and 3 on October 1 to combine with the lambs of lot 1 for sale as feeder lambs. One ewe was lost from lot 2 on August 27. Her place was taken immediately by an extra ewe, but the pasture results for this lot are based on the 5 ewes to begin and to end the summer grazing experiment.

Both the seasonal and the total rainfall were slightly below the average. The pasture season, however, was of about average length, and the gains of the ewes and lambs were of about average. The pasture season was longest, 132 days, on sheep-grazing rotation

51. The heaviest gains of ewes, 15 pounds, were in lots 1 and 3; the heaviest gains of lambs, 43.4 pounds, were in lot 2.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1928 are given in table 10.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was late. The 10 ewes and 15 lambs grazed on this area from June 7 to October 1.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 9 lambs grazed on this area from May 19 to October 1. The 6 ewes grazed on from October 1 to 26.

The grazing season was extended too late, resulting in a loss in the weight of the ewes between October 1 and 26.



Figure 14.—One of the barley plots of the sheep-grazing rotations in 1921 which yielded 35.9 bushels per acre; station buildings in the background. This land had been duckfoot cultivated in preparation for barley.

The rye came on slowly but was pastured from May 19 to June 29, a period of 41 days, and from July 14 to August 9, an additional period of 26 days. The west half of the plot was double-disked on July 26, and the entire plot was duckfoot cultivated on August 21 in preparation for winter wheat, which was seeded on September 24.

The 2-acre sod plot was grazed from June 29 to July 14, a period of 15 days, and from October 16 to 26, an additional period of 10 days. This later grazing was by the 6 ewes alone.

Winter wheat and barley were threshed on August 7. The barley stubble was pastured from August 9 to 22, a period of 13 days, after which the land was cross duckfoot cultivated on August 22 and seeded to winter rye on September 24. The winter-wheat stubble plot was grazed from August 22 to October 16, a period of 55 days. The grazing from October 1 to 16 was by the 6 ewes alone.

One ewe was found dead on the wheat-stubble plot on August 27. The cause of her death was not determined, but bloat was suspected. She was replaced by a dry ewe.

The yield of winter wheat from the pastured rye plot was 7.4 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 21.0 bushels per acre. A full crop of rye was plowed under in bloom stage on this plot on June 2, 1927 and the land cultivated on June 25, July 13, and August 13 and 29, after which it was seeded to winter wheat on September 10.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 9 lambs pastured on this area from June 7 to October 1. The 6 ewes grazed on from October 1 to 26.

The fallow plot was plowed and packed on March 7 and 8. Weeds came on very slowly and did not offer pasture until June 29. The 6 ewes and 9 lambs grazed on the weeds on this fallow plot from June 29 to August 9, a period of 41 days. For the second year in succession the sheep did not hold the weed growth under control, so the west half of the plot was disked on July 6. The remainder of the plot was double-disked on August 24 and the entire plot seeded to winter wheat on September 24.

When the sheep were placed on this fallow plot on June 29 there was a question whether there was weed growth enough to warrant grazing; by July 6 the weeds were from 8 to 10 inches tall and growing so rapidly that the control cultivation was necessary.

The 2-acre sod plot was grazed from June 7 to 29, a period of 22 days, and from October 16 to 26, an additional period of 10 days. The latter period was by the 6 ewes alone.

The barley stubble was grazed from August 9 to 22, a period of 13 days. The winter-wheat stubble plot was pastured from August 22 to October 16, a period of 55 days. The grazing from October 1 to 16 was by the 6 ewes alone.

The yield of winter wheat from the pastured fallow plot was 9.8 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 24.5 bushels per acre. This plot was plowed and packed on June 25, 1927, after having been early spring disked; thereafter it was cultivated on July 13 and August 13 and 29; it was seeded to winter wheat on September 10.

Summer Grazing Test, 1929

The allotment of ewes and lambs for the tenth summer grazing test was made on May 10, at the time the rye pasture became available. This was before the ewes had been clipped but after they had lambed. The three lots were made up as follows: lot 1, 10 ewes and 11 lambs; lots 2 and 3, 6 ewes and 7 lambs each. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas.

Plans had been made to close the summer grazing test on November 1, but a very heavy rain and snowfall ending in a blizzard began on October 28 and extended through November 1. Forage feed was hauled to the marooned ewes on November 1. The sheep were removed from the pasture on November 4. It was evident that final weights on that date would be useless, since the ewes were gaunt from their restricted feed since October 28, and since the wool was impregnated with snow and ice. The weights of October 10, therefore, must be accepted as final weights for determining gains or losses. The pasture season, however, is counted to October 29.

Lambs were removed from the lots on September 7 to be sold as feeder lambs.

The season was favorable. The total and the seasonal rainfall were well above the averages. The pasture season was longest, 172 days, and the gains of the ewes and lambs the heaviest, 31.6 and 62 pounds, respectively, on the rye rotation.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1929 are given in table 11.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was comparatively early. The 10 ewes and 11 lambs pastured on this area from May 25 to September 7. The 10 ewes pastured on from September 7 to October 29.

This, the tenth consecutive year of grazing this 10-acre native-sod area, had the longest grazing season, 157 days; it produced the greatest gain of ewes, 27 pounds, and the fourth greatest gain of lambs, 42.7 pounds. This is especially interesting as indicating that the carrying capacity of this native-sod plot had not been reduced by the close grazing of the preceding 9 years.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 7 lambs grazed on this area from May 10 to September 7. The 6 ewes grazed on from September 7 to October 29.

The rye came on slowly but was grazed by the 6 ewes and 7 lambs from May 10 to June 19, a period of 40 days, and from July 18 to August 3, an additional period of 16 days. After this the land was duckfoot cultivated on August 9 and seeded to winter wheat on September 13.

The 2-acre sod plot was grazed from June 19 to July 18, a period of 29 days.

Winter wheat and barley were threshed on July 30. The barley-stubble plot was grazed from August 3 to 20, a period of 17 days, after which the land was cross double-disked on August 20 and seeded to winter rye on August 30. The winter-wheat stubble was pastured from August 20 to October 10, a period of 51 days. The grazing from September 7 to October 10 was by the 6 ewes alone. The winter rye seeded on the barley-stubble plot on August 30

emerged promptly and was grazed by the 6 ewes from October 10 to 29, a period of 19 days.

The yield of winter wheat from the pastured rye plot was 6 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 4.3 bushels per acre. A full crop of rye in bloom stage was plowed under on this plot on June 7, 1928. The plot was immediately packed and thereafter cultivated on July 7 and 27 and August 13 and seeded to winter wheat on September 27.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 7 lambs pastured on this area from May 25 to September 7. The 6 ewes pastured on from September 7 to October 29.

The fallow plot was plowed and packed on April 1. Weeds came on comparatively early and were grazed from June 3 to August 3, a period of 61 days. The sheep did not control the weeds, which were largely Russian-thistles, so the west half of the plot was double-disked on June 27. The whole plot was duckfoot cultivated on August 9 and then seeded to winter wheat on September 13.

The 2-acre sod plot was grazed from May 25 to June 3, a period of 9 days.

The barley-stubble plot was pastured from August 3 to 20, a period of 17 days, and from October 10 to 29, a period of 19 days. This later grazing was by the 6 ewes alone. The winter-wheat stubble was grazed from August 20 to October 10, a period of 51 days. This grazing from September 7 to October 10 was by the 6 ewes alone.

The yield of winter wheat from the pastured fallow plot was 6.3 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 10.7 bushels per acre. This plot was disked on March 3, 1928 and thereafter plowed and packed on May 24, after which it was cultivated on June 29, July 27, and August 13; it was seeded to winter wheat on September 27.

Summer Grazing Test, 1930

The allotment of ewes for the eleventh summer grazing test was made April 18, at the time the rye pasture became available. This was before the ewes had been clipped and before they had lambed.

The ewes were bred very late, on January 1, partly because of the late date of closing the pasture season of 1929 and partly because of the heavy late snowfall of that year, which interfered with conditioning the ewes for breeding.

The three lots for the year of 1930 were made up of ewes showing signs of being in lamb. Chances had to be taken with the number of lambs dropped and the number saved, since the lambing

occurred after the start of the summer grazing season for all three lots. The lots for 1930 were as follows: lot 1, 10 ewes and 10 lambs; lot 2, 6 ewes and 6 lambs; and lot 3, 6 ewes and 5 lambs. Lots 1 and 3 were kept in dry lot until pasture became available on their respective areas.

One ewe had to be removed from lot 2 on May 31 because of screw-worm infestation on her hindquarter. Her place was immediately taken by a dry ewe.

One lamb was lost from lot 3 about the middle of the summer, thus reducing the number of lambs in this lot to 4. This lamb's death was caused by an ailment which resembled sheep bot or grub-in-head.

The season was favorable as is reflected by the long pasture season and good gains. The longest pasture season, 166 days, and the heaviest gain of ewes and lambs, 31.6 and 62 pounds, respectively, were on the rye rotation.

Detailed data of the pasture periods and the weights and gains of the ewes and lambs in 1930 are given in table 12.

Lot 1, on 10-Acre Native-Sod Pasture

The spring was comparatively early, and the 10 ewes and the 10 lambs pastured on this area from May 21 to October 15. This lot lambed on the sod pasture and saved 10 lambs.

Lot 2, on Sheep-Grazing Rotation 51

The 6 ewes and 6 lambs grazed on this area from April 18 to October 1. This lot lambed on the rye pasture and saved 6 lambs. The pasture results for this lot are based on the weight of the 5 ewes to begin and to end the pasture season.

The rye came on early and was grazed from April 18 to June 28, a period of 71 days, by which time the remaining rye was in head and apparently very unpalatable. The remaining rye was harvested with a binder, and 30 bundles were hauled off the plot. This plot was again grazed, the vegetation being mainly weeds, from July 24 to August 12, a period of 19 days. After this it was duckfoot cultivated on August 20 in preparation for winter wheat, which was seeded on September 16.

The 2-acre sod plot was pastured from June 28 to July 24, a period of 26 days.

Winter wheat and barley were threshed on July 24. The barley-stubble plot was pastured from August 12 to 26, a period of 14 days, after which the land was duckfoot cultivated on August 26 and seeded to winter rye on August 27. The winter-wheat stubble was grazed from August 26 to October 1, a period of 36 days.

The yield of winter wheat from the pastured rye plot was 13 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 13.7 bushels per acre. A full crop

of rye in bloom stage was plowed under on this plot on June 17, 1929. The land was immediately packed and thereafter cultivated on July 27 and August 19 and 31 in preparation for the winter wheat, which was seeded on September 14.

Lot 3, on Sheep-Grazing Rotation 28

The 6 ewes and 5 lambs, later 4 lambs, pastured on this area from May 21 to October 1. The ewes of this lot lambled on the 2-acre sod plot and saved 5 lambs.

