VEGETATION IN KANSAS PASTURES AND THE RELATION OF ORGANIC FOOD RESERVES OF SOME PASTURE GRASSES TO THE EFFECTIVENESS OF THEIR DEFOLIATION

by

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INTRODUCTION

On passing through the pasture areas one may note the difference in the type of vegetation in adjoining pastures. The contrast may be visible for several miles. We know that the soil is the same and that originally the vegetation was the same, so it is evident that the difference in the vegetative covering is not due to the location of the fence, but to the difference in the grazing management of the two areas.

Pasture improvement is one of the problems that has been neglected until of recent years. Many of the problems of the conservation and improvement of pastures are now being studied by the United States Department of Agriculture and the state experiment stations. Great Britain has long realized the importance of its pastures to livestock production and has started many extensive and intensive experiments some of which are of long duration, to learn how their maximum productivity can be maintained. In recent years the producers of this country have come to

the realization of the fact that high producing pastures have a distinct economic advantage. The interest of the producer in this big problem has been brought about largely by the results of cattle feeding experiments, cost of production records, and grazing experiments carried on by the experiment stations. Because of this ever increasing interest it is important that research be carried on pertaining to the fundamental problems of pasture improvement. Such problems as the effects of different intensities of grazing and grazing methods on the vegetative population should receive consideration as well as devising means of restoring weedy and rundown pastures to their normal productivity.

Since all weeds are not only worthless in pastures but occupy space that should be used for palatable forage plants, any plan of pasture improvement should take into consideration their eradication in order to facilitate the return of the desirable species. Considering the weed eradication problem from a plant physiology viewpoint it was believed that the weeds could be more easily killed at the stage of growth when they have the least amount of organic food reserves.

A study was therefore made to determine if the weeds are more susceptible to injury at certain stages of growth.

L. H. Woodward (1) says, "in the functioning of agri-

cultural science our aim is to discover the principle underlying the great facts of agriculture and to put the knowledge thus gained into form in which it can be used by teachers, investigators and farmers for the upraising of country life and the improvement of the standards of farming." If the approximate time to cut the weeds that infest practically all the pastures of the state can be determined, it will aid in solving one of the big problems confronting the pasture owner today.

It has been conservatively estimated from statistical records that one-half the feed consumed by livestock in the United States is secured from pastures. If this be true, the great importance of pastures to the welfare of this country and this state may be readily seen.

Kansas, with 23,000,000 acres of pasture lands, estimated to have an average carrying capacity of seven acres per head at the present time, would have a potential capacity of approximately 3,300,000 head of cattle. If, by better management, this carrying capacity could be reduced from seven acres to five acres, it would mean increasing the carrying capacity of the pastures from 3,300,000 to 4,600,000 or an increase of 37 head per section of grazing land. In order to increase the carrying capacity, a better understanding must be had of the vegetation making up the pastures and the effect that grazing has upon it.

A. E. V. Richardson (2) in an article on the condition of grass lands in Australia says, "The effect of grazing animals on any flora is more or less harmful. Degenerative changes in the vegetation and the elimination of some of the more palatable species have resulted. Indeed it is even more than probable that some of the more valuable species have disappeared completely and are lost forever to the pastoralists as a result of the lack of knowledge of the ecological factors influencing grass lands and the application of unscientific methods of grazing." He gives three problems underlying grass land development, Ecology, Agrostology and Genetics.

It seems logical to believe that if conditions are favorable for normal vegetative growth that the more desirable species will predominate and keep out the weeds and obnoxious grasses. Since the present methods of grazing have caused the trend of vegetation to go from the palatable grass and more desirable herbage to the unpalatable grass types and weeds it will be necessary to reverse the order of vegetative succession by killing out the weeds and unpalatable grasses to allow the more desirable ones to gain a foothold. In order to aid in the solution of this phase of the problem this investigation was undertaken.

ACKNOWLEDGMENT

The writer wishes to express his appreciation of the helpful suggestions and criticism of Professor A. E. Aldous under whose direction this investigation was undertaken. Thanks are due to Dr. Edwin C. Miller of the Botany Department under whose direction the laboratory work was carried out and also to Dr. F. L. Duley for helpful suggestions.

MATERIAL AND METHODS

This investigation consists of two phases of work, first a study of pasture conditions in Kansas and second, a detailed plot count and observation of three perennial weeds that are common in Kansas pastures, and the laboratory determination of the organic food reserves in the roots at intervals throughout the growing season.

Survey of Kansas Pastures

A survey of the grazing lands of the state was made to determine the present conditions of the pastures as to the stage of the succession of the vegetation in the different sections of the state and also to determine if possible the condition of the areas that are being grazed in comparison to their normal carrying capacity.

In making the survey individual pastures were examined. The approximate location of the areas is shown in figure 1. Only the pastures that were typical of the surrounding country and those having the native grass sod were included in the survey.

A record was made of each pasture examined as to the county and location from the nearest town. This was done by the use of a detailed road map and by recording the mileage as shown on the car speedometer.

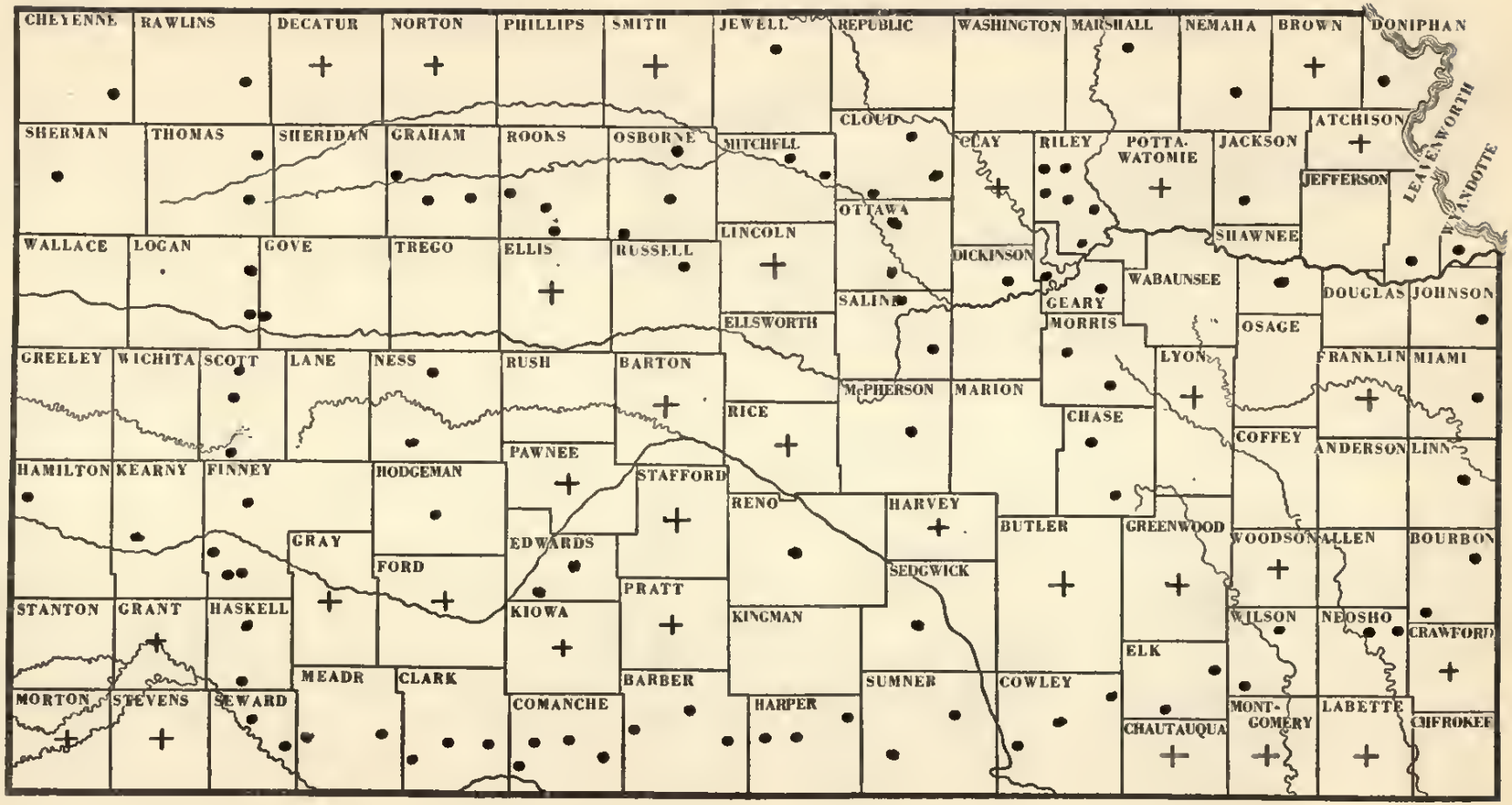

Fig. 1. Map of Kansas showing location of pastures examined.

