SOME EXPERIMENTS AND OBSERVATIONS ON REVEGETATION OF OKLAHOMA RANGE LANDS WITH NATIVE GRASS BY SEEDING

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PREFACE

"As the first white settlers drove their covered wagons slowly westward across the seemingly limitless expanses of the Great Plains, they found the Red Man living in rude but productive harmony with Nature. The Winter snows and Spring rains clothed the land in grass; forests covered the foothills and lined the upper reaches of clear streams; the buffalo furnished food, clothing, shelter, and other simple necessities without diminishing in number. Living as he did, the Indian could laugh at the burning sun, the strong but dustless winds. He had made his truce with them, and with the land."

"The White Man knew no truce. He came as a conqueror first of the Indian, then of Nature. Today we see foothills shorn of timber, deeply gullied, useless or rapidly losing their fertile soil under unwise cultivation; the fertile earth itself drifts with the wind in sand hills and in dust clouds; where once the grass was rank, cattle now nibble it to the scorched roots; the water of streams and the ground water too often irrigate poor land, leaving the richer thirsty; men struggle vainly for a living on too few acres; the plough ignores Nature's "Keep Off" signs; communities, for all the courage of their people, fall into decay, with poor schools, shabby houses, the sad cycle of tax sales, relief, and aimless migrations."

"The land may bloom again if man once more makes his peace with Nature. Careful planting will give him back the foothill trees; terracing will save lush foothill farms; a wise use of the land will restore grass for controlled grazing; fewer and larger farms on scientifically selected sites may yield under the plough a comfortable living; dams will hold back the waters from rains and melting snow, giving power and controlling the flow of the life-giving streams; springs may be developed, water pumped by windmills to water cattle, moisture held in the soil by scientific methods of tillage; by such means the life of man on the land may be made happier, more prosperous, more secure. The sun, the wind, the rain, the snow can be friends of man, not enemies. This is no Utopian dream. It is a promise, to be realized if we will."

These words, taken from a report of the Great Plains Committee(27), have inspired this thesis. It is not my

purpose to portray Oklahoma as a stricken area where men struggle vainly for a living or as a community falling into decay, but from the words and experiences of those who have gone before us, let us profit, and in so doing we will well realize the value of establishing and maintaining good pastures not only for fattening our livestock but in furnishing a cover for the soil so that it will not be blown by the wind or washed by the rain. The land will bloom and the life of man on the land will be happier, more prosperous, and more secure. In accomplishment of this goal the conservation and storage of soil moisture, humus and organic matter in our prairie lands will mean our truce with nature.

It is for these reasons that I have directed my study to some of the native grasses adapted for pastures in Oklahoma. I feel that a thorough knowledge of these plants may facilitate our attaining the promised "Utopian dream" without going through the deterioration processes and experiencing the ill effects that other communities have suffered before realizing their pasture and range condition. With this information, we can and should immediately step forward to hasten the desirable work of nature and halt the inhibiting factors, which stand obstructive in the path to our goal, whether they be induced by the elements of nature or by man.

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GENERAL INTRODUCTION AND CHARACTERISTICS OF THE AREA

Before considering the immediate problem at hand, let us first look into a few facts about Payne County. This information may be considered representative of general conditions which occur in nine-tenths of this state, and by viewing the situation we can estimate the relation between these facts and the possibilities of re-establishing grass on the land.

Land Utilization and Census Data

According to a bulletin published by the United States Department of Commerce (10), there are 414,724 acres of farm land and 3034 farmers in Payne County. The total farm population, however, is 13,963, and the average size farm is 137 acres. The land values average $25.00 per acre, but some of the improved farms sell as high as $37.00 an acre.