The fallow plot was plowed and packed on April 5 and 10. Weeds came on slowly but were grazed from June 28 to July 5, a period of 7 days; from July 24 to 31, a further period of 7 days; and from August 8 to 12, an additional period of 4 days, after which the land was duckfoot cultivated on August 30 in preparation for the winter wheat, which was seeded on September 16.

The 2-acre sod plot was grazed from May 21 to June 28, a period of 38 days, and from July 5 to 24, an additional period of 19 days.

The barley-stubble plot was grazed from August 12 to October 1, a period of 50 days. The winter-wheat stubble was pastured from July 31 to August 8, a period of 8 days.

The yield of winter wheat from the pastured fallow plot was 15.7 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 20.7 bushels per acre. This plot was disked on April 29, 1929 and thereafter plowed and packed on June 6. It was cultivated on June 29, July 27, and August 19 and 31 in preparation for the winter wheat, which was seeded on September 14.

Cropping Results, 1931

The yield of winter wheat from the pastured rye plot was 3.2 bushels per acre. The yield of winter wheat from the plowed-under rye plot of main rotation 51 was 5.7 bushels per acre. A full crop of rye in bloom stage was plowed under on this plot on June 5, 1930. The land was immediately packed and thereafter cultivated on June 28, July 18, and August 8 and 20 in preparation for winter wheat, which was seeded on September 19.

The yield of winter wheat from the pastured fallow plot was 7.3 bushels per acre. The yield of winter wheat from the cultivated fallow plot of main rotation 28 was 14.5 bushels per acre. This plot was disked on April 23, 1930 and plowed and packed on June 21. After this the land was cultivated on June 28, July 18, and August 8 and 20 in preparation for winter wheat, which was seeded on September 19.

The yield of barley from the pastured rye rotation was 7.8 bushels per acre. The yield of barley from the plowed-under rye plot of main rotation 51 was 7.9 bushels per acre. The yield of

barley from the pastured fallow rotation was 8.8 bushels per acre. The yield of oats from the cultivated fallow plot of main rotation 28 was 14.7 bushels per acre.

SUMMATION OF PASTURE PERIODS, 11 YEARS

The summaries of the pasturing periods each year on the 10-acre native-sod pasture, the sheep-grazing rotation 51, and the sheep-grazing rotation 28 are given in tables 13, 14, and 15, respectively. The same data are shown graphically in figure 15.

The 10 acres of native sod was pastured by lot 1 each year from as early in the spring as it was ready until as late in the fall as it provided sufficient feed. The date of turning onto this pasture ranged from May 21 to June 20, the average date being June 5. The date of closing the pasture ranged from September 8 to November 10, the average date being October 14. The shortest season in any 1 year was 85 days in 1925, and the longest was 163 days in 1927. The lambs did not always pasture as late in the fall as the ewes, because sometimes they were removed for sale as fat lambs and at other times to go on an early feeder-lamb market. The average pasture period was 131 days for the ewes and 117 days for the lambs.

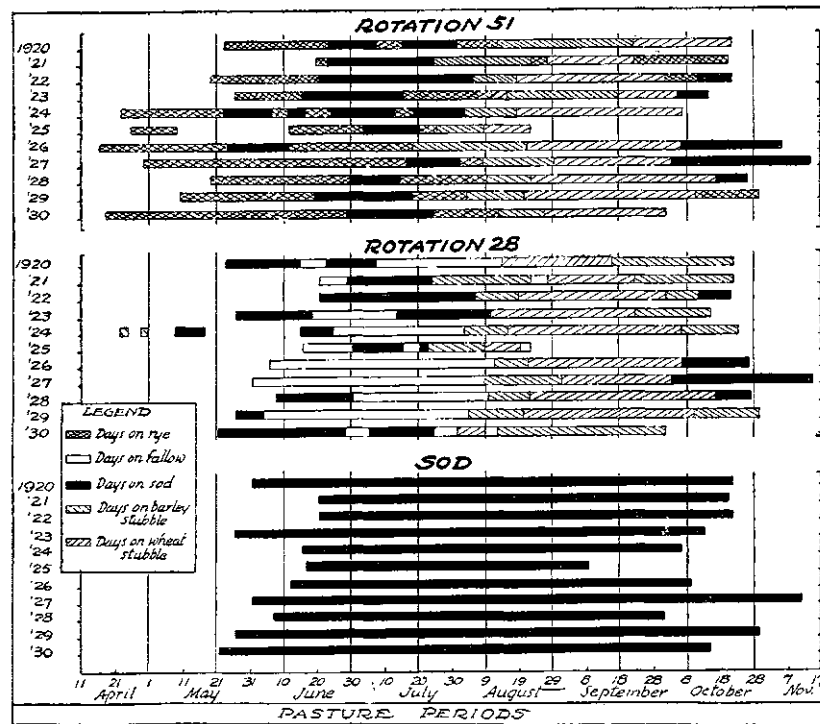


Figure 15.—Graphic illustration of the data in tables 13, 14, and 15.

The sheep-grazing rotation 51 was grazed by lot 2. It was composed of 2 acres in native sod and 8 acres in cultivated land divided into four 2-acre fields cropped to a 4-year rotation of winter rye for pasture, winter wheat, corn, and barley. The average grazing season of this lot began on May 13 and extended 157 days to October 17. The longest grazing season was 203 days, the shortest 86 days. The average pasture season was made up of 38 days on sod, 60 days on the winter rye, 37 days on the winter-wheat stubble, and 22 days on the barley stubble. The number of days pasture on the barley stubble was undoubtedly shortened by the land of this plot being early fall prepared and seeded to winter rye. The corn land was not pastured during the summer but carried an average of 8 ewes for an average period of 94 days during the winter.

It was found by experience that land under this system would not provide summer pasture for as many sheep, due to an early summer shortage, as would an equal area in native sod, and the allotment was reduced at the end of the first 5 years from 10 ewes and their lambs to 6 ewes and their lambs on 10 acres. It provided pasture for a longer season than the strictly native-sod pasture, principally because the winter rye was ready earlier in the spring. This early availability of pasture was not taken advantage of in the first years of the experiment, but nevertheless the average date of beginning pasture on the rye was May 13, which was 22 days earlier than on native sod. In about half the years the winter rye was ready for pasture in April, the earliest date being April 16. In only 3 years out of the 11—1922, 1923, and 1929—did the rye furnish any pasture the same fall it was seeded.

It is necessary to begin pasturing the rye early enough and to stock it heavily enough to keep the growth down, as it becomes unpalatable if allowed to develop towards maturity. The 10, and later the 6 ewes and their lambs, grazed the 2 acres of rye so closely that there was only one year, 1930, when a partial crop of seed could have been harvested; and that seed crop would have been light, for only 30 bundles of grain were taken from the entire 2 acres. This would have been a better working unit if it had contained an extra unit with both rye and fallow as available early summer pasture, or if a somewhat larger acreage of native sod had been provided.

Sheep grazing rotation 28 was a similarly sized and divided tract, except that summer fallow took the place of winter rye. This reduced the average pasture season to 136 days (21 days less than the winter-rye rotation) beginning on June 4 and ending October 18. The longest grazing season was 167 days and the shortest 69 days. This was practically the same season obtained on the 10-acre native-sod plot. The same reduction of the allotment to 6 ewes and their lambs was made as with lot 2 on grazing-rotation 51. The average season's pasture was made up of 34 days on native sod, 36 days on

fallow, 29 days on barley stubble, and 37 days on winter-wheat stubble.

The starting pasture unit on this area was the native sod for 7 years and the weeds on the fallow for 4 years. The earliest date at which weeds on fallow became available as pasture was May 31, in 1927. The average date was June 15. This is about the date that the rye of grazing-rotation 51 became most unpalatable because of jointing and heading. The barley stubble of this unit produced only 7 more pasture days than the same unit of grazing-rotation 51, which was early fall prepared and seeded to winter rye. The pasture burden on the native-sod units of grazing rotations 51 and 28 was about equal, as revealed by the pasture days of 38 and 34, respectively.

A larger acreage of native sod in this system would obviate the necessity of making the fallow provide so much pasture and would probably result in an increased yield of winter wheat from the pastured fallow. Two acres of rye added to this unit (12 acres instead of 10) would have made the unit more satisfactory by making possible an earlier starting date.

SUMMATION OF GAINS OF EWES AND LAMBS, 11 YEARS

The number of ewes and lambs and the average individual and total gains of each lot of sheep while on pasture at the Dry-land Field Station at Akron each year from 1920 to 1930, inclusive, together with the 11-year average pasture periods, are shown in table 16. The average allotment and initial and final weights of ewes and lambs for each lot for each year from 1920 to 1930, inclusive, are shown in table 17.

The ewes of each lot averaged a little less than 20 pounds' gain during the pasture season. The lowest average gain was 17.3 pounds, in lot 1 on the 10-acre native-sod pasture. The ewes of lots 2 and 3, on grazing rotations 51 and 28, respectively, made almost identical gains, about 2½ pounds greater than those of lot 1. The lambs of lot 1 made the lowest average gains, 33.8 pounds. Lots 1 and 3 had about the same length pasture season, and the gains of the ewes and lambs of these 2 lots were not greatly different, though the greater gains in each case were in lot 3. The lambs of lot 2 made the heaviest gains, 44.9 pounds, after having started with an average initial weight of about 7 pounds less than the lambs of the other 2 lots; they also had a longer grazing season by reason of being on pasture earlier in the spring.

Lots 1 and 3 had nearly identical numbers of pasture days and nearly identical initial weights. Any difference in the gains of these two lots should be traceable to the difference in the numbers of ewes and lambs in the two lots or to a difference in the relative efficiency of the two types of pasture. Lot 3, with 28 percent less allotment of

ewes and lambs, made only 8 percent greater gains, which indicates that of these two pastures the sod grass was appreciably more efficient for pasturing sheep than the varied pasture offered by sheep-grazing rotation 28.

Lots 2 and 3 had nearly identical allotment numbers of ewes and lambs and nearly identical initial weights of ewes. The initial weights of the lambs of lot 2, however, were about 7 pounds lighter. Any difference in the gains of these two lots should be traceable to the difference in the length of the pasture season, to the difference in the initial weights of the lambs, or to the relative efficiency of the two types of pasture. The difference in the length of the two pasture seasons was due chiefly to a difference in the spring starting dates. The lighter lambs of lot 2 started pasture at an earlier date than the lambs of lot 3. The latter lot had only 85 percent as many pasture days as lot 2 and made 85 percent as many pounds of gain of ewes and lambs. Since there is such a close correlation between the relative lengths of the two grazing seasons and the relative gains, it must be concluded that the two types of pasture were about equally efficient, but that the rye rotation produced greater gains chiefly because of the greater number of early spring days it added to the pasture season.

When the total gains per acre are computed and averaged for the 11 years, it is shown that they were heaviest, 49.3 pounds, in lot 1 on the 10-acre native-sod pasture. Lot 2, on sheep-grazing rotation 51 with rye as one of its pasture units, made an average gain of 44.4 pounds per acre. Lot 3, on sheep-grazing rotation 28 with weeds on fallow as one of its pasturing units, made the lowest acre gains, 37.9 pounds.