• Pastures examined

+ Counties in which general observations were made

The general topography of the area was also recorded as this has considerable bearing on the value, management and proper utilisation of the land. The topography of the major part of the pasture lands of Kansas is such that they cannot be farmed. Soil characteristics were recorded to give more detailed description of the land.

These data were recorded on a specially prepared form, a sample of which is shown on figure 2. Ecological studies indicate that different types of vegetation are associated with different soil and climatic conditions. As this state is generally known to have three definite vegetative regions it was thought that the boundaries of these regions might be more definitely established by giving the vegetation type and the density of the vegetative cover. The density was expressed on the basis of 10 representing a perfect normal covering of such density that the ground is completely covered. The vegetation was divided into three classes, grasses, weeds and shrubs, and the per cent that each of these occupied in the total vegetative covering was recorded. A list of the predominating species of vegetation for each vegetative region was also prepared. The general pasture conditions surrounding each area examined and the condition of the vegetative growth and its utilization were recorded under general remarks.

PASTURE SURVEY

DATE_____

COUNTY_____

Location of pasture_____

General Topography_____

Soil Characteristics_____

Vegetation percent_____

Per cent of normal stand or density_____

Per cent grasses_____

Per cent weeds_____

Per cent shrubs_____

Type of Vegetation_____

Species of the three types of vegetation in order of their predominance:

Grasses	Weeds	Shrubs

General Remarks:

Fig. 2. Form used on survey

Experimental Plots

Experimental plots were established to determine the relation of the time of cutting weeds to the effect on the following years growth. As it was impossible to find plots that contained all the weeds of the state or of one vegetative region, it was necessary to select an area containing a few of the more troublesome ones which in this section include Solidago rigida, Verbenia stricta, and Vernonia Baldwinii.

The area finally selected was located two miles northeast of Manhattan in a typical small farm pasture where no particular attention has been paid to management or weed control. The pasture contains 40 acres and when the plots were established it was badly over-grazed. The plots are located on a high rocky limestone flat well drained and having a north slope. The area contained a large number of the Solidago rigida and Verbenia stricta and only a few Vernonia Baldwinii. Figure 3 is a photograph of the plots. The soil is of the Summit series ranging in depth from three to four feet. The top soil is 12 to 18 inches deep, grading down to a light calcaricus subsoil before striking the limestone rock.

The area containing the plots was 84 feet long and 40 feet wide, in which 12 plots 12 feet square separated by two-foot alley ways were located.

Fig. 3. Location of experimental plats .

One plot was cut each two weeks through the growing season. At each cutting the following data were recorded for each species under observation:

1. Number of plant stems in plot.
2. Avera e number stems per plant.
3. Maximum and minimum number per plant.
4. Average height of stems.
5. Maximum and minimum height of stems.
6. Stage of maturity.

Notes were made on each plot as the season progressed, noting the growth on plots previously cut and the general grazing conditions of the pasture. The plots were not fenced and the pasture was being continually grazed by cattle.

At the date of cutting each plot, root samples were taken from a number of plants of the three species of weeds selected for the experiment, growing in close proximity to the plots. These were taken to the laboratory, washed with tap water and placed in 95 per cent alcohol. In each case the entire plant was dug up, the tops cut off above the crown and discarded. The roots were later used in the analysis for total carbohydrate and nitrogen content.

Figure 4 shows the root systems of the three weeds studied. Each has a very different type. Number 1, Verbenia striota has a tap root with small secondary roots. Number 2

Fig. 4. Rooting system of No. 1 Verbenia stricta, No. 2 Solidago rigida, and No. 3 Vernonia Baldwinii.

Solidago rigida has a large number of roots branching off directly from the crown, and Number 3, Vernonia Baldwinii has an underground stem with a large number of secondary roots branching from it.

Method of Chemical Analysis

To determine whether the plant food reserves were stored as starch, microscopic slides were cut from the root material and the iodine test for starch made.

To prepare the root material for chemical analysis they were taken from the alcohol, run through a food chopper and again placed in the alcohol. This pulpy mixture was dried in an oven at about 90° C. and again run through the chopper and then pulverized in a mortar until all passed through a 40 mesh screen. Total carbohydrate and total nitrogen analyses were made of this finely ground material using the methods described in the following paragraphs which were adopted from the Methods of Analysis of the Association of Official Agricultural Chemists (3). Triplicate analyses were made of each sample for the carbohydrate, and the duplicate samples were used in the nitrogen determination.

Total Carbohydrate Analysis. For all samples the material was dried to a constant weight and samples of the finely ground material weighed and placed in a flask with 200 cc. of distilled water and 20 cc. of HCl (sp. gr. 1.12) added. The flask was provided with a reflux condenser and

heated for 2.5 hours, cooled and nearly neutralised with sodium hydroxide, filtered, washed and the volume completed to 250 cc. The dextrose was determined from an aliquot portion of this solution.

Dextrose Determination. Transferred 25 cc. of each of the copper sulfate and alkaline tartrate solutions of Fehling solution to a 400 cc. beaker and added 50 cc. of the sugar solution. The solution was then heated on an asbestos gauze over a Bunsen burner, regulated to bring the solution to boiling in four minutes. The boiling was continued for exactly two minutes. The solution was then filtered through asbestos mats prepared in Gooch crucibles, using a filter pump. The precipitate of cuprous oxide was washed thoroughly with distilled water, at a temperature of about 60° C. then with 10 cc. of alcohol and 10 cc. of ether. The crucibles were then placed in an automatically controlled electric oven and dried for 30 minutes at 100° C., weighed and the amount of dextrose calculated per dry weight of the sample.

Total Nitrogen Analysis. In all cases .7 grams of the oven-dried material was weighed and transferred to an 800 cc. Kjeldahl flask and 20 cc. of concentrated H_2SO_4, 10 gr. K_2SO_4, and .7 gr. of $CuSO_4$ was added. This was shaken thoroughly and digested until all organic matter was destroyed, cooled and 350 cc. of NH_3 free water added and shaken.

Seventy-five cc. of N/20 HCl were placed in a 600 cc. Erlenmeyer flask and put under the receiver of the still. Eighty cc. of 50 per cent NaOH solution and a few zinc granuals were added to the Kjaldahl flask, connected immediately to the still and shaken thoroughly, placed over a low flame at first, the heat being gradually increased. After about 150 cc. had distilled over, the flasks were disconnected and the pipette receiver washed down. Five drops of sodium alizarin sulphonate indicator was added and the excess acid titrated with N/20 NaOH and the per cent of nitrogen calculated.

Soil Moisture

In order to be able to check on the growth of plants after cutting and the ability of the plot to recover the next seasons it was thought that soil moisture samples should be taken at the time of cutting each plot. These samples were taken in the alleyways adjoining the plots. Samples were taken from two horizons, the first 0" to 12" and the second 12" to 36", weighed, dried in an oven to a constant weight and the per cent of moisture determined.