TABLE 1

LAND UTILIZATION IN PAYNE COUNTY (10)

Harvested Crop Land	145,001	Acres
Crop Failure (In Fiscal Year)	 15,684	"
Idle Land (In Fiscal Year)	 229	"
Plowable Pasture	 36,508	"
Woodland	 74,000	"
Other Pastures	 82,696	"
All other land in Farms	 29,848	"

Tenantry and Ownership

Tenantry and ownership (Table 2), will rise to significance when we consider re-grassing some of the areas in the county. The tenant is, generally, not

deeply interested in seeing good cover for the soil, and his livestock enterprises are, in the main, limited. He will "make out", so to speak, on what he has there already. This is often insufficient as a ground cover or a pasture.

Tenantry is generally of a temporary nature, and neither tenant nor owner in this case gives due emphasis to the importance of grass. The owner is not willing to make the necessary expenditures for fence and seed and the tenant is mainly interested in a cash crop for the present with intentions of moving on to another place in the future.

Some owners are often more aware than others of the value of grass pasture. Their knowledge of the subject will make them willing to start a project of this kind, while others will have a tendency to stand back and carry on with the programs they have employed for many years. Thus, emphasis must be given to the tenantry and ownership population and should it be my job or yours to re-establish grass in the county, we should work whole-heartedly with those desirous of getting better grass and patiently with great effort try to educate others to its importance and value.

TABLE 2

TENANTRY AND OWNERSHIP (10)

Full (White) Owners	837
Full (Colored) Owners	25
Part (White) Owners	341
Part (Colored) Owners	8
Share Croppers (White)	108
Share Croppers (Colored)	44
Other Tenants (White)	1614
Other Tenants (Colored)	41

Soils

The topography in Payne County varies from gently undulating, rolling to level. As stated by the Payne County Soils Survey (33)

> "The climate is characterized by rather long, hot summers and generally mild winters. The Mean annual temperature is 59.1° F., and the average annual rainfall is 33.83 inches. The greater part of the rainfall comes during the growing season, but in many years the precipitation is not favorably distributed, and crops may suffer from drought for long periods during the summer."

There is no particular system of crop rotation employed in the county, and very little fertilizer is used. Very few of the farms could be classed as diversified.

The types of soils and the areas they constitute are listed in table 3. The soil can be cultivated easily with light farming implements, and plowing is generally done in the spring. This is due to the fact that fall-plowed fields have a tendency to blow and erode during the winter months. This practice of spring plowing should be remembered in re-establishing grass. Savage (29), states that best results have been obtained from spring plowing and spring planting, or planting in sorghum stubble or other types of mulch. Grasses established on cultivated land in the fall of the year are usually killed by frost, and the land blows badly, making an uneven surface even if a few plants survive.

Vernon, Kirkland, and Bates soils are the major soil types in the county. Soil Survey of Payne County (33) states,

> "The greater part of the upland soils are residual from sandstone and shales, which vary from red to brown in color and give rise to similarly colored surface soils. The red or Vernon soils occur chiefly in the western and central parts of the county, while the brown-colored or Bates and Kirkland soils occupy the eastern and central parts of the county."

The Summit Series is an upland soil occuring in the eastern part of the county. It is derived from limestone. The soils found in the rolling topography areas of the county are more sandy, and have a more friable sub-soil than the level soils. These upland soils are used for kafir, oats, wheat, cotton, and the grazing of cattle and production of hay, while in some cases are timbered with Post Oak-Black Jack association.

The Knox and Derby series are upland soils that are not residual. These soils are sandy to texture and of eolian origin. The Derby soil is a more productive series than the Knox.

Along the Cimarron River the Terrace soils of the county occur. These soils are very productive and are considered to be some of the very best soil in the county. It is here that the more valuable legume pastures and hay crops may be established, such as alfalfa and lespedeza which are not adapted to the upland soils. The higher priced lands in the county are found in this area.

> "The first-bottom soils consist mostly of material washed from the upland soils of the Permian Red Beds Region. The alluvial soils in Cimarron River bottoms are more or less calcareous, while those in the creek bottoms are generally neutral." (33)

Most of the land in this bottom area is in cultivation at the time, and our problem is not of chief concern here. The yield on the land is high, and in most cases the highest yields in the county are obtained on this land. Therefore, it is the upland regions that the problem of re-establishing grass is of greatest concern.