The greater acre gain of lot 1, on the 10-acre native-sod pasture, was the result of its heavier allotment of ewes and lambs, since the individuals made the lowest gains, as has already been brought out. Lots 2 and 3 were made up of substantially the same numbers of ewes and lambs, and the greater acre gain in lot 2 must be attributed to the additional pasture furnished by the winter rye over that furnished by the weeds on the fallow, 60 and 36 days, respectively, as the other pasture units of these two lots did not differ appreciably.

RELATION OF PRECIPITATION TO PASTURE SEASON AND GAINS

It is a matter of common observation and knowledge that within the range of precipitation at Akron the growth of vegetation in the native sod is dependent to a considerable extent on the quantity of precipitation received during the growing season and the year. Some correlations were calculated in order to have a mathematical expression of the relation between the seasonal and annual quantities of precipitation, on the one hand, and the length of the pasture

season and the total gains of the sheep of a unit tract on the other. The seasonal precipitation was calculated for the 6-months period from April to September. Calculations showed that the precipitation for the 12-months period ending October 31, the normal end of the summer grazing periods, did not give correlation coefficients significantly different from those obtained with the use of the precipitation for the calendar year. The correlations presented, therefore, were calculated from the precipitation for the year ending December 31.

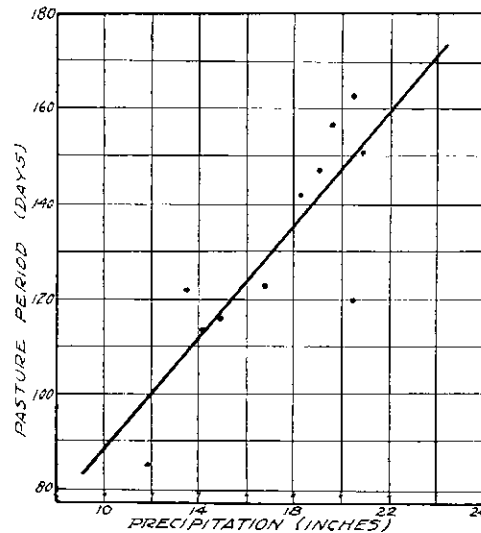


Figure 16.—Annual precipitation and length of pasture period of sheep in lot 1, on native sod at Akron, 1920 to 1930. The coefficient of correlation is .84. The diagonal line is drawn from the regression equation: number of pasture days, 24.1, plus 6.19, times the precipitation in inches.

The correlation between the annual precipitation and the length of the pasture season of lot 1 on the 10-acre native-sod pasture for the 11 years from 1920 to 1930 was $.84 \pm .06$. This means that about 70 percent of the variations in the length of the pasture period can be accounted for by variations in the amount and distribution of the annual precipitation. Figure 16 is a dot chart showing this relationship between annual precipitation and the length of the grazing season. The only 2 years which departed far from the straight-line relationship determined by the regression equation were 1926, when the pasture season was not so long, and 1921, when it was longer than the precipitation indicated that it should have been.

It will be recalled that the wether lambs were removed on September 6 in the year of 1926 and sold as grass-and-milk-fat lambs. This early fall removal of the wether lambs because they were fat, and not a shortage of feed, was what shortened the graz-

ing season of that year. There was an abundance of rainfall in 1920, the first year of the grazing on this pasture, which may have stored subsoil moisture for a greater grass growth than the 1921 rainfall alone would have produced.

The correlation between the seasonal, April to September, rainfall and the length of the grazing season for lot 1 was $.73 \pm .09$. There is, then, a closer correlation between the annual precipitation and the length of the grazing season on native sod than between the seasonal precipitation and the length of the grazing season. This was to be expected, for any precipitation which fell on the sod land after the close of the grazing season tended to be stored there as soil moisture to aid with an earlier spring growth of the sod grasses, thus contributing to a longer grazing season the next year.

The correlation between the annual precipitation and the total gains of ewes and lambs on this 10-acre native-sod pasture was $81 \pm .07$, while that between the seasonal precipitation and the total gains was $89 \pm .04$. There is, then, a closer correlation between the seasonal precipitation and the gains than between the annual precipitation and the gains. This likewise is no surprise, for the seasonal rainfall averages 75 percent of the total rainfall of any one calendar year. It is but natural that a variation in this seasonal rainfall coincident with the pasture period should exert a stronger influence over the gains than the annual. A shortage in the seasonal precipitation might mean a drought period in the midst of the pasturing season which would affect first the gains and second the length of the grazing season.

The correlation between the annual precipitation and the total gains of ewes and lambs in lot 2 on sheep-grazing rotation 51 was $.30 \pm .18$. The correlation between the same factors for lot 3 on sheep-grazing rotation 28 was $.65 \pm .12$. These figures show a lessened effect upon total annual gains by annual precipitation when cultivated crops are introduced into the system, particularly when rye is used.

UTILIZATION OF CORNSTALKS

The standing cornstalks from which the corn had been husked in sheep-grazing rotations 51 and 28 were utilized as winter pasture for the bred ewes during some of the winters from 1920 to 1928. The pasture record of this by-product is an important item in determining the sheep-carrying capacity of cropped land as exemplified in grazing rotations 51 and 28, although it was a part of the winter feeding rather than of the summer grazing experiments that were conducted.

The number of sheep, the pasture periods, and the supplementary grain ration on cornstalks each year are given in table 19. The data are for a unit of 2 acres, the record being the same for

grazing rotations 51 and 28. The yields of ear corn husked from these rotations and of the ear corn and stalks harvested from similar rotations in the main field are given in table 18.

In 1925 the corn dried up without producing ears. Since other pasture was short that year, the cornstalks were utilized from August 22 to November 14. In other years the pasturing began in November or December, after the corn had been husked. Early, deep, and continuous snow-covering prevented pasturing the stalks in the winter of 1929 and 1930. The stalks were not pastured during the winter of 1930 and 1931, because the grazing experiment was ended.

The 2 acres of cornstalks carried an average of 8 ewes for an average of 94 days over the 9-year period. The stalks were pastured until all leafy portions were consumed and until bare stems from knee- to waist-high were all that remained. The estimated average yield of corn stover that could have been harvested with a row binder was about 1,400 pounds per acre, or 2,800 pounds for each 2-acre unit. This estimate assumes that the yields in these fields were the same, or nearly the same, as those harvested off similar rotations in the main field.

During three of the winters the ewes received no other feed while on the stalk pasture, but during the other 6 years they were given a supplementary grain ration. In the winter of 1922-1923 the 9 ewes on the cornstalks without supplemental feed gained an average of 16 pounds each over an 84-day period. Again in the winter of 1925-1926 the 6 ewes on the cornstalk pasture without supplemental feed gained an average of 20 pounds each over the 84-day period.

The cornstalk pasture proved to be very satisfactory ewe roughage but offers some danger of cornstalk poisoning. Sheep are not immune to that mysterious death that sometimes invades the cornstalk fields.

AGRONOMIC EFFECTS OF PASTURING

Some measure, although not an exact one, of the effects which sheep pasturing has on the yields of subsequent crops may be obtained from a comparison of the yields in the pastured rotations with those in similar rotations in the main rotation field. Comparisons are not exact, because the two areas were not alike in their exposure to soil blowing, because they may have suffered differently from cutworm damage in 1925, and because some of the cultural practices in the grazed rotations were directed towards greater weed production, causing them to digress from the cultural practices on the main rotation field. However, the dates of seeding, the rates of seeding, the seeding implements, and like operations were kept just as uniform between the pastured and the non-pastured rotations as conditions permitted. There was most varia-

tion in the seeding date of the winter wheat. There was a great urge to seed the 2-acre sheep-grazing rotation winter-wheat plots just as soon after August 25 as soil-moisture conditions seemed to promise prompt emergence and considerable top-growth. On the other hand, there was the established average seeding date of September 16 on the main rotation plots which governed the seeding there. The sheep rotation fields were always seeded concurrently with the main rotation plots. With the exceptions noted here, the dates of seeding the winter wheat on the two separate projects did not vary more than three days: 1922, 14 days; 1923, 9 days; 1927, 16 days; and 1928, 9 days. A study of the Date-of-Seeding-Winter-Wheat Experiment at this station during those same years shows that, with the exception of 1922, the conditions favored slightly the earlier seeding date.

The annual and average acre yields of grain and straw in rotations 51 and 28, each grazed and not grazed, are given in table 18.

Utilizing the winter rye for pasture instead of plowing it under for green manure at bloom stage appears to have been slightly beneficial, on the average, to the yield of winter wheat that immediately followed. Corn, the second crop after the winter rye, and barley, the third crop, showed slightly higher average yields also in the pastured rotation. The variations in the yields from year to year indicate, however, that the differences in all three crops are well within the range of experimental error. A more intensive study did not bring out any strong evidence of a cumulative effect on the yields in either direction.

The results with winter wheat on fallow in grazing rotation 28 were not so favorable to grazing. The primary purpose of fallow in the Central Great Plains area is to conserve water in the soil. This is accomplished by cultivating sufficiently often during the season to prevent the growth of vegetation, so that the rainfall which is stored in the soil may be preserved. This object was departed from to some extent in the grazing experiment by handling the land in such a manner as to provide as much weed growth as possible to be used as pasture during the first half of the summer period. To the extent that this was successful the conditions departed from good fallow and approached that of land bearing a crop. The average yield of winter wheat following the pastured fallow was larger than the average following winter rye, either pastured or plowed under, but 4 bushels less than the yield from the cultivated fallow in rotation 28, not grazed. There was a slight increase in the yield of corn, the second crop in the pastured rotation. The corn is followed by barley in the rotation that was pastured and by oats in the other. The average yield of barley was 13.6 bushels per acre, and of oats 16.5 bushels per acre. The ratio of barley to oats is a little lower than the ratio computed from the average yields of all plots of barley and oats on disked corn ground

on the main rotation field. The probable yield of barley on rotation 28, not grazed, had the crop been barley instead of oats, is 12.5 bushels per acre.

An analysis of the crop results from rotations 28, grazed and not grazed, shows about the same results as were deduced from the study of rotations 51, grazed and not grazed. However, it is very significant that all grain crops, except winter wheat in 28, in the two pastured rotations exceeded the yields from the same rotations, not grazed, on the main rotation field. It must be concluded then that the pasturing had a beneficial effect on the crop yields.

A more significant result, perhaps, is shown in the reduced number of cultural operations required in the pastured rotations. It was soon found that pasturing the barley stubble made it unnecessary to plow in preparation for seeding to winter rye. A good seed bed could usually be prepared in one operation with a duckfoot cultivator or a tandem disk. Following the rye and the fallow in the pastured rotations, a similar operation was found to be sufficient preparation for the winter wheat. This took the place of one plowing and two to three subsequent cultivations, and of two to three cultivations in main rotations 51 and 28, respectively. The cultural operations for the corn and barley did not differ in the four rotations. In the pastured rotation 51 it was necessary to plow the ground but once in 4 years, but in the plowed-under rye rotation 51 it was plowed two times in the same period.