HISTORICAL

Perhaps the reason pasture investigation has lagged behind other agronomic fields of research is because of the low returns per acre from grazing land and from the fact

that grasing lands are the cheapest and a small return was all that was demanded.

Pasture lands have been considered as waste lands that could not be improved. If they deteriorated it was a natural consequence and not worth any effort that might be put forth to improve them.

As land increases in value the demand for larger returns becomes more apparent. The question seemed important enough to Carrier (4) who expressed it by saying, "Any method of general application which increases the return from pastures by even a few pounds of meat, wool or milk per acre, adds in the aggregate a large sum to the agricultural wealth of the country."

Pastures are a source of a large supply of cheap feed and with the deterioration of this supply of feed the cost of livestock production increases. Jardine (8) estimates that the 150 million acres of private holdings which is mainly under fence in the western range country is producing at the present time, twenty per cent below maximum natural production and gives five reasons for this condition, "(1) Overstocking, (2) Excessive grasing early in the growing season, (3) Season long or continuous grasing, (4) Erosion, (5) Rodents." The first three reasons probably affect this state more and are of greater importance in a pasture program. Aldous (6) sights the first two as being the prin-

cipal causes of pasture deterioration in this state and says, "The rate that the pastures have decreased in productivity is governed largely by the rate to which these two abuses have been practiced."

Over-grazing and grazing early in the season has done to the more desirable grasses what we are now trying to do to the weeds that have been allowed to come into the pastures because of the killing out of the grasses. There has been considerable research on alfalfa and other forage plants to determine the best time to cut them in order to prolong their life. This investigation is for the purpose of finding the best time to cut some of the perennial weeds in order to shorten their life.

As early as 1902 the Kansas Station started work on the question of the stage for cutting alfalfa primarily to increase the tonnage. Later this work as carried out by Salmon (7) et.al. (1914-1921) published in 1925, who compared the effect of cutting alfalfa at different stages of growth to prolong the life of the plant. They state, "Cutting in the bud stage markedly decreases the vigor of growth the stand and the yield of alfalfa hay and permitted the encroachment of grasses. The effect was clearly apparent the second year of the experiment. Cutting when the plants reached the tenth bloom stage also injured the plants, reduced the stand and permitted the encroachment of grasses,

but the result was not apparent until much later. Permitting the plants to reach the full bloom stage before cutting maintained the vigor of the plant and the stand to a very satisfactory degree for eight years after the beginning of the experiment."

In 1557, Thomas Tusser (8) in his "Five Hundred Points of Good Husbandrie" says regarding the eradication of the Bracken fern from pastures, "In June and in August, as well doth apeere, Is best to mowe Brakes of all times of the yerre."

The ability of the plants to withstand frequent cuttings and the storage of reserve carbohydrates in the roots was first mentioned by Waters (9) in connection with timothy. He states, "Early cutting thins the stand. Allow the plants to mature and they will have large, well filled and well matured bulbs. The period of greatest development of these bulbs and the most rapid storage of plant food in them is between the time when the plants are just headed and when they are fully ripe." This fact may be true of other plants and may be used as a means of eradication as well as preservation.

The importance of stored organic food reserves in plants have been recognized to have an influence on their productivity by Kraus and Kraybill (10). Graber (11) spoke of the necessity of having a supply of organic food reserve,

"In 1927 white grubs riddled thousands of acres of permanent blue grass pastures. In 1928 an alarming outbreak of annual weeds prevailed in pastures. Both of these circumstances have been largely the result of deficient supplies of reserve foods in the pasture grasses." It may be true of other plants that if their supply of food reserves could be limited the plant might be weakened or even killed.

Smith (12) worked with the Bracken fern and from his observation from the work of date of cutting, found that fronds are removed at the stage when their formation has used up the greatest amount of food reserve in the rhizomes and before they themselves have time to replenish the loss, at Boghall Glen this date is about the first of July when the fronds have been eight to ten weeks above ground, the plants are greatly weakened; 2nd, continued cutting gradually exhausts the rhizomes till the older plants die away and the growing points produced become smaller each year so that any fronds arising from them are smaller; 3rd, the continuous rhizome system is broken up by the decay of older parts, hence, the fronds arise from detached groups of branches nearer the surface and the supplies of water etc. from the deeper soil layers are cut off; 4th, cutting induces development of buds that would normally remain dormant for a year or longer."

There is no doubt that at certain stages of development of perennial plants, there is a period when the organic food reserves stored in the roots are low and if the source of supply to replace the loss is removed the plant will be weakened and may die. Aldous (1) found that at certain stages of development of buckbrush and sumac there was a period of low organic food reserves and if these plants were cut at that time it greatly lessened the next years growth. He states, "The work done this far on starch content indicates that the plants have the least amount of starch about the time they are in flower, and it is believed that this can be used as an indicator as to the most effective time to eradicate these two shrubs by mowing."

PRESENTATION OF DATA

Results of the Survey

From the information collected in the survey of the pastures it is evident that the condition of the pasture lands of the state are below normal and the present carrying capacity is far below what it should be or has been. The greatest and most urgent problem is that of building up and conserving the small farm pastures, many of which are now nothing more than weed patches. It is doubtful if some of them could be restored to their former productivity without seeding with grass mixtures. A number of the smaller

pastures and many of the larger ones, however, can be greatly improved by eradicating the weeds and by increasing the forage stand by the proper management of the livestock.

That our better pastures are decreasing in carrying capacity is shown by an analysis of the statistical data for Chase and Butler counties, which contain some of the best pastures in the Blue Stem region of the state. A. E. Aldous in analyzing this data showed that the grazing capacity of these two counties had decreased 30 per cent in the past 25 years. This decrease has resulted in a lowering of the average of grazing capacity from a little over five acres per head to over seven acres per head. There are many pastures in the state that will ave a much lower carrying capacity, particularily in the short grass region where the buffalo and grama grasses are being killed out by grazing and being replaced by Aristido findleriana, Needle grass, Stipa comata, and some of the crab grasses, Synothrisma digitaris and Schedonnardus paniculatus, snake weed, Gutierrezia sarothrae, and a number of other more or less unpalatable species. Some of these are also found in the transition region along with a more luxuriant weed growth. The over-grazed areas in the Prairie grass region are characterized by the absence of the blue stems, Andropogon scoparius and Andropogon furcatus. Their place has been taken by weeds, brush and some of the unpalatable grasses.

Figure 5 shows the boundaries of the three vegetative regions as established by the survey made of the pastures of the state. From a study of the map it may be noted that the boundaries of the different regions follow very closely the rainfall lines across the state from north to south. The line of twenty-five inches of annual rainfall is approximately the eastern boundary of the short grass region. The only place in which this is not true is in the southern part where the topography is very rough and broken and the soil contains a large portion of coarse sand and gravel which seem to be favorable to the growth of the deeper rooted pasture grasses such as the blue stems (Andropogon scoparius and Andropogon furcatus.) Throughout the short grass region there are small areas in which the vegetation is not strictly short grass, particularly in that area immediately south of the Arkansas river, locally known as the sand hills. The vegetation here is very much the same as the transition region.