TABLE 3

AREAS OF PAYNE COUNTY SOILS (33)

Soils	Acres	Percent of area they constitute
Vernon loam	82,944	24.1
Heavy subsoil phase	24,448	
Vernon very fine sandy loam	56,000	19.9
Shallow phase	32,512	
Bates fine sandy loam	20,544	8.9
Shallow phase	19,008	
Bates loam	35,584	8.0
Kirkland silt loam	34,176	7.7
Yahola very fine sandy loam	27,904	6.3
Derby fine sandy loam	19,264	4.3
Knox fine sand	15,872	3.6
Yahola silt loam	14,016	3.2
Vernon clay loam	9,536	2.1
Canadian loam	9,088	2.0
Canadian very fine sandy loam	6,464	1.5
Summit stony clay	4,928	1.1
Osage silt loam	2,176	.5
Yahola silty clay loam	1,728	.4
Reinach fine sandy loam	1,024	.2
Miller clay	832	.2

Climatological Data

In reviewing weather conditions it is well to remember these facts. The normal growing season for native grass, Gernert (14), is approximately 200 days. The average date of first killing frost occurs about November first and the last killing frost is approximately April first. The

prevailing wind is Southern but North winds are experienced in the winter months. Most of the rains occur in May with more torrential rains in the fall. The effectiveness of the precipitation is depreciated by free surface evaporation of more than twice as much as the annual rainfall.

The summer months for a four year period, 1935 to 1938 inclusive, are discussed briefly, and a summation of the yearly temperature and precipitation is presented in tables 4, 5, 6, and 7 which follow the discussion. The grasses discussed in this experiment were planted in these years.

June, 1935, as reported by Wahlgren (40), was abnormally cool and wet. The average temperature for the month was 73° F. which is very moderate, and the rainfall 10.31 inches which is about 6 inches more than the average received in this month. Conditions were favorable for planting and growth in this month.

July, 1935, was a very warm month with average temperature of 83.9° F. and rainfall of 0.51 inches which is 2 inches below the average for this month. The weather was very unfavorable for crops and pastures.

August, 1935, was decidedly warm with temperature of 83.5° F. and rainfall 3.08 inches. Most of the rains occured late, and it might be said that the scant moisture and intense heat gave a draughty environment for the grass during the first four weeks of this month.

June, 1936, was a warm and dry month. The mean temperature reached 80.7° F. and precipitation 1.91 inches.

A severe early summer and late spring drought occurred.

July, 1936, was also a very hot and dry month with average temperature of 87.8° F. and precipitation of 0.37 inches. This was not favorable weather for the propagation of grass.

August, 1936, was another hot and dry month with temperature of 89.6° F. and less than 0.01 inches precipitation. This temperature equaled the high monthly mean temperature established in 1934 which was a very serious drought. The intense heat and lack of precipitation since January first resulted in one of the worst droughts in the history of the state. According to the Bureau of Agricultural Economics, crop conditions at the close of this period were the poorest in history.

TABLE 4

MONTHLY TEMPERATURE AND PRECIPITATION FOR 1935 (40)
Departure from mean listed as plus*or minus

Month	Mean Temp.	Departure	Mean Rainfall	Departure
January	40.4	*4.1	0.60	-0.52
February	41.4	*2.6	1.38	*0.17
March	55.3	*5.3	3.15	*0.80
April	56.1	-3.3	2.45	-1.57
May	63.6	-4.0	3.59	-1.42
June	73.3	-3.3	10.31	*6.36
July	83.9	*3.3	0.51	-2.15
August	83.5	*2.7	3.08	*0.10
September	69.6	-3.6	2.26	-1.44
October	61.5	*0.4	2.18	-0.82
November	44.6	-4.6	2.16	-0.03
December	38.8	*0.8	1.92	*0.54