Considerable difficulty was had with volunteer rye in the winter-wheat crop of grazing rotation 51. This was true in the early years when the remaining rye was plowed under, as well as in later years when the land was merely duckfoot cultivated in preparation for the seeding of the winter wheat. Because of the extreme tenacity of winter rye on the hard lands of the Northeastern Colorado region it should not be followed immediately by winter wheat. Winter rye in a pastured rotation containing winter wheat should be followed by a row crop or by a feed crop such as barley, which in turn is followed by a row crop or by a season of clean fallow.

The evidence of the effect of pasturing on the reduction of weed growth is not very direct nor positive. This was perhaps to be expected in dealing with small tracts of land and annual weeds such as Russian-thistles that are moved about by the wind, scattering seeds as they go. Certainly the sheep consumed many weed seeds and prevented many weeds from producing seeds. On large tracts, or as a community measure, this should have a cumulative effect on the weed population. On the small tracts of these experiments there was little observable or measurable effect. The carrying capacity of weeds on fallow and on the stubble plots did not appear to become less with the passage of the years.

REVIEW AND CONCLUSIONS

It is desirable to bring to mind again the problems responsible for the inception of this investigation and in the light of these problems to consider the evidence presented.

Many farmers in the Colorado plains region started out to hold livestock distinctly in a secondary place in their scheme of operations, and they have been prone to continue that practice. Some have even held to a single cash crop, notably wheat. The better farmers, however, practice rotation, many providing a season of fallow in the rotation and keeping livestock to utilize the roughage produced. With this system of farming the problem of pasturage arises, unless considerable native sod has been left unplowed. Even then it has been a moot question whether the feed produced on a given acreage cropped would not keep more animals than the same acreage left in native sod.

It is felt that the records presented throw sufficient light upon these problems to warrant drawing conclusions concerning:

1. The carrying capacity of sod in a fairly typical short-grass section of the Eastern Colorado plains.
2. The practicability of sheep as a livestock unit on dry-land farms.
3. The practicability of the use of sheep in connection with crop rotations which include either summer fallow or fall rye; the effect of grazing by sheep upon crops subsequently grown upon the ground; the effect upon labor saving, in farm operations, when the weed growth upon fallowed ground is pastured by sheep instead of removed by cultivation.
4. The proportion of acreage which should be left in native sod to provide pasturage during periods when pasturage is not available upon rotated ground.
5. The number of sheep which it may seem advisable, in view of the results presented, to keep upon a dry-land farm of given acreage.
6. The effect upon weed growth on fallow land of grazing by sheep over a period of years.
7. To some extent the grazing preferences of sheep and other pasturing information.

Carrying Capacity of Native Sod

The results indicate a carrying capacity of about 160 ewes and their lambs per quarter-section of native, short-grass sod, provided one is satisfied with a yearly average of 131 days' pasturage. A smaller number of ewes and lambs would undoubtedly result in a proportionately longer yearly pasture season.

It is realized that conditions vary over the plains area enough that the results presented apply only to similar type of sod in similar climatic regions.

Practicability of Sheep on Dry-Land Farms

It is believed the gains made by lambs upon the feed utilized is sufficient warrant, in connection with other advantages shown, for the use of sheep upon dry-land farms. It may also be said that since the early years of this investigation many farmers in the region adjacent to Akron have successfully fitted sheep into their farming scheme.

Sheep in Connection with Crop Rotations

Necessarily this investigation was limited to specific rotations. For these it has been shown that in the 4-year fallow rotation—fallow, winter wheat, corn, and barley—the wheat crop was reduced about 30 percent, the corn crop was increased slightly, and the barley crop apparently was at least normal.

The reduced yield in wheat was offset, or more than offset, by saving of labor upon fallow ground. On the other hand, fencing is necessary. The chief benefits of sheep in connection with this rotation is in their utilization of stubble and cornstalks and in adding another source of income.

The data indicate a carrying capacity of 96 ewes and their lambs to each quarter-section of land devoted to a cropping layout as exemplified by grazing rotation 28 for an average pasture period of 136 days.

For the 4-year rye rotation—rye, winter wheat, corn, and barley—all crops were benefited by the grazing, so that here is a clear-cut place for rye where it will give not only another source of income but additional income.

The data indicate a carrying capacity of 96 ewes and their lambs to each quarter-section of land devoted to a cropping layout as exemplified by grazing rotation 51, with an average annual grazing season of 157 days.

There is argument in favor of increasing the number of units by adding one in the rotation rather than towards an increase in the size of the units or towards a reduction in the allotment of sheep. Thirty-two acres of fallow in a similar rotation along with rye would easily furnish the 20 days of early summer pasture necessary to bridge the pasture of the rye plot over to that of the stubble plots. This would be but little more than half the 36 days of pasture actually furnished by the fallow plot of grazing-rotation 28, and this reduction in the pasture burden should go about half way in restoring the 30-percent loss in winter wheat suffered by the pastured fallow. This would leave the sod supplemental plot avail-

able for fall pasture and should result in about 177 instead of 157 days of pasture. This would still seem to be short of a desirable grazing season for sheep in this region. Sixteen more acres in native sod would add another potential 18 days to the pasture season, which would bring a total of about 195 days or 6½ months.

This increased grazing in the fall should extend to near November 20, by which time the corn normally should be husked. The 32 acres of standing cornstalks should furnish the 96 bred ewes an average of 120 days of winter roughage each year. The remaining 40 to 50 days of the calendar year would be in the spring of the year, when the sheep normally would be in dry lot for lambing.

Acreage Needed in Native Sod

The data given does not permit specifying an optimum acreage in native sod in relation to crop acreage. The proportion used—1 to 5—did very well. It can be seen that a little more sod or the addition of rye acreage in the fallow unit would have relieved fallow ground from the necessity of producing so much pasturage and so probably would have resulted in greater wheat yield and also in a longer grazing season. The problem, therefore, resolves itself into a question as to what part of an additional acre out of each 10 acres in the farm might profitably be kept in sod or put in rye in order to insure against a 30-percent reduction of wheat yield, and to provide a longer period of winter grazing. The suggested sod acreage is left at 2 acres in every 10, because an increase in sod means a corresponding decrease in crop acreage and winter feed.

Number of Sheep Per Farm

The results would indicate feed for about 96 ewes and their lambs per quarter-section under the rotation systems outlined, disregarding other livestock units which would require fitting into the system according to particular conditions.

It is realized that not all farmers will find themselves fitted to handle sheep, nor is such a plan advocated for every farm as a result of this investigation. Farming cannot be standardized. All farms and farmers have their individual conditions and limitations, and this plan of grazing sheep on dry-land farms can only be offered as worthy of consideration in most cases.

Suggested Rotation

The following is a suggested rotation for furnishing six ewes and their lambs 195 days of summer and fall pasture: The area would be 13 acres, with 3 acres permanently in native sod and five 2-acre plots cropped as follows: winter rye, corn, barley, fallow, and winter wheat.

The results would indicate a capacity of 72 ewes and their lambs per quarter-section under this suggested rotation system, disregarding other livestock units which would require fitting into the system according to particular conditions, with an average annual grazing season of about 195 days.

Effect Upon Weed Control

Grazing by sheep over a period of years did not apparently reduce weed growth on the cultivated rotations. Weed reseeding occurred plentifully, if not from locally produced seed then from wind-borne seed.

The sheep grazed and apparently relished all forms of waste vegetation on their respective areas except the cacti (largely *Opuntias*), the common buffalo-bur (*Androsera rostrata*), the bunch or dogtown grass (*Aristida longiseta*), and the biennial Flodman's thistle (*Cirsium flodmanii*). They did not relish the western wheat-grass (*Agropyron smithii*) except at an early stage of growth in the very early spring.

The weed pasture on the fallow plot always gave the appearance of being all Russian-thistles (*Salsola pestifer*). For the sake of variety the sheep always kept the other weeds under complete control. This succulent young thistle growth was very washy, this effect being especially noticeable on the lambs. The weed growth on the stubble plots was also largely Russian-thistle, with generally a goodly showing of redroot pigweed (*Amaranthus retroflexus*) and a few lamb's-quarters (*Chenopodium album*). In some years these redroot pigweeds were quite succulent and growthy by the time the threshing was accomplished, but only once was there a suspicion of bloat in the flock at this station during the grazing season. In some years the thistles were quite advanced and woody by the time the sheep were turned into the stubble plots, in which case they grazed the outer, more tender shoots and kept the plants skeletonized throughout the remainder of the fall.

Miscellaneous Grazing Information

The fall-sown winter rye produced the earliest spring pasture in this experiment involving three areas. The rye was followed in carliness by weeds on fallow and by sod-grass growth. The rye was usually heading and hence was at a relatively unpalatable stage of growth by the date the sod-grasses or the weeds on the fallow became available. The fall-sown winter rye thus fits into a sheep-pasturing project as furnishing the earliest spring pasture. The weeds on fallow or the native-sod pasture are then valuable for furnishing pasture up to the date of the threshing of the fall- and early spring-sown small grains. After the small grains are threshed there should be continuous pasture until frost, provided there is an

acreage ratio to sheep as great or greater than that in these experiments.

The weed growth on the 2 acres of fallow furnished early summer pasture for an average of 7.7 ewes and 6.4 lambs for a yearly average of 36 days. The pasturing on the fallow plot in this experiment was limited on one side by the relative earliness that weeds became available and on the other by the date that the small grains were threshed. At this altitude, about 4,500 feet, weeds on fallow cannot be relied on until an average date of June 15.

Pasturing of the weeds on the fallow land by the sheep during the early summer period saved approximately two weed-eliminating cultivations but resulted in a 30-percent lower yield of winter wheat the following year.

The 2 acres of winter rye furnished early summer pasture for an average of 7.7 ewes and 6.5 lambs for a yearly average of 60 days. The pasturing of the rye plot in this experiment was also limited by its relative earliness and by the date that the small grains were threshed. In only 3 years out of 11 did the rye produce pasture in the same fall in which it was seeded. The average beginning date of the spring pasture on the rye was May 13. After about June 15 there was usually a preponderance of weed vegetation on this rye plot, hence the pasture period under winter rye on table 14 means pasture obtained on the rye plot, not necessarily on rye pasture. The sheep seemed to graze the weeds with equal relish. A plot or field in winter rye can be made to carry a preponderance of the early summer pasture burden up to the date of the threshing of the fall- or spring-sown small grains.

Pasturing the rye instead of plowing it under for green manure, as was done on main field rotation 51, saved one to two weed-eliminating cultivations and one plowing every 4 years and in addition resulted in a 15½-percent higher yield of winter wheat the following year. The crop following pastured rye, however, did not yield as well by 15-percent as that following pastured fallow.