The transition region is that area lying between lines of twenty-five and thirty inches of annual rainfall, a narrow belt across the state about seventy-five miles wide in which the vegetation is a mixture of the short grass region and the prairie grass region types. East of the

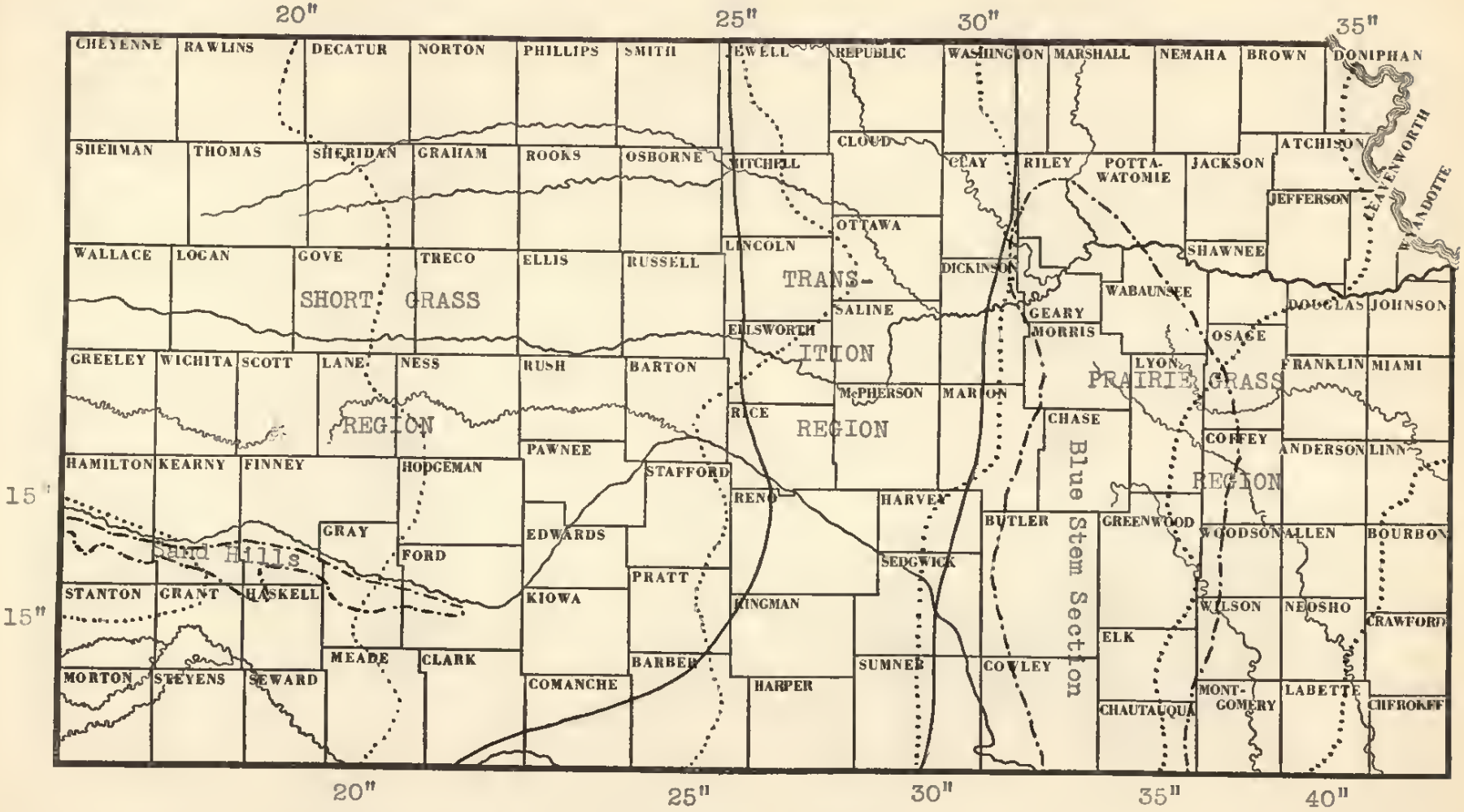

Fig. 5. Map of Kansas showing vegetative regions

——Boundary of vegetative regions

— — Boundary of outstanding grazing areas

·····Annual precipitation

line of thirty inches of annual rainfall is the prairie grass region which includes the principal grazing section of Kansas known as the Blue Stem area and all the blue grass pasture areas of the eastern counties. From the foregoing information, it is evident that rainfall is the principal factor controlling the distribution of our native vegetation.

In establishing the boundaries of the vegetative regions, that region where a majority of the pastures examined showed a predominance of the short grass types was classed, as short grass. Where the prairie grass types predominated the region was classed as prairie grass. Between these two regions there is an intermingling of the two types of vegetation, and the area is known as the transition region.

The following is a list of the predominating species of grasses, weeds and shrubs for the different regions, listed in the order of their predominance.

Prairie grass region

Grasses

1.	Andropogon scoparius	Little blue stem
2.	Andropogon furcatus	Big blue stem

3.	Poa pratensis	Kentucky blue stem
4.	Bouteloua curtipendula	Side oats grama
5.	Bouteloua hirsuta	Hairy grama
6.	Sorghastrum nutans	Indian grass
7.	Sporobolus cryptandrus	Prairie drop seed
8.	Hordeum pusillum	Little barley
9.	Panicum Scribnerianum	Scribners panic grass
10.	Schedonnardus paniculatus	Texas crab grass
11.	Panicum virgatum	Switch grass
12.	Koelaria cristata	Prairie June grass
13.	Agropyron Smithii	Western wheat grass
14.	Sporobolus vaginiflorus	Annual Poverty Grass

Weeds

1.	Ambrosia psilostachya	Perennial rag weed
2.	Ambrosia elatior	Annual rag weed
3.	Artemisia graphaloides	Pasture sage
4.	Aster multiflorous	Many leaved Aster
5.	Erigeron ramosus	Daisy flea bane
6.	Psoralea floribunda	Leather root
7.	Solidago rigida	Stiff leaved Golden rod
8.	Verbenia stricta	Vervain
9.	Vernonia Baldwinii	Iron weed
10.	Euthamia gymnospermoides	Broom weed

11.	Erigeron canadensis	Horse weed
12.	Eurhorbia marginata	Snow-on-the-Mountain
13.	Achillea Millefolium	Yarrow
14.	Helianthus orgyalis	Limestone sunflower
15.	Cirsium pumilum	Pasture thistle

Shrubs

Rhus glabra and copallina	Sumac
Symphoricarpos vulgaris	Buck brush
Quercus marilandica	Black jack oak

Short grass region

Grasses

1.	Bulbilis dactyloides	Buffalo grass
2.	Bouteloua gracalis	Blue grama
3.	Bouteloua hirsuta	Hairy grama
4.	Bouteloua curtipendula	Side oats grama
5.	Aristida fendeloriana	Triple awn
6.	Andropogon scopariue	Little blue stem
7.	Agropyron Smithii	Western wheat grass
8.	Schedonnardus paniculatus	Texas crab grass
9.	Hordeum pusillum	Little barley
10.	Agropyron tenerun	Slender wheat grass
11.	Sporobolus cryptandrus	Prairie drop seed

12.	Stipa comata	Needle grass
13.	Sitanion hystrix	Foxtail grass
14.	Hordeum jubatum	Squirrel grass
15.	Distichlis spicata	Salt grass
16.	Andropogon succharoides	

Weeds

1.	Ambrosia psilostachya	Perennial rag weed
2.	Psoralea floribunda	Leather root
3.	Ratibida columnaris	Cone flower
4.	Erigeron canadensis	Horse weed
5.	Verbenia stricta	Vervain
6.	Solidago rigida	Stiff Leaved Golden Rod
7.	Vernonia Baldwinii	Iron weed
8.	Euthamia gymnospermoides	Broom weed
9.	Plantago Purshii	Silver plantin
10.	Grindelia squarrosa	Gum weed
11.	Euphorbia marginata	Snow-on-the-Mountain
12.	Astragalus mollisimus	Texas loco
13.	Yucca glauca	Soap weed
14.	Lithospermum arvense	Puccoon
15.	Oxytropis Lamberti	White loco

Shrubs

Artemisia graphalodes	Sage brush
Artimisia filifolia	Sand sage
Rhus glabra	Sumac
Gutiertezia sarothrae	Snake weed

Transition region

Grasses

1.	Andropogon scoparious	Little blue stem
2.	Bouteloua curtipendula	Side oats grama
3.	Bouteloua dactyloides	Buffalo grass
4.	Bouteloua hirsuta	Hairy grama
5.	Hordeum pusillum	June grass
6.	Poa Protensis	Kentucky blue grass
7.	Schedonnardus paniculatus	Texas crab grass
8.	Bouteloua gracelis	Blue grama
9.	Agropyron Smithii	Western wheat grass
10.	Koelaria cristata	Prairie June grass
11.	Aristida fendeloriana	Tripple awn
12.	Andropogon furcatus	Big blue stem
13.	Panicum virg tum	Switch grass
14.	Sitanion hystrix	Foxtail grass