TABLE 5

MONTHLY TEMPERATURE AND PRECIPITATION FOR 1936 (40)
Departure from mean listed as plus*or minus

Month	Mean Temp.	Departure	Mean Rainfall	Departure
January	34.1	-2.2	0.14	-1.00
February	32.4	-7.0	0.25	-1.07
March	57.0	*7.0	0.02	-2.86
April	61.2	*1.8	1.11	-2.86
May	71.4	*3.8	4.84	-0.11
June	80.7	*4.1	1.91	-2.08
July	87.8	*7.2	0.37	-2.39
August	89.6	*8.8	0.00	-3.08
September	78.0	*4.8	5.77	*2.07
October	59.2	-1.9	2.31	-0.78
November	47.8	-1.4	0.08	-2.30
December	43.6	*5.6	1.49	*0.35

In June, 1937, the average temperature was 78.8° F., and rainfall reached 6.61 inches. This was a very favorable month for growth of the grass species under observation.

July, 1937, was a decidedly warm month with temperature reaching 85.0° F. and precipitation 1.76 inches.

August, 1937, was a very favorable month from a moisture standpoint with rainfall of 3.46 inches and accompanying temperature of 86.0° F.

June, 1938, was a mild month with temperature of 76.6° F. and rainfall of 4.80 inches. The rains of June, added to that of the five preceding months, produced good mid-year conditions from a soil-moisture standpoint.

July, 1938, was a favorable month for crop prospects with temperature of 82.2° F. and rainfall of 3.88 inches. It was the wettest July since 1933 and coolest since 1931.

In August, 1938, temperature reached 83.4° F., and rainfall exceeded 4 inches. It was a warm month, but not unfavorable for growth.

TABLE 6

MONTHLY TEMPERATURE AND PRECIPITATION FOR 1937 (40)
Departure from mean listed as plus* or minus

Month	Mean Temp.	Departure	Mean Rainfall	Departure
January	30.6	-5.7	0.91	-0.23
February	40.9	*1.5	0.23	-1.09
March	46.1	-3.9	0.96	-1.35
April	61.0	*1.6	1.72	-2.25
May	70.6	*3.0	2.86	-2.09
June	78.8	*2.2	6.61	*2.62
July	85.0	*4.4	1.76	-1.00
August	86.0	*5.2	3.46	*0.38
September	75.0	*1.8	2.24	-1.46
October	62.2	*1.1	2.38	-0.71
November	46.5	-2.7	0.87	-1.51
December	38.1	*0.1	1.49	*0.35

TABLE 7

MONTHLY TEMPERATURE AND PRECIPITATION FOR 1938 (40)
Departure from mean listed as plus* or minus

Month	Mean Temp.	Departure	Mean Rainfall	Departure
January	41.6	*5.3	0.57	-0.57
February	46.3	*6.9	2.25	*0.93
March	58.4	*8.4	5.63	*3.32
April	60.0	*0.6	2.51	-1.46
May	68.7	*1.1	5.71	*0.76
June	76.6	*0.0	4.80	*0.81
July	82.2	*1.6	3.88	*1.12
August	83.4	*2.6	4.39	*1.31
September	74.8	*1.6	2.16	-1.54
October	68.2	*7.1	0.37	-2.72
November	48.6	-0.6	2.60	*0.22
December	40.6	*2.6	0.42	-0.72

Crops

A study of our crop situation, as outlined in table 8, and the discussion of the soil give emphasis to the fact that some of this land should be retired from cultivation. The yields are low, and income from them is not profitable in many cases. The 15,684 acres of crop failure in the year 1940, could have been eliminated and the land well used had it been in grass. Erosion on the slopes is frequently excessive and the land is in much need of organic matter, (15). By growing winter cover crops, re-establishing grass pastures, and terracing, the organic matter content can be increased, and the soil will be held in place.