The barley and the winter-wheat stubble plots, 4 acres, carried an average of 7.7 ewes and 6.5 lambs for a yearly average of about 62 days, or until fall frost killed all succulent forms of vegetation.

The relative carrying capacities of the different pastures for sheep as determined by this experiment and expressed as percentages of winter rye are as follows: winter rye, 100; sod grass, 60; weeds on fallow, 60; weeds and waste grain on stubble land, 52.5.

The two acres of standing cornstalks furnished on the average sufficient forage for 8 bred ewes for a period of 94 days, or approximately 3 months.

The average gain of a ewe and a lamb of lot 1 on the 1-acre native-sod pasture was 9.5 and 33.8 pounds, respectively.

The average gain of a ewe and a lamb of lot 2 on the grazing rye rotation 51 was 19.8 and 44.9 pounds, respectively.

The average gain of a ewe and a lamb of lot 3 on the grazing fallow rotation 28 was 19.7 and 35.3 pounds, respectively.

The average gain per season for 10 ewes and their lambs on the 10-acre sod pasture was 493.2 pounds.

The average gain per season for 6 to 10 ewes and their lambs on rotation 51 was 444.3 pounds.

The average gain per season for 6 to 10 ewes and their lambs on rotation 28 was 379.2 pounds.

These figures show that the gain per lamb was greatest on rotation 51, the next highest on rotation 35, and the lowest on the native-sod pasture; but the total gain on the 10-acre sod pasture, 493.2 pounds, was greatest, 48.9 pounds less per season on the average in rotation 51 and 114 pounds less per season on rotation 28.

Miscellaneous Flock Information

The three lots during the summer, and the ewes during the winter, were signally free of parasitic infestation during the entire 11-year period, with the single exception of sheep tick (*Melophagus ovinus*) infestation. After the wool was clipped in the spring, the ticks largely left the ewes to congregate on the lambs, and the lambs were dipped in nicotine-sulphate solution, with excellent control results.

There was only one case of screwworm (*Cochliomyia macellaria*) infestation, despite the fact that the ewes, and particularly the lambs, were constantly dirty over their rump-ends each and every year while pasturing chiefly on the Russian-thistle vegetation of the fallow plot. The one case of infestation occurred near the first of June, 1930.

There was one well-defined symptomatic case of grub-in-head (*Cestrus ovis*). It occurred in a lamb near the middle of the summer of 1930.

No trouble was experienced with any of the internal parasites, despite the facts that the original ewes were mature westerners, that ewe lambs from the irrigated feeder-lamb section of Colorado were introduced into the flock in 1922, and that a new purebred, registered Hampshire buck was introduced into the flock every 2-year period from the breeding flock at the Colorado Experiment Station at Fort Collins. It is known that stomach worm (*Haemonchus contortus*) infestation either did not exist at all or was kept at a very low incidence, for many ewes were post-mortem examined each year, particularly from 1921 to 1925.

There was no very marked observable difference in the quality of the lambs from the three lots year in and year out. Whenever there was a slight observable difference, it was between the lambs from the two cultivated areas and the slightly less well-finished lambs from the native-sod pasture. The lambs sold readily each and every

year as feeder lambs, and one year as grass-and-milk-fat lambs, at the current market price for those grades.

The average wool clip from the ewes of the three lots of the year before did not vary greatly and was well within the range of experimental error. The average clip per ewe by pasture lots was as follows: lot 1, 7.2 pounds; lot 2, 7.1 pounds; lot 3, 7.5 pounds. This indicates that the pasture period, during which the ewes were suckling and growing out their lambs, exercised no influence on the ultimate wool clip.

It was soon found that the lamb crop and also the wool clip were influenced almost wholly by the care and the food of the ewe during the dormant and pregnant period of the late fall, winter, and early spring. This is not surprising when it is considered that the pasture period was also the nursing and growing-out period for the lamb, and that the longest pasture period, 157 days, is only 43 percent of the calendar year.

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SUPPLEMENTARY TABLES

TABLE I.—*Monthly, seasonal, and annual precipitation at the U. S. Dry-land Field Station, Akron, Colo., 1920-1930, compared with the corresponding data for the same station for the 23-year period, 1908 to 1930.*
(Data in inches. T=trace)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season- al, Apr. to Sept.	Annual
1920 .....	.00	.02	.90	3.28	2.90	3.97	4.72	1.45	1.80	.44	.47	.90	18.12	20.85
1921	1.22	T	1.25	2.77	.47	1.32	2.88	.92	.79	.97	.20	.65	9.15	13.44
1922 .....	.65	.25	.15	3.96	3.63	1.43	3.24	1.24	.06	.05	1.90	.10	13.56	16.66
1923	T	.18	.95	1.65	4.94	2.17	3.62	.75	.82	1.91	.47	.70	13.95	18.16
1924 .....	.50	.59	1.25	.31	3.26	.35	1.71	.77	4.04	.40	.13	.77	10.44	14.08
1925 .....	.05	T	.39	2.24	1.19	2.90	1.08	1.01	.50	1.46	.47	.53	8.92	11.82
1926 .....	.41	.05	.36	.18	3.77	1.42	6.46	5.07	.72	1.03	.41	.28	17.62	20.16
1927 .....	.17	.29	2.41	2.27	1.46	5.16	3.00	3.74	.90	.14	.64	.22	16.53	20.40
1928 .....	.13	.17	.32	.17	3.52	5.39	3.14	.25	.04	1.75	.49	T	12.51	15.37
1929 .....	.07	.34	.32	3.43	1.19	1.15	4.44	2.66	2.67	2.76	.49	.09	15.54	19.61
1930 .....	.07	T	.17	2.28	5.52	1.61	3.54	3.48	.39	.83	1.05	.09	16.82	19.03
Average 11 years, 1920-1930 .....	.30	.17	.77	2.05	2.90	2.44	3.44	1.94	1.16	1.07	.61	.39	13.92	17.23
Average 23 years, 1908-1930 .....	.31	.43	.78	2.21	2.76	2.32	2.78	2.23	1.50	1.15	.59	.65	13.81	17.72

TABLE 2.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1920.

Item	Lot and pasture					
	Lot 1		Lot 2		Lot 3	
	10-acre native-sod pasture		10-acre sheep-grazing rotation 51		10-acre sheep-grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	9	10	9	10	8
Pasture period:						
Winter rye ^b days.....	..	..	51	51	..	..
Fallow ^c days.....	..	..	..	..	45	45
Barley stubble, days.....	..	..	41	41	36	36
Winter-wheat stubble, days.....	..	..	29	29	33	33
Native sod, days.....	151	151	30	30	37	37
Total pasture.....	151	151	151	151	151	151
Weight records; average weights:						
Allotment weight May 23—						
pounds.....	72.5	..	72.3	..	71.7	..
Initial weight May 23 ^d ,						
pounds.....	82.5	18.7	63.3	22.2	62.2	17.0
Weight June 22 ^d , pounds....	84.4	31.8	82.0	33.8	81.5	30.8
Weight July 22, pounds.....	90.7	46.6	90.4	47.0	89.4	46.9
Weight August 21, pounds....	91.0	55.3	93.0	57.8	94.6	69.8
Weight September 20, pounds	90.2	55.3	92.9	62.3	92.6	63.0
Final weight October 21 ^e ,						
pounds.....	88.8	59.8	89.0	61.1	94.2	66.8
Average gains, pounds.....	26.3	41.1	25.7	38.9	32.0	49.8

^aNine lambs were selected for lot 3, but one died 4 days after experiment started.

^bSee discussion of the rye plot, 1920.

^cSee discussion of the fallow plot, 1920.

^dActual weight minus 10.0, 9.0, and 9.5 pounds of wool, the average clip for lots 1, 2, and 3, respectively, clipped July 1. Average weight of 9 lambs in lot 3.

^eAverage weight of 8 lambs in lot 1. One lamb was killed on October 10.

TABLE 3.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1921.

Item	Lot and pasture					
	Lot 1		Lot 2		Lot 3	
	10-acre native-sod pasture		10-acre sheep-grazing rotation 51		10-acre sheep-grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep.....	10	10	9	5	9	4
Pasture period:						
Winter rye ^a , days.....	..	..	35	7	..	..
Fallow, days.....	..	..	..	..	13	13
Barley stubble, days.....	..	..	29	29	57	29
Winter-wheat stubble, days....	..	..	26	26	26	26
Native sod.....	122	94	32	32	26	26
Total pasture.....	122	94	122	94	122	94
Weight record; average weights:						
Allotment weight June 20 ^b ,						
pounds.....	82.7	35.6	83.2	36.5	82.9	30.0
Initial weight June 20 ^b ,						
pounds.....	82.7	35.6	83.2	36.5	82.9	30.0
Weight July 21, pounds....	94.6	40.8	88.7	40.8	88.9	35.5
Weight August 22, pounds....	96.2	48.2	96.8	52.4	92.4	38.5
Weight September 22 ^c ,						
pounds.....	97.6	51.8	102.4	60.0	99.0	47.5
Weight October 20 ^d , pounds	95.0	..	100.4	..	99.1	..
Average gains, pounds.....	12.3	16.2	17.2	23.5	16.2	17.5

^aIncludes 28 days fall pasture on rye seeded in 1921.

^bAllotment and initial weight of lambs secured June 27.

^cFinal weights of the lambs of all lots.

^dFinal weights of the ewes of all lots.

TABLE 4.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1922.

Item	Lot and pasture					
	Lot 1		Lot 2		Lot 3	
	10-acre native-sod pasture	10-acre sheep-grazing rotation 51	10-acre sheep-grazing rotation 51	10-acre sheep-grazing rotation 28	10-acre sheep-grazing rotation 28	10-acre sheep-grazing rotation 28
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	5	10	5	10	5
Pasture period:						
Winter rye ^b , days.....	..	..	42	42	..	..
Fallow ^c , days.....	..	..	..	..	..	..
Barley stubble, days.....	..	..	13	13	23	23
Winter-wheat stubble, days.....	..	..	44	44	44	44
Native sod, days.....	123	123	56	56	56	56
Total pasture, days.....	123	123	155	155	123	123
Weight record; average weights:						
Allotment weight June 20, pounds.....	77.9	32.7	76.7	32.7	77.8	32.7
Initial weight June 20, pounds.....	77.9	32.7	76.7	32.7	77.8	32.7
Weight August 18, pounds.....	92.5	59.4	80.6	55.0	95.5	56.0
Weight September 23, pounds.....	98.0	70.0	97.2	66.0	102.5	67.0
Final weight October 21, pounds.....	100.0	68.0	97.2	68.0	106.0	70.0
Average gains, pounds.....	22.1	35.3	20.5	35.3	28.2	37.3

^aThere were 10 ewes in lot 2 all season, but weights and gain are the averages of the 9 ewes that began and ended the season.

^bThe entire flock grazed this rye from May 19 to June 20. Lot 2 grazed the rye seeded in 1922 for 10 days in the fall.

^cSee text for fallow management this year.

TABLE 5.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1923.