Weeds

1.	Ambrosia psilostachya	Perennial rag weed
2.	Psoralea floribunda	Leather root
3.	Veronia Baldwinii	Iron weed
4.	Artemisia graphaloides	Pasture sage
5.	Verbenia stricta	Vervain
6.	Solidago rigida	Stiff Leaved Golden Rod
7.	Ambrosia elatior	Annual rag weed
8.	Plantago Purshii	Silver plantin
9.	Erigeron canadensis	Maris tail
10.	Euphorbia marginata	Snow-on-the-Mountain
11.	Achillia Millefalium	Yarrow
12.	Cirsium pumilum	Pasture thistle
13.	Ratibida columnaris	Cone flower
14.	Aster multiplorous	Many leaved aster
15.	Grindelia squarrosa	Gum weed
16.	Baptisia australis	False indigo (blue)

Shrubs

Astemisia gnaphalodes	Sage brush
Rhus glabra	Sumac
Symphoricarpus vulgaris	Buck brush

The sand hill area which is within the short grass region is fit only for grazing because of the sandy character of the soil. Figure 6 shows the topography and something of the type of vegetation. As will be noted in protected area this type of land supports the more desirable forage species. The following is a list of some of the grasses found in this area:

Andropogon scorparious	Little blue stem
Bouteloua gracelis	Blue grama
Bouteloua hirsuta	Hairy grama
Agropyron Smithii	Western wheat grass
Bouteloua curtipindula	Side oats grama
Andropogon furicatus	Big blue stem
Andropogon halli	Sand Hill blue stem
Paspalum ciliatifolium	Paspolum
Bouteloua doctyloides	Buffalo grass
Sporobolus cryptandrus	Prairie drop seed
Sorghastrum nutans	Indian grass
Panicum virgatum	Switch grass
Stipa comata	Needle grass
Cenchrus pauciflorus	Sand bur

The Buffalo grass is found in the depressions between the sand dunes.

Fig. 6. Character of the sandhill section. (See Fig. 5).

The density and percentage of the vegetative types from the result of the survey, shows a range in density from two in the badly over-grazed areas to as high as nine in the blue-grass pastures of the eastern part of the state.

The following Table I shows the average density of vegetation in the different regions and the per cent of each type of vegetation found.

Table I. Average density and percentage of different types of vegetation in Kansas

Vegetative Region	Pastures examined	Average density	Pastures having a normal density	Pastures below a normal density	Vegetation percentage		
					Grasses	Weeds	Shrubs
Prairie Grass	35	6.89	4	31	60.3	33.6	6.1
Transitional	23	6.33	0	23	68.5	31.4	1.0
Short grass	39	5.97	0	39	73.1	23.8	3.0
State average	97	6.26	4	93	69.8	26.4	2.7

The density of the vegetative covering decreases in going east to west. The percentage of grasses increase in the same direction while the percentage of weeds decrease. In the latter case, however, in the place of weeds we find that unpalatable types of grasses make up a part of the grass composition.

Wherever there is a decrease in the percentage of the palatable grasses which is largely due to over-grazing the percentage of weeds, unpalatable grasses and shrubs increases.

RESULTS OF FIELD PLOTS AND LABORATORY ANALYSIS

The results of the field notes and laboratory analysis is being presented as far as possible in tabular form accompanied by a graph to show the correlation or lack of correlation in the phases of the work studied in detail in both field and laboratory.

During the growing season of 1928 the plots established were cut every two weeks and counts made of the number of stems and plants of the three weeds studied.

The root samples for the analysis of total carbohydrates and total nitrogen were taken first on March 3 before growth started, and at intervals throughout the growing season until October 15 which was after all plants were

well matured.

Results of Weed Counts

Table II shows the results of the plot counts made on Verbenia stricta in the dates of cutting and again on May 20, 1929. There was a reduction in both the number of stems and the number of plants in all of the plots. By expressing the number of plants in the plots at the second count in per cent of the first count and plotting as shown on figure 7, the curve shows a low point in the number of plants surviving on June 23. At this time, the plants are in the bud stage of development. The same was true of the Solidago rigida. Table III shows there was a reduction in the number of stems and number of plants. Figure 8 shows the low point in the curve to be on July 21 which is when the plants are in the bud stage.

Test for Starch

By using the iodine method for starch determination, a microscopic examination of sections of all the roots samples showed that none of the three plants stored the reserve food in the form of starch. This indicates that the reserve food in all three of these weeds is stored as inulin or in some other carbohydrate form.

Laboratory Analysis of Verbenia stricta

In Table IV is shown the laboratory analysis of the roots of Verbenia stricta taken at intervals throughout the season show the roots to be more nearly depleted of their organic food supply on July 8 which is about two weeks earlier than the date of the most effective cutting on July 23. However, the cutting made on June 8 was more effective than the one made on July 7 which would indicate a low point between the dates of June 8 and 23.

Table V gives the results of the total nitrogen determination, showing a low point on June 8 which is the same date as the low point in the total carbohydrates.

Table II. Counts, measurements, and stage of growth of Verbenia stricta

Plot No.	Date of observation and cutting	No. stems in plots At time of cutting	No. stems in plots Counts made 5/20/29	No. plants in plots At time of cutting	No. plants in plots Counts made 5/20/29	Percent of plants in plots 5/20/29	Average height of stems when cut	Stage of Growth
*	3/13							Dormant
*	3/30							Dormant
*	4/14							Dormant
*	4/28						2	
*	5/12						4	
1	5/26	88	13	22	5	22.7	7	
2	6/8	51	1	17	1	5.8	10	Bud
3	6/23	48	0	16	0	0.0	14	Bud
4	7/7	29	4	15	2	13.3	18	½ bloom
5	7/21	51	1	17	1	5.8	18	½ bloom
6	8/3	30	4	10	3	30.0	27	Full bloom
7	8/18	23	7	8	3	37.5	24	Full bloom
8	9/1	27	10	7	3	42.8	24	Mature
9	9/15	29	5	14	3	21.4	22	Mature
10	9/29	23	8	8	4	50.0	26	Mature

* Observations were made on plants out side as well as on the plots.

Table IV. Total carbohydrates in the roots of Verbenia stricta, estimated as dextrose on a dry basis, from a 2 gr. sample

Date of sampling	Weight of Cu_2O gr.	Average wt. Cu_2O gr.	Grams dextrose	Percentage dextrose
3/13	.2938			
	.2930			
	.3072	.2980	.6000	30.0
5/12	.2118			
	.2344			
	.2168	.2762	.5520	27.6
6/8	.2292			
	.2326			
	.2342	.2320	.4590	22.5
7/7	.2610			
	.2774			
	.2538	.2641	.5280	26.4
8/3	.2938			
	.2876			
	.2942	.2919	.5855	29.3
9/1	.2998			
	.2944			
	.2850	.2931	.5880	29.4
10/15	.2900			
	.2906			
	.2930	.2912	.5830	29.2

Table V. Total nitrogen in the roots of Verbenia stricta on a dry basis from a .7 gr. sample

Date of sampling	CC N/5 HCl neutralized by N.	Average of duplicate samples	Percentage of total nitrogen
5/13	9.8		
	10.8	9.90	.99
5/12	8.9		
	8.9	8.90	.89
6/8	7.0		
	6.8	6.90	.69
7/7	7.5		
	7.4	7.45	.75
8/3	7.3		
	7.4	7.35	.74
9/1	8.2		
	8.3	8.25	.83
10/15	8.5		
	8.7	8.60	.86