TABLE 8

CROPS IN PAYNE COUNTY (10)

Crops	Acres	Yield
Orchards	908	
Grain Sorghums	24,551	
Production in bushels		153,854
Sorghums for Silage,Hay and Fodder	16,779	
Production in tons per acre		2
Alfalfa	6,228	
Production in bushels		7,276
Sweet Clover and Lespedeza	102	
Production in bushels		55
Oats	18,229	
Production in bushels		267,891
Cotton Lint	27,713	
Production in bales		2,893
Potatoes	587	
Production in bushels		27,187
Wheat	6,128	
Production in bushels		63,651

Livestock and Pastures

In table 1, we find that there are 36,508 acres of plowable pasture, 82,696 acres of other pastures which make a grand total of 119,204 acres. In table 10, however we find that the animal population exceeds 58,000 head, and the poultry population is 168,225. From my own observations in the county, it readily becomes evident that the native pastures are of very poor quality. The land which the farmers and stockmen refer to as their pasture land is filled with contaminates and presents evidence of poor management and overpasturing. This should not be the case, as the number of acres available as pasture should be sufficient for that number of livestock. It may then be assumed, that establishment of more desirable pastures and proper management will facilitate a better utilization of the land in that more livestock can be carried on the same acreage we now have.

TABLE 9

LIVESTOCK IN PAYNE COUNTY (10)

Mules and Horses (All ages)	8,741
Mules and Horses (2 years)	7,811
Cattle and Calves (All ages)	35,281
Heifers (1 yr. and under 2 yr.)	4,598
Cows and Heifers (2 yr. and older)	17,237
Cows and Heifers milked all or part of year	12,616
Sheep (All ages)	3,831
Chickens	164,137
Turkeys	4,118
Swine (All ages)	8,560
Goats and kids	1,664

TABLE 10

SUMMATION OF CLASSES OF LIVESTOCK (10)

Mules and Horses	8,741	Chickens ...	164,137
Cattle	35,281	Turkeys ...	4,118
Sheep	3,831		
Swine	8,560		
Goats	1,664		
	58,007		168,225
	Head of livestock		Head of poultry

The value of livestock products sold or traded in the county have an annual value of $800,337. These figures may partially indicate that grass can be a new kind of cash crop from Payne County Farmers. To illustrate my point, I refer to a pasture experiment at Bethany, Missouri, which has been called to my attention by H. W. Staten of Oklahoma Agricultural and Mechanical College.(38) The land was on an 8% slope, and received an annual rainfall of 34.8 inches. This land was capable of producing only 20 and 25 bushels of Corn, but when put in pasture the gain on beef was equivalent to a much greater yield of corn than the land could actually produce. As shown in table 11, the equivalent yields of Corn were doubled in some cases by putting the land in grass and interpreting the yield in pounds of beef. It must be remembered that the plants in table 11 are not adapted to Payne County, but similar results can be obtained with our native grasses.

TABLE 11

INCREASE OF YIELD EQUIVALENT BY USE OF PASTURE (38)

Pasture	Length of time Pastured	Pounds of Beef Produced	Bu. Corn Equivalent
Blue Grass	10/15 to 4/15	158	31.6
Orchard Grass and Lespedeza	6/8 to 9/6	215	43.0
Wheat and Lespedeza	3/26 to 10/1	206	41.2
Rye and Korean Lespedeza	4/19 to 11/1	165	33.0

Assume:
20 bushels of corn required to produce 100 pounds of gain.

EXPERIMENTATION

The experiments studied in this thesis were established in the years 1935, 1936, 1937, and 1938 at the nursery on the Oklahoma Agricultural and Mechanical College Experiment Station, by the Soil Conservation Service. A few years later it was abandoned by the same organization but given to Oklahoma Agricultural and Mechanical College for supervision. The plantings still remain on the site, however, and have been for the greater part, unmolested. Some of the species have become badly mixed, and the contaminates in some cases have crowded out the species planted. It remains only to be said however, that although the grasses have occupied the area for 3, 4, and 5 years, they still offer a very desirable study.