Item	Lot and pasture					
	Lot 1		Lot 2		Lot 3	
	10-acre native-sod pasture	10-acre sheep-grazing rotation 51	10-acre sheep-grazing rotation 51	10-acre sheep-grazing rotation 28	10-acre sheep-grazing rotation 28	10-acre sheep-grazing rotation 28
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	6	10	6	10	6
Pasture period:						
Winter rye, days.....	..	..	45	45	..	..
Fallow, days.....	..	..	..	..	24	24
Barley stubble, days.....	..	..	33	33	23	0
Winter-wheat stubble, days.....	..	..	23	10	43	43
Native sod, days.....	142	119	41	31	52	52
Total pasture.....	142	119	142	119	142	119
Weight record; average weights:						
Allotment weight May 19, pounds.....	75.5	35.7	71.1	34.7	71.5	34.3
Initial weight May 19 ^b , pounds.....	75.5	35.7	71.1	34.7	71.5	34.3
Weight June 21, pounds.....	95.0	51.7	85.0	41.7	81.0	47.7
Weight July 21, pounds.....	98.5	64.2	77.8	48.3	90.0	59.3
Weight August 20, pounds.....	104.0	70.8	82.2	52.1	95.0	60.8
Weight September 22 ^c , pounds.....	104.0	71.7	82.8	55.7	98.0	66.7
Weight October 15 ^d , pounds.....	101.5	..	84.4	..	94.5	..
Average gains, pounds.....	26.0	36.0	13.3	21.0	23.0	32.4

^aThere were 10 ewes in lot 2 all summer, but weights and gains are the averages of the 9 ewes that began and ended the season. Lot 2 consisted of 7 lambs from July 1 to the end of the season.

^bThe actual date of the beginning of the pasture season was May 26; the delay after the initial weights were taken was due to inclement weather.

^cThe final weights of the lambs; there were 7 in lot 2.

^dThe final weights of the ewes.

TABLE 6.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1924.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	10	10	9	10	9
Pasture period:						
Winter rye, days.....	..	..	48	48	..	..
Fallow, days.....	..	..	..	..	39	39
Barley stubble ^b , days.....	..	..	16	16	34	13
Winter-wheat stubble, days ..	..	..	49	49	52	52
Native sod ^c , days.....	114	114	54	54	18	10
Total pasture.....	114	114	167	167	143	114
Weight record; average weights:						
Allotment weight April 22, pounds.....	89.5	..	95.0	..	91.5	..
Initial weight April 22 ^d , pounds.....	..	..	67.2	9.6	..	..
Weight May 22 ^e , pounds... ..	..	..	82.3	37.8	..	..
Weight June 14 ^f , pounds... ..	77.0	39.5	89.4	45.6	76.0	36.7
Weight July 15, pounds... ..	101.0	56.0	90.0	52.2	91.0	53.8
Weight August 15, pounds... ..	95.0	61.0	91.9	54.4	83.5	56.1
Weight October 6 ^g , pounds... ..	79.0	56.0	96.9	53.8	88.0	60.0
Weight October 23 ^h , pounds ..	..	..	..	..	85.5	..
Average gains, pounds.....	2.0	16.5	29.7	49.2	9.5	23.3

^aThere were 10 ewes in lot 2 all summer, but the weights and the gains are the averages of the 8 ewes that began and ended the season. There were only 8 lambs in lot 2 after August 2.

^bLot 3 includes 4 days in early spring on stubble of 1923 barley crop, before the lambs had been dropped. This grazing was outside the regular grazing season.

^cLot 3 includes 8 days in the early spring, before the ewes had lambed, on western wheatgrass on the sod plot before the beginning of, and hence outside, the regular grazing season.

^dThe ewes of lot 2 lambed and were sheared on pasture. The initial weight is the allotment weight minus 19.1 pounds parturition loss, estimated from data of the Bureau of Animal Industry, U. S. Department of Agriculture, and 8.7 pounds of wool, the average clip from this lot, clipped June 13.

^eActual weight minus 19.1 pounds estimated parturition loss and 8.7 pounds wool.

^fThe actual weights of lots 1, 2, and 3, and the initial pasture weights of lots 1 and 3. The ewes had lambed and had been clipped by this date.

^gFinal weights of all sheep except the ewes of lot 3. Only 8 lambs in lot 2.

^hFinal weight of the ewes of lot 3.

TABLE 7.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1925.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	10	6	5	6	6
Pasture period:						
Winter rye, days.....	..	..	41	41	..	..
Fallow, days.....	..	..	..	..	24	24
Barley stubble, days.....	..	..	14	14	17	17
Winter-wheat stubble, days ..	..	..	14	14	11	11
Native sod, days.....	35	35	17	17	16	16
Total pasture, days.....	85	85	86	86	68	68
Weight record; average weights:						
Allotment weight April 25, pounds.....	102.0	..	102.5	24.5	102.5	..
Initial weight April 25 ^b , pounds.....	..	..	95.1	24.5	..	..
Weight May 9 ^c , pounds.....	..	..	106.8	38.0	..	..
Weight June 11 ^c , pounds.....	..	..	96.7	48.0	..	..
Weight June 15 ^d , pounds.....	88.0	46.5	..	..	88.3	45.8
Weight July 25, pounds.....	101.5	66.0	99.2	62.0	98.3	62.5
Weight August 3, pounds.....	96.5	60.0	111.7	64.0	104.2	61.7
Weight August 19, pounds.....	91.5	64.5	..	..	..	..
Weight August 22 ^e , pounds ..	..	..	109.2	68.0	98.3	63.3
Weight September 8 ^f , pounds.....	85.0	59.0	..	..	..	..
Average gains ^g , pounds.....	-3.0	12.5	14.1	43.5	10.0	17.5

^aSix lambs were selected for lot 2, but one died 4 days after experiment started.

^bActual ewe weight minus 7.4 pounds wool, the average clip from this lot, clipped June 8.

^cEwes and lambs off pasture from May 9 to June 11, 33 days.

^dThe initial pasture weights for lots 1 and 3.

^eFinal weights for lots 2 and 3.

^fFinal weights for lot 1.

^gAverage gains of ewes and lambs in lot 2 do not include the period May 9 to June 11, and are the sums of the gains for the 2 pasture periods.

TABLE 8.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1926.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	9	6	5	6	5
Pasture periods:						
Winter rye, days.....	..	..	75	75	..	..
Fallow ^b , days.....	..	..	..	..	67	67
Barley stubble, days.....	..	..	34	34	10	10
Winter-wheat stubble ^c , days ..	..	..	46	22	46	40
Native sod ^c , days.....	120	105	48	18	30	0
Total pasture, days.....	120	105	203	149	153	117
Weight record; average weights:						
Allotment weight April 1, pounds	133.5	..	137.5	..	137.0	..
Initial weight April 16 ^d , pounds .....	..	..	108.7	11.0	..	..
Weight May 24 ^e , pounds.....	..	..	108.6	32.0	..	..
Weight June 5 ^f , pounds.....	..	..	..	..	94.2	31.0
Weight June 11 ^g , pounds.....	95.5	29.0	..	..	..	..
Weight July 6, pounds.....	103.5	49.9	125.0	64.0	103.0	48.0
Weight August 11, pounds.....	..	..	127.5	80.0	110.0	66.0
Weight August 19, pounds.....	115.0	66.1	..	..	..	..
Weight September 6 ^h , pounds	125.0	76.7	137.5	90.0	121.0	78.0
Weight October 6 ⁱ , pounds.....	..	..	134.2	85.0	129.0	81.3
Weight October 9 ^j , pounds.....	129.0	80.0	..	..	..	..
Weight November 5 ^k , pounds ..	..	..	136.7	..	127.0	..
Average gains ^k , pounds.....	33.5	49.5	28.0	78.0	32.8	49.6

^aThere were 6 ewes in lot 3 all summer, but the weights and the gain are the averages of the 5 ewes that began and ended the season.

^bOne-half the fallow plot—1 acre—was spring seeded to winter rye.

^cPasture days for the lambs of all 3 lots are weighted averages.

^dThe ewes of lot 2 lambed on the pasture. This lamb weight is the average weight of the lambs taken within 24 hours after birth. This initial weight of the ewes is the actual weight minus 19.1 pounds estimated parturition loss, and 8.1 pounds of wool, the average clip from this lot, clipped June 11.

^eThis is the actual ewe weight minus 19.1 and 8.1 pounds, parturition and wool loss.

^fThis is the initial pasture weight for lot 3. It is the actual weight minus 7.8 pounds of wool, the average clip from this lot, clipped June 11.

^gThis is the initial pasture weight for lot 1 and is the actual weight.

^hAverage weight of 4, 4, and 1 wether lambs removed from lots 1, 2, and 3, respectively.

ⁱThe final weight of the ewes of lot 1. Also the final weight of 5, 1, and 4 ewe lambs remaining in lots 1, 2, and 3, respectively.

^jThe final weights of the ewes of lots 2 and 3.

^kThe gain of the lambs in all 3 lots is a weighted average.

TABLE 9.—*Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1927.*

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	10	6	6	6	6
Pasture period:						
Winter rye, days.....	..	..	85	85	..	..
Fallow, days.....	..	..	..	..	69	69
Barley stubble, days.....	..	..	21	21	23	23
Winter-wheat stubble ^b , days ..	..	..	35	31	33	25
Native sod ^b , days.....	163	128	58	44	42	14
Total pasture, days.....	163	128	199	181	167	131
Weight record; average weights:						
Allotment weight April 29, pounds.....	118.0	..	126.0	..	120.0	..
Initial weight April 29 ^c , pounds.....	..	..	118.3	16.5	..	..
Weight May 28, pounds.....	..	..	143.0	36.7	..	..
Weight May 31 ^d , pounds.....	111.0	32.0	..	..	112.5	35.0
Weight July 1, pounds.....	121.0	47.0	120.0	48.3	116.7	59.2
Weight July 16, pounds.....	..	..	122.0	45.8	..	..
Weight August 1, pounds.....	125.5	63.0	128.0	60.0	117.5	72.5
Weight August 29, pounds.....	123.0	71.5	130.0	68.3	118.3	79.2
Weight September 21 ^e , pounds.....	..	74.3	..	68.0	..	77.5
Weight October 3, pounds.....	123.0	78.3	136.0	68.8	120.0	77.5
Weight November 10 ^f , pounds.....	113.5	76.7	..	..	..	..
Weight November 14 ^g , pounds.....	..	..	132.0	70.0	113.3	77.5
Average gain ^h , pounds.....	7.5	43.0	13.7	52.8	5.8	42.5

^aThere were 6 ewes in lot 2 all summer, but the weights and the gain are the averages of the 5 ewes that began and ended the season.

^bPasture days for the lambs of all 3 lots are weighted averages.

^cThe initial pasture weight for this lot is the allotment weight minus 7.7 pounds wool, the average clip from this lot, clipped May 20.

^dThe initial pasture weights for lots 1 and 3.