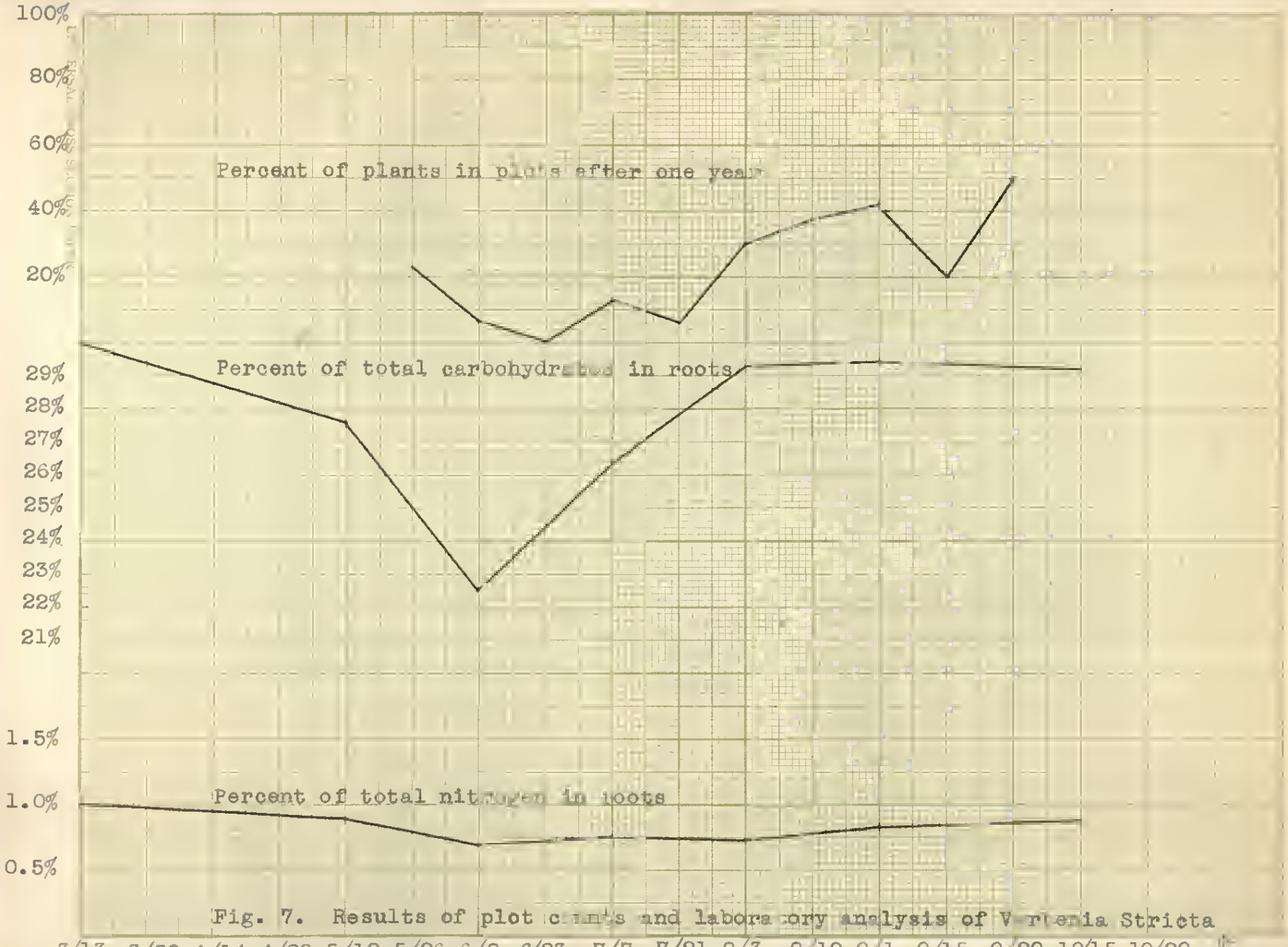

Fig. 7. Results of plot counts and laboratory analysis of Veronia Stricta

Laboratory Analysis of Solidago rigida

The laboratory analysis for total carbohydrates and total nitrogen as shown in Tables VI and VII respectively expressed in percentage of the dry weights and plotted on figure 8 shows the low point for the organic food supply to be July 7 two weeks before the date of the most effective cutting. However, there was very little difference between the effectiveness of cutting on the dates of July 7, 21, and August 3.

Table III. Counts, measurements and stage of growth of Solidago rigida

Plot No.	Date of observation	No. stems in plots: At time of cutting	No. stems in plots: Counts made 5/20/29	No. plants in plots: At time of cutting	No. plants in plots: Counts made 5/20/29	Percentage of plants in plots 5/20/29	Average height of stems when cut	Stage of Growth
*	3/13							Dormant
*	3/30						1	
*	4/14						2	
*	4/28						4	
*	5/12						6	
1	5/26	192	158	28	26	92.8	6	
2	6/8	165	153	33	25	75.7	9	
3	6/23	116	116	29	19	65.5	10	
4	7/7	188	118	31	19	61.3	8	
5	7/21	37	21	12	7	58.3	8	Bud
6	8/3	15	8	5	3	60.0	16	Bud
7	8/18	21	19	7	6	85.7	12	Flowering
8	9/1	17	14	8	7	87.5	16	Flowering
9	9/15	9	9	3	3	100.0	18	Full bloom
10	9/27	6	6	2	2	100.0	17	Full bloom

* Observations were made on plants outside as well as on the plots

Table VI. Total carbohydrates in the roots of Solidago rigida, estimated as dextrose on a dry basis, from a 2 gr. sample

Date of sampling	Weight of Cu_2O gr.	Average wt. Cu_2O gr.	Grams Dextrose	Percentage dextrose
5/13	.2334			
	.2354			
	.2362	.2354	.4425	22.1
6/12	.1946			
	.1846			
	.1876	.1889	.3705	18.5
6/8	.1988			
	.1980			
	.1944	.1971	.3845	19.2
7/7	.1694			
	.1706			
	.1690	.1697	.3515	16.6
8/3	.1934			
	.1948			
	.1946	.1943	.3820	19.1
9/1	.2000			
	.2018			
	.1972	.2030	.3985	19.9
10/15	.2194			
	.2220			
	.2208	.2207	.4335	21.7

Table VII. Total nitrogen in the roots of Solidago rigida, on a dry basis, from a .7 gr. sample

Date of sampling	CC N/5 HCl neutralized by nitrogen	Average of duplicate samples	Percentage of total nitrogen
5/13	13.8 13.9	13.85	1.39
5/12	11.3 11.4	11.35	1.14
6/8	13.5 13.4	13.45	1.35
7/7	11.2 11.0	11.10	1.11
8/3	11.2 11.1	11.15	1.12
9/1	11.8 11.9	11.85	1.19
10/15	13.2 12.9	13.05	1.31