The plots observed appear in Section 16, Township 19N., Range 2 E., of Payne County, Oklahoma, and the results interpreted herein may be expected to apply to nine-tenths of the state, and probably would be applicable to like regions elsewhere.

The land on which the plots are found is sloping moderately to the East and Northeast, but no appreciable difference was noted in the grasses whether on the top or bottom of the slope. The soil is typical of most of the soil in the county, being Vernon, Kirkland and Bates types which represent 63% of the types in the county, and may be considered representative of a large percentage of the soils found in the range areas of the state. A discussion

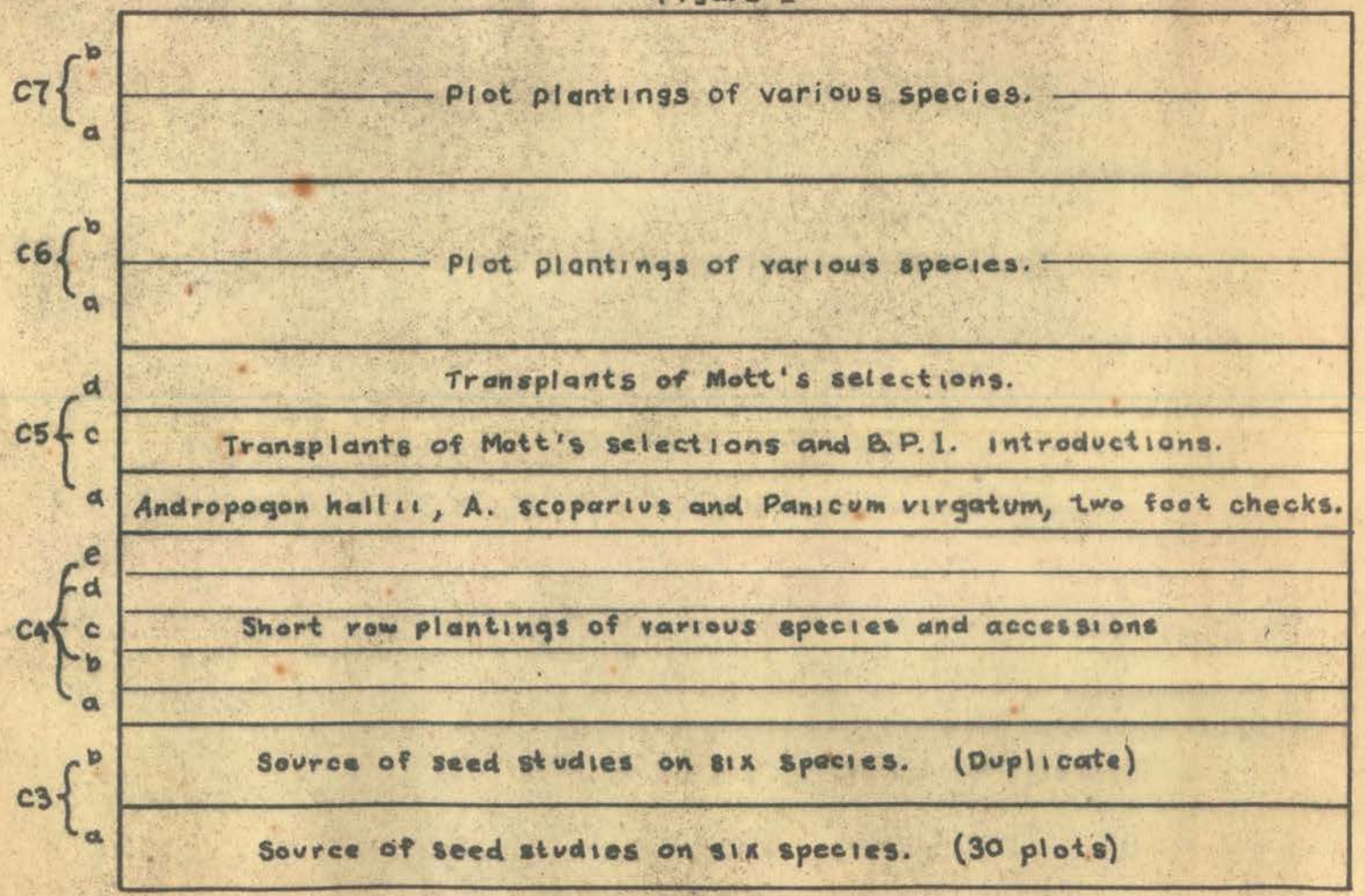
of these types and areas in which they occur in the county may be found in table 3, in the general introduction and statement of the situation.