^eThe average final weight of 7, 2, and 4 wether lambs from lots 1, 2, and 3, respectively.

^fThe final weight of the ewes and the remaining 3 ewe lambs of lot 1.

^gThe final average weight of the ewes, and of 4 and 2 ewe lambs, respectively, from lots 2 and 3.

^hThe average gains of the lambs are weighted averages.

TABLE 10.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1928.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 61		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	15	6	9	6	9
Pasture period:						
Winter rye, days.....	..	..	67	67	..	..
Fallow, days.....	..	..	..	..	41	41
Barley stubble, days.....	..	..	13	13	13	13
Winter-wheat stubble, days ..	..	..	55	40	55	40
Native sod, days.....	116	116	25	15	32	22
Total pasture, days.....	116	116	160	135	141	116
Weight record; average weights:						
Allotment weight May 19, pounds.....	129.5	22.7	132.0	24.4	129.2	21.7
Initial weight May 19 ^b , pounds.....	..	..	123.1	24.4	..	..
Weight June 7 ^c , pounds.....	113.0	27.7	111.0	33.9	110.8	26.1
Weight June 29, pounds.....	124.5	39.3	97.0	36.7	119.2	35.0
Weight July 30, pounds.....	129.5	52.0	106.0	50.6	118.3	50.0
Weight August 30, pounds.....	130.5	59.3	130.0	61.7	132.5	59.4
Weight October 1 ^d , pounds.....	128.0	62.7	136.0	67.8	125.8	58.3
Weight October 26 ^e , pounds ..	..	..	123.0	..	125.8	..
Average gains, pounds.....	15.0	35.0	—1	43.4	15.0	32.2

^aThere were 6 ewes in lot 2 all summer, but weights and the gain are the averages of the 5 ewes that began and ended the season.

^bThe initial pasture weight of the ewes is the actual weight minus 8.9 pounds wool, the average clip from this lot, clipped June 5.

^cThe initial pasture weights of lots 1 and 3.

^dFinal weight of the ewes of lot 1 and of the lambs of lots 1, 2, and 3.

^eFinal weight of the ewes of lots 2 and 3.

TABLE 11.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1929.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep.....	10	11	6	7	6	7
Pasture record:						
Winter rye ^a , days.....	..	..	75	56	..	..
Fallow, days.....	..	..	..	..	61	61
Barley stubble, days.....	..	..	17	17	36	17
Winter-wheat stubble, days ..	..	..	51	18	51	18
Native sod, days.....	157	105	29	29	9	9
Total pasture, days.....	157	105	172	120	157	105
Weight record; average weights:						
Allotment weight May 10, pounds.....	111.0	25.9	105.8	29.3	105.8	25.7
Initial weight May 10 ^b , pounds.....	..	..	98.9	29.3	..	..
Initial weight May 25 ^b , pounds.....	100.0	30.9	..	..	96.2	30.0
Weight June 8 ^b , pounds.....	113.0	40.5	..	..	105.5	35.7
Weight June 18, pounds.....	..	..	122.3	48.6	..	..
Weight July 9, pounds.....	122.0	56.8	127.5	63.6	121.7	53.6
Weight August 8, pounds.....	123.0	66.4	115.8	65.0	113.3	62.9
Weight September 7 ^c , pounds.....	125.5	73.6	125.9	75.7	120.8	63.6
Weight October 10 ^d , pounds.....	127.0	..	123.3	..	116.7	..
October 29 ^e.....	..	..	..	..	..	..
Average gains, pounds.....	27.0	42.7	24.4	46.4	20.5	33.6

^aIncludes 19 days fall pasture on rye seeded in 1929.

^bActual weights minus 6.5, 6.9, and 5.7 pounds of wool, the average clip from lots 1, 2, and 3, respectively, clipped June 18.

^cFinal weights of the lambs of the 3 lots.

^dFinal weights of the ewes of the 3 lots. However, these ewes grazed on to October 29 when a severe blizzard made final weights on that date impossible.

^eThe date of closing the pasture season for the ewes of lots 1, 2, and 3.

TABLE 12.—Summary of summer grazing period; average allotment, initial, monthly, and final weights; and average gains of ewes and lambs at the U. S. Dry-land Field Station, Akron, Colo., during the season of 1930.

Item	Lot and pasture					
	Lot 1 10-acre native- sod pasture		Lot 2 10-acre sheep- grazing rotation 51		Lot 3 10-acre sheep- grazing rotation 28	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
Number of sheep ^a	10	10	6	6	6	5
Pasture period:						
Winter rye, days.....	..	..	90	90	..	..
Fallow, days.....	..	..	..	..	18	18
Barley stubble, days.....	..	..	14	14	50	50
Winter-wheat stubble, days ..	..	..	36	36	9	8
Native sod, days.....	147	147	26	26	57	57
Total pasture, days.....	147	147	166	166	133	133
Weight record; average weights:						
Allotment weights ^b , pounds.....	117.5	..	119.2	..	117.5	..
Initial weight April 18 ^c , pounds.....	..	..	93.4	10.5	..	..
Weight May 21 ^d , pounds.....	91.5	10.4	119.2	..	92.5	10.0
Weight June 28, pounds.....	133.0	..	130.0	..	120.0	..
Weight July 5, pounds.....	..	..	..	..	107.5	23.8
Weight, July 26, pounds.....	126.0	25.0	131.0	26.0	115.0	38.3
Weight August 21, pounds.....	123.0	43.5	135.0	48.3	118.3	47.5
Weight October 1 ^e , pounds.....	114.2	53.6	125.0	72.5	115.8	62.5
Weight October 15 ^f , pounds.....	113.3	54.0	..	..	..	..
Average gains, pounds.....	21.8	43.6	31.6	62.0	23.3	52.5

^aThere were 6 ewes in lot 2 all summer, but the weights and the gain are the averages of the 5 ewes that began and ended the season.

^bAllotment dates: Lot 2, April 18; lots 1 and 3, May 21.

^cAllotment weight minus 19.1 pounds estimate parturition loss and 6.7 pounds wool, the average clip from this lot, clipped June 8. The initial weight of the lambs is the average birth weight, weights taken within 24 hours after birth.

^dThe initial weights of lots 1 and 3. These weights are the allotment weights of lots 1 and 3, and the actual weight of lot 2, minus 19.1 pounds estimated parturition loss and 6.9, 6.7, and 5.9 pounds of wool, the average clip from lots 1, 2, and 3, respectively, clipped June 8. The lamb weights are the average birth weights taken within 24 hours after birth. Lot 1 lambed between June 7 and August 1, with 8 lambs dropped by July 5. Lot 2 lambed between June 2 and 24. Lot 3 lambed between June 2 and 18.

^eThe final weights of the ewes and lambs of lots 2 and 3.

^fThe final weight of the ewes and lambs of lot 1.

TABLE 13.—Annual and average pasture periods of sheep of lot 1 on 10-acre native-sod pasture at the U. S. Dry-land Field Station, Akron, Colo., 1920 to 1930.

Year	Began	Ended	Days
1920.....	May 23	October 21	151
1921.....	June 20	October 20	122 ^a
1922.....	June 20	October 21	123
1923.....	May 26	October 15	142 ^b
1924.....	June 14	October 6	114
1925.....	June 15	September 8	85
1926.....	June 11	October 9	120 ^c
1927.....	May 31	November 10	163 ^d
1928.....	June 7	October 1	116
1929.....	May 25	October 29	157 ^e
1930.....	May 21	October 15	147
Average.....	June 5	October 14	131

^aLambs, June 20 to September 22, 94 days.

^bLambs, May 19 to September 22, 119 days.

^cLambs, June 11 to September 24, calculated from 105 weighted pasture days.

^dLambs, May 31 to October 6, calculated from 128 weighted pasture days.

^eLambs, May 25 to September 7, 105 days.

The 11-year average number of lamb pasture days was 117.

TABLE 14.—Annual and average pasture periods of sheep of lot 2 on sheep grazing rotation 51 at the U. S. Dry-land Field Station, Akron, Colo., 1920 to 1930.

Year	Summer pasture period		Number of days	Number of days on			Winter-wheat stubble
	Began	Ended		Winter rye	Native sod	Barley stubble	
1920.....	May 23	Oct. 21	151	51	30	41	29
1921.....	June 20	Oct. 20	122 ^a	35 ^b	32	29	26
1922.....	May 19 ^c	Oct. 21	155	42	56	13	44
1923.....	May 26	Oct. 15	142 ^d	45	41	33	23
1924.....	Apr. 23	Oct. 6	167	48	54	16	49
1925.....	May 28 ^e	Aug. 23	86	41	17	14	14
1926.....	Apr. 16	Nov. 5	203 ^f	75	48	34	46
1927.....	Apr. 29	Nov. 14	199 ^g	85	58	21	35
1928.....	May 19	Oct. 26	160 ^h	67	25	13	55
1929.....	May 10	Oct. 29	172 ⁱ	75	29	17	51
1930.....	Apr. 18	Oct. 1	166	90	26	14	36
Av.....	May 13	Oct. 17	157	60	38	22	37

^aLambs, June 20 to September 22, 94 days; only 7 days on rye pasture.

^bWinter rye available for pasture May 20 was not utilized by lot 2 until after June 20. Twenty-eight of these pasture days by ewes alone, from September 22 to October 20, 1921, on the crop seeded that fall.

^cAdjusted date. Actual date of starting lot 2 was June 20, but the rye was available and was grazed by the entire flock of 23 ewes and their lambs from May 19 to June 20, a period of 32 days.

^dLambs May 26 to September 22, 119 days. Only 10 and 31 days on winter-wheat stubble and native-sod plots, respectively.

^eAdjusted date. Pasturing began April 25, but there was no pasture from May 10 to June 12, a period of 33 days.

^fLambs April 16 to September 12, calculated from 149 weighted pasture days. Only 22 and 18 days on winter-wheat stubble and native-sod plots, respectively.

^gLambs from April 29 to October 27, calculated from 181 weighted pasture days. Only 31 and 44 days on winter-wheat stubble and native-sod plots, respectively.

^hLambs May 19 to October 1, 135 days. Only 40 and 15 days on winter-wheat stubble and native-sod plots, respectively.

ⁱLambs May 10 to September 7, 120 days. Only 56 and 18 days on rye and winter-wheat stubble plots, respectively.

The 11-year average number of lamb pasture days was 133.

TABLE 15.—Annual and average pasture periods of sheep of lot 3 on sheep grazing rotation 28 at the U. S. Dry-land Field Station, Akron, Colorado, 1920 to 1930.