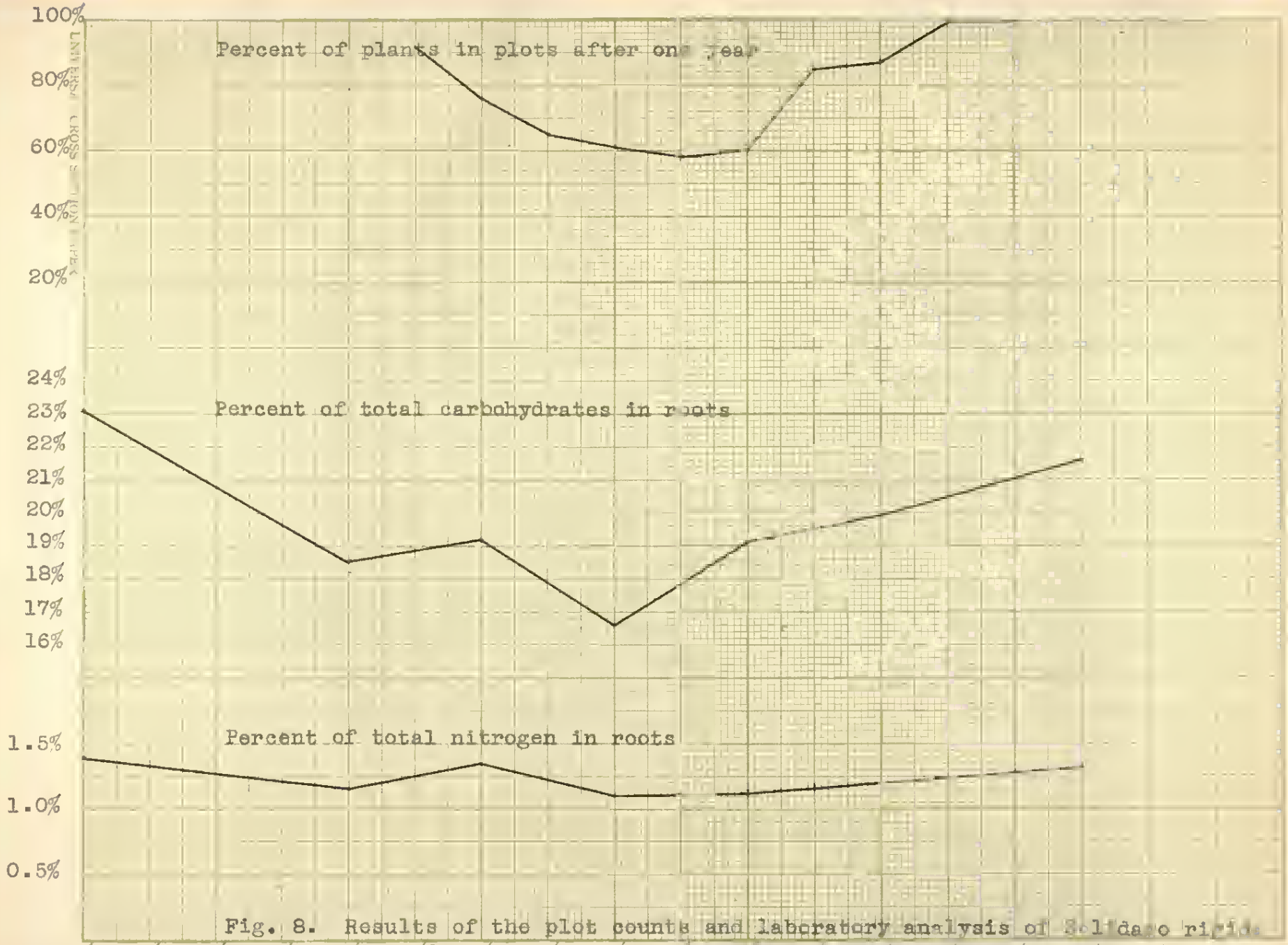

Fig. 8. Results of the plot counts and laboratory analysis of Solidago ridi.

Laboratory Analysis of Vernonia Baldwinii

Tables VIII and IX give the results of the laboratory analysis of the total carbohydrates and total nitrogen, expressed in per cent of the dry weight in the roots of Vernonia Baldwinii. The percentage of each is plotted on figure 9 which indicates a low point for both total carbohydrates and total nitrogen on July 7.

Table VIII. Total carbohydrates in the roots of Vernonia Baldwinii estimated as dextrose on a dry basis, from a 3 gr. sample

Date of sampling	Weight of Cu_2O gr.	Average weight Cu_2O gr.	Grams dextrose	Percentage dextrose
5/13	.3454			
	.3472			
	.3434	.3453	.7035	23.5
5/12	.3340			
	.3338			
	.3374	.3350	.6810	22.7
6/8	.3314			
	.3394			
	.3328	.3345	.6785	22.6
7/7	.2656			
	.2690			
	.2604	.2650	.5280	17.6
8/3	.3000			
	.3040			
	.3066	.3055	.6145	20.5
*8/18				23.7
*9/15				24.5
10/13	.3360			
	.3390			
	.3292	.3347	.6788	22.6

* Samples were analyzed by the chemistry department by the titration method and only the percent of dextrose is given

Table IX. Total nitrogen in the roots of Vernonia Baldwinii on a dry basis, from a .7 gr. sample

Date of sampling	CC N/5 HCl neutralized by nitrogen	Average of duplicate samples	Percentage of total nitrogen
3/13	13.3 13.4	13.55	1.54
5/12	10.8 10.6	10.70	1.07
6/8	10.8 10.7	10.75	1.08
7/7	9.1 9.0	9.05	.91
8/3	11.2 11.2	11.20	1.12
8/18	11.8 11.8	11.80	1.18
9/15	10.9 10.7	10.80	1.08
10/15	12.7 13.0	12.85	1.29