Year	Summer pasture period			Number of days on			
	Began	Ended	Number of days	Fallow	Native sod	Barley stubble	Winter-wheat stubble
1920.....	May 23	Oct. 21	151	45	37	36	33
1921.....	June 20	Oct. 20	122 ^a	13	26	57	26
1922.....	June 20	Oct. 21	123	0	56	23	44
1923.....	May 26	Oct. 15	142 ^b	24	52	23	43
1924.....	June 2 ^c	Oct. 23	143 ^d	39	18	34	52
1925.....	June 15	Aug. 22	68	24	16	17	11
1926.....	June 5	Nov. 5	153 ^e	67 ^f	30	10	46
1927.....	May 31	Nov. 14	167 ^g	69	42	23	33
1928.....	June 7	Oct. 26	141 ^h	41	32	13	55
1929.....	May 25	Oct. 29	157 ⁱ	61	9	36	51
1930.....	May 21	Oct. 1	133	18	57	50	8
Av.....	June 4	Oct. 18	136	36	34	29	37

^aLambs June 20 to September 22, 94 days; only 29 days on barley-stubble plot.

^bLambs May 19 to September 22, 119 days; did not graze on barley-stubble plot.

^cAdjusted date. Pasturing began June 14, but there were three earlier grazing periods totaling 12 days.

^dLambs June 14 to October 6, 114 days; only 13 and 10 days on barley stubble and native-sod plots, respectively.

^eLambs June 5 to September 30, calculated from 117 weighted-lamb pasturing days; only 40 days on winter-wheat stubble plot and not on sod plot at all.

^fOne acre of the 2-acre fallow plot spring seeded to fall rye.

^gLambs May 31 to October 9, calculated from 131 weighted-lamb pasturing days. Only 25 and 14 days on winter-wheat stubble and native-sod plots, respectively.

^hLambs June 7 to October 1, 116 days; only 40 and 22 days on winter-wheat and native-sod plots, respectively.

ⁱLambs May 10 to September 7, 105 days; only 17 and 18 days on barley- and winter-wheat stubble plots, respectively.

The 11-year average number of lamb pasture days was 116.

TABLE 16.—*The number of ewes and lambs, their average gain or loss, and the total gain on each pasture at the U. S. Dry-land Field Station, Akron, Colo., for the years 1920 to 1930.*

Year	Lot 1, on 10-acre sod pasture					Lot 2, on sheep-grazing rotation 51					Lot 3, on sheep-grazing rotation 28				
	Ewes		Lambs		Total gain	Ewes		Lambs		Total gain	Ewes		Lambs		Total gain
	Num-ber	Average gain	Num-ber	Average gain		Num-ber	Average gain	Num-ber	Average gain		Num-ber	Average gain	Num-ber	Average gain	
1920	10	26.3	9	41.1	632.9	10	25.7	9	38.9	607.1	10	32.0	8	49.8	718.4
1921	10	12.3	10	16.2	285.0	9	17.2	5	23.5	272.3	9	16.2	4	17.5	215.8
1922	10	22.1	5	35.3	397.5	10	20.5	5	35.3	381.5	10	28.2	5	37.3	468.5
1923	10	26.0	6	36.0	476.0	10	13.3	6	21.0	259.0	10	23.0	6	32.4	424.4
1924	10	2.0	10	16.5	185.0	10	29.7	9	49.2	739.8	10	9.5	9	23.3	304.7
1925	10	-3.0	10	12.5	95.0	6	14.1	5	43.5	302.1	6	10.0	6	17.5	165.0
1926	10	33.5	9	49.5	780.5	6	28.0	5	78.0	558.0	6	32.8	5	49.6	444.8
1927	10	7.5	10	43.0	505.0	6	13.7	6	52.8	399.0	6	5.8	6	42.5	289.8
1928	10	15.0	15	35.0	675.0	6	-1	9	43.4	390.0	6	15.0	9	32.2	379.8
1929	10	27.0	11	42.7	739.7	6	24.4	7	46.4	471.2	6	20.5	7	33.6	358.2
1930	10	21.8	10	43.6	654.0	6	31.6	6	62.0	561.6	6	23.3	5	52.5	402.3
Average	10	17.3	9.5	33.8	493.2	7.7	19.8	6.5	44.9	444.3	7.7	19.7	6.4	35.3	379.2
11-year average pasture days....	131		117			157		138			136		116		

TABLE 17.—Average yearly allotment, initial, and final weights of ewes and average initial and final weights of lambs at the U. S. Dry-land Field Station, Akron, Colo., for the years 1920 to 1930.

Year	Lot 1					Lot 2					Lot 3				
	Ewe weight, pounds Allot- ment	Initial	Final	Lamb weight, pounds Initial	Final	Ewe weight, pounds Allot- ment	Initial	Final	Lamb weight, pounds Initial	Final	Ewe weight, pounds Allot- ment	Initial	Final	Lamb weight, pounds Initial	Final
1920	72.5	62.5	88.8	18.7	59.8	72.3	63.3	89.0	22.2	61.1	71.7	62.2	94.2	17.0	66.8
1921	82.7	82.7	95.0	35.6	51.8	83.2	83.2	100.4	36.5	60.0	82.9	82.9	99.1	30.0	47.5
1922	77.9	77.9	100.0	32.7	68.0	76.7	76.7	97.2	32.7	68.0	77.8	77.8	106.0	32.7	70.0
1923	75.5	75.5	101.5	35.7	71.7	71.7	71.7	84.4	34.7	55.7	71.5	71.5	94.5	34.3	66.7
1924	89.5	77.0	79.0	39.5	56.0	95.0	67.2	96.9	9.6	58.8	91.5	76.0	88.5	36.7	60.0
1925	102.0	88.0	85.0	46.5	59.0	102.5	95.1	109.2	24.5	68.0	102.5	88.3	98.3	45.8	63.3
1926	133.5	95.5	129.0	29.0	78.5	137.5	108.7	136.7	11.0	89.0	137.0	94.2	127.0	31.0	80.6
1927	118.0	111.0	118.5	32.0	75.0	126.0	118.3	132.0	16.5	69.3	120.0	112.5	118.3	35.0	77.5
1928	129.5	113.0	128.0	27.7	62.7	132.0	123.1	123.0	24.4	67.8	129.2	110.8	125.8	26.1	58.3
1929	111.0	100.0	127.0	30.9	73.6	105.8	98.9	123.3	29.3	75.7	105.8	96.2	116.7	30.0	63.6
1930	117.5	91.5	113.3	10.4	54.0	119.2	93.4	125.0	10.5	72.5	117.5	92.5	115.8	10.0	62.5
Av.	100.9	88.6	105.9	30.8	64.6	102.0	90.9	110.6	22.9	67.8	100.7	87.7	107.4	29.9	65.2

TABLE 18.—Annual and average yields of winter wheat, corn, and barley, in bushels per acre, in rotations 51 and 28, grazed and not grazed, at the U. S. Dry-land Field Station, Akron, Colo., from 1921 to 1931.

Year	Rotation 51				Rotation 28			
	Not grazed		Grazed		Not grazed		Grazed	
	Grain, bushels	Straw, pounds	Grain, bushels	Straw, pounds	Grain, bushels	Straw, pounds	Grain, bushels	Straw, pounds
	Winter wheat							
1921	14.8	1550	31.6	3113	28.5	2790	21.3	1805
1922	2.0	.....^a	5.0	721	1.7	2150	11.2	658
1923	3.2	1060	7.1	2040	7.3	1610	8.2	1453
1924	2.8	480	8.3	1013	11.2	1510	11.3	1003
1925	1.7	250	4.7	759	15.8	1350	5.5	619
1926	2.7	1790	.9	501	2.5	1200	4.5	795
1927	11.7	1450	8.9	1505	20.8	3550	10.6	1684
1928	21.0	2240	7.4	1155	24.5	4080	9.8	1197
1929	4.3	740	6.0	721	10.7	1110	6.3	716
1930	13.7	2030	13.0	1783	20.7	2760	15.7	1845
1931	6.7	810	3.2	434	14.5	2530	7.3	1520
Average	7.6	1127	8.7	1250	14.4	2240	10.2	1209
	Corn							
1921	7.7	920	9.1	.....	8.1	880	9.1	.....
1922	10.4	1940	9.5	.....	10.3	1640	8.2	.....
1923	26.5	2360	14.4	.....	16.5	2360	21.0	.....
1924	1.7	1250	1.7	.....	1.3	1050	1.0	.....
1925	0	650	0	.....	0	750	0	.....
1926	6.5	2060	10.4	.....	10.9	2230	7.1	.....
1927	7.6	840	16.1	.....	8.8	1150	16.1	.....
1928	8.0	1640	6.4	.....	6.4	1760	4.2	.....
1929	10.9	1040	5.2	.....	16.0	1580	8.5	.....
1930	11.5	850	29.9	.....	15.9	1660	24.5	.....
Average	9.1	1355	10.3	.....	9.4	1506	10.0	.....
	Barley ^b							
1921	17.7	1070	18.8	1019	16.3	500	13.4	653
1922	9.6	1240	17.1	1140	22.8	970	16.1	1078
1923	19.8	1750	18.4	1913	21.7	1005	18.1	1815
1924	3.8	270	4.1	378	5.3	280	4.7	400
1925	1.3	490	7.1	620	9.1	560	7.9	387
1926	2.5	180	4.0	688	.3	590	3.4	480
1927	21.3	2380	32.4	2418	35.3	1970	24.6	1070
1928	42.5	2110	33.4	1563	48.8	2490	35.9	1745
1929	.6	720	3.8	515	.9	270	4.3	528
1930	9.6	290	15.4	1060	6.3	450	12.6	918
1931	7.9	220	7.8	267	14.7	430	8.8	296
Average	12.4	975	14.8	1053	16.5 ^b	865	13.6	852

^aYield not recorded because straw was apparently all weeds; used in the 11-year average as zero.

^bThe yields under barley in rotation 28, not grazed, are of oats. The calculated yield of barley is 12.5 bushels per acre.

TABLE 19.—*Number of ewes, pasture period, and supplementary feed on 2 acres of cornstalks in sheep-grazing rotation 51 at the U. S. Dry-land Field Station, Akron, Colo., each year from 1920 to 1928. Sheep-grazing rotation 28 had the same record.*

Year	Number of ewes	Pasture period		Number of days	Grain fed
		Start	End		
1920-1921.....	10	Nov. 19	Mar. 15	116	0.50 lb. ground barley
1921-1922.....	9	Nov. 15	Mar. 15	120	0.33 lb. equal parts ground corn and barley
1922-1923.....	9	Dec. 22	Mar. 16	84	None
1923-1924.....	10	Dec. 3	Mar. 3	91	1.025 lbs. 1.0 lb. ground barley, .025 lb. linseed oil meal
1924-1925.....	10	Dec. 12	Feb. 10	60	0.75 lb. equal parts ground corn and barley
1925-1926.....	6	Aug. 22 ^a	Nov. 14 ^a	84	None
1926-1927.....	6	Dec. 21	Mar. 15	84	None
1927-1928.....	6	Nov. 15	Mar. 27	133	0.50 lbs. equal parts corn-and-cob meal and ground barley
1928-1929.....	6	Dec. 14	Feb. 28	76	0.44 lb. equal parts corn-and-cob meal and ground barley
Average.....	8	Dec. 4	Mar. 9	94	

^aNot used in determining the average starting and ending dates.

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