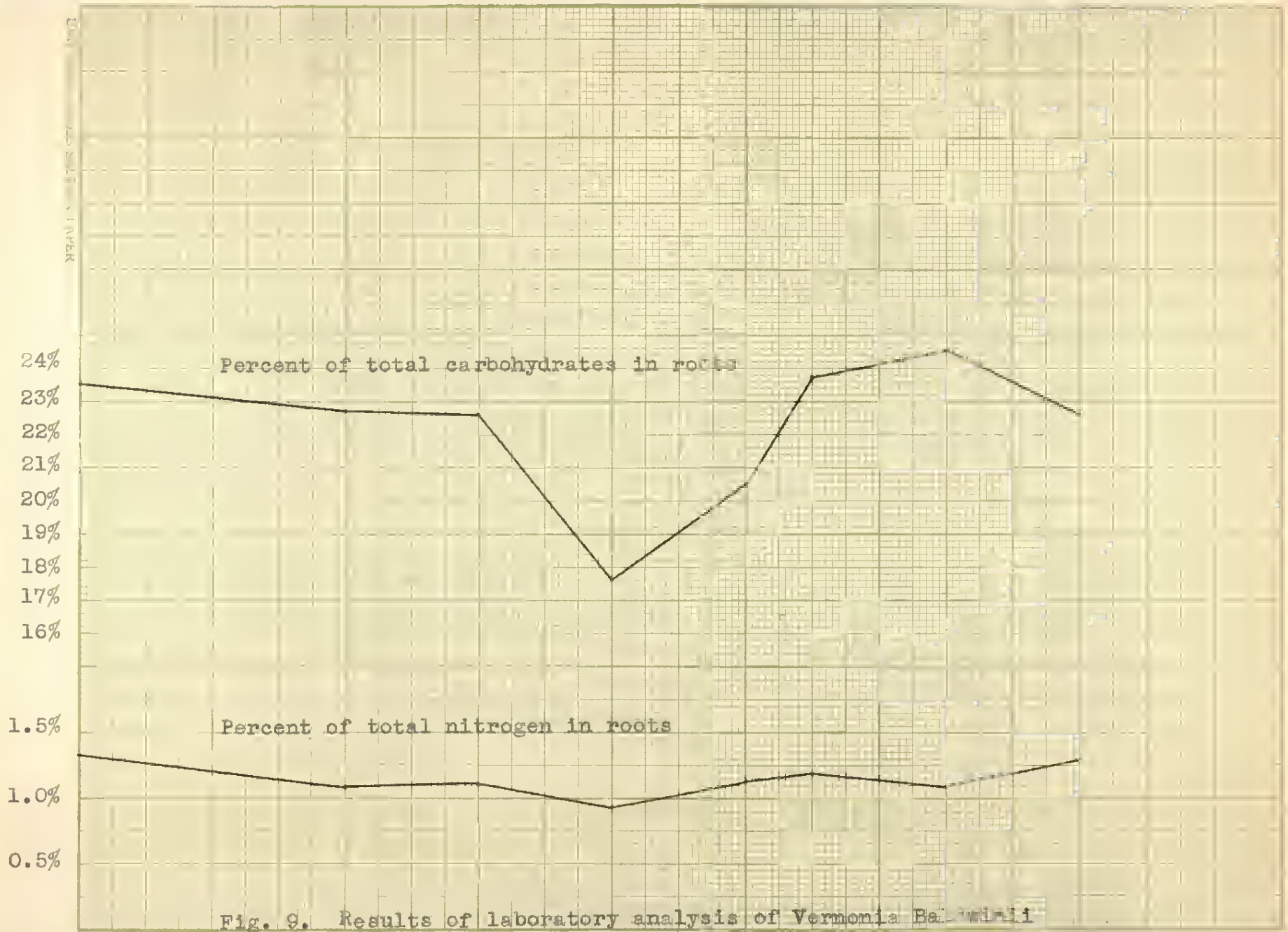

Fig. 9. Results of laboratory analysis of Vernonia Baldwinii

Soil Moisture

In order to determine if there was a relation between the amounts of organic food reserves, the ability of the plant to survive the following year and the soil moisture soil samples were taken from two horizons, the first 0"-12" and the second 12"-36". The results of the soil moisture samples are shown in Table X. The rainfall in inches that fell between the cuttings is shown in Table XI. The graphs showing the per cent of soil moisture for the two depths at the different dates and the total rainfall in inches between these dates are plotted on figure 10. A comparison of the data on figures 8, 9, and 10 does not show any apparent relation between the amount of moisture and the organic food reserves. There was plenty of moisture through the growing season which may account for the lack of correlation.

Table X. Percentage moisture in soil from two horizons taken on the same date of cutting the plots

Date sampled	Percentage moisture, dry basis	
	0-12"	12"-36"
April 28	26.6	22.2
May 12	30.9	20.9
May 26	17.1	20.8
June 8	26.6	23.4
June 25	31.6	24.4
July 7	25.0	22.8
July 21	26.6	22.8
August 3	31.2	22.8
August 18	29.8	25.9
September 1	16.2	22.8
September 15	19.0	29.5
September 27	23.1	19.0

Table XI. Total inches of rainfall at Manhattan, between dates of samplings. Report from Government Weather Bureau Station

Dates	Inches of rainfall
March 3 to March 13	.54
March 14 to March 30	.52
April 1 to April 14	1.77
April 15 to April 28	.00
April 29 to May 12	1.71
May 13 to May 26	.21
May 27 to June 8	1.92
June 9 to June 25	2.44
June 24 to July 7	1.38
July 8 to July 21	5.10
July 22 to August 3	2.99
August 4 to August 18	3.15
August 19 to September 1	.97
September 2 to September 15	2.13
September 16 to September 29	.06

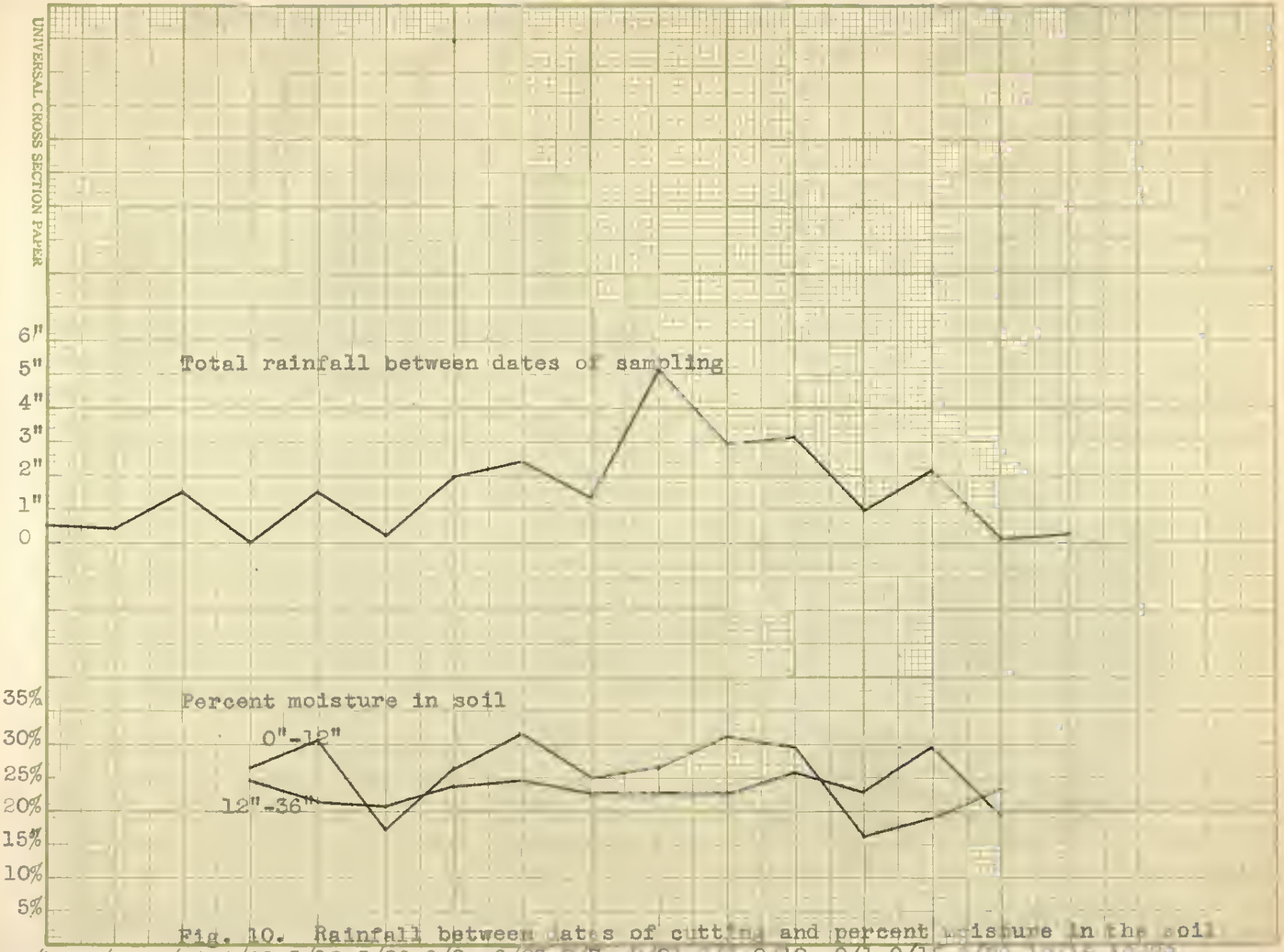

Fig. 10. Rainfall between dates of cutting and percent moisture in the soil

DISCUSSION

It would indicate from the results of the laboratory analyses for total carbohydrates and total nitrogen in the root samples, that there is a definite period in the stage of growth of the plant at which time the reserve organic food is limited. In each case this low point occurred just before the plants began to show buds. During the rapid development of the stems and leaves of the plant a large part of the carbohydrates and nitrogen manufactured by the plant are used up and until the rapid growth and development of plant tissue is completed there is not enough organic foods synthesized to allow for storage in the roots. When the plant is about ready to reproduce, the development of plant tissue is not nearly so rapid, the leaf surface is large and there is a rather rapid increase in the amount of organic food reserves being stored in the roots. In the case of Verbenia stricta from the time the plant started budding to the time it was in full bloom there was an increase of from 22.5 per cent to 29.3 per cent of total carbohydrates. The same is true in the case of the Solidago rigida and the Vernonia Baldwinii. Under the conditions of this experiment it is evident from these data that from the time of budding to the time the plant is in full bloom the organic food reserves is being stored in the roots at a

rapid rate.

If this source of organic food supply can be cut off at the time when there is a low reserve in the roots, there would be a tendency to starve the plant system or at least stop the shortage of the reserve which is necessary for the rapid growth and development of plant tissue the next season. From the counts made of the plants in the plots the season following the cutting, it would indicate that there is a direct correlation between the number of plants the second season and the amount of organic food reserve in the roots at the time of cutting. The results obtained would indicate that by following this system of cutting, at the time of low organic food reserves for several seasons that complete eradication would result. From the work done on these three plants the date of cutting should be just before or at the bud stage of the plants development.

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