The grass stands were obtained from seeding, sodding, and transplanting individual plant selections which were collected from various counties of this and other states; namely, Texas, Kansas, New Mexico, Arizona, Arkansas, Nebraska, and North Dakota. In this article, however, the seeding experiments are given special attention.

The species to be considered here are Big Bluestem, Little Bluestem, Blue Grama, Side-oats Grama, Indian Grass, Switch Grass, and Buffalo Grass. The plan of the Nursery, location, and identification of each species and strain is illustrated in Figure I.

From the observations made, it is my desire to throw additional light on the principles and practices of re-grassing the upland soils of the state. The facts considered and presented are effect of source of seed or sod on stand obtained, availability of the forage for pasture from such seedings, and ability of forage to cover the ground. It is my hope that the readers of this thesis will be convinced that the native grasses may be established by seeding, and since the need and desirability of good range land is so evident, that this method will rapidly become a prevalent practice.

Figure I



A map of the grass plantings in the nursery for the purpose of determining location and nomenclature of each plot and series. Sections are numbered and lettered from South to North. Plots and rows are numbered from East to West.

PROCEDURE

Prior to 1934, the land on which the grasses were planted was in use as general farm land by the Animal Husbandry Department of Oklahoma Agricultural and Mechanical College. In the fall of 1934, the ground was plowed and the area was occupied by trees. In the spring of 1935 the trees were removed, and the land disced into a fine, firm seed-bed for the grasses planted at that time. The plants which appear in the two-foot rows were established in soil with the above history. The land, now occupied by the C3a and C3b plots, however, was disced again in the spring of 1938, the grasses planted there in 1935 were removed, and the ground was made ready for planting the strains which appear there today. The land was prepared in the same manner as that for a small grain crop, with possibly a more friable seed bed, and the seeds from various sources were planted in March of that year.

The seed originally received was in about the same condition as that combined with a small machine for that purpose or collected by hand. The seed was cleaned by hand and separating machinery and stored in a dry place, free from mixture or impurities and ready for planting.

In some cases, selections of various species were collected from areas in this state and others and transplanted in the nursery. Mott's selections are illustrated in figure I. It was his belief that superior plants could be obtained from seed of his selections. A part of

the work in the nursery was done along this line, however, notes are incomplete and results are not completely established. From the studies made of his selections it appears altogether possible that this can be done if the mother plant selection is not removed too far from its original habitat, and the existing conditions of the new region are similar to the region from which it was selected. Some of his selections at the nursery were superior to others, and it would be of interest to know more about this subject.

The whole area indicated in figure I is 270 by 250 feet. The areas into which it was divided and plantings made may be seen in the diagram of the site. C3a and C3b however, are plots 9 by 18 feet, and as said before were planted in the spring of 1938. The two foot rows discussed in this article are represented by the numbers and letters C4a, C4c, C4d, and C4e, and are shown as such on the map afore mentioned. These sites were planted in March, 1935, and for the most part as indicated by tables 13 and 14, were seeded. The Buffalo Grass plots are 18 by 24 feet and represented as C7a, and were planted in April, 1937. These plots of Buffalo Grass were established by sodding; however, the methods and measurements of checking are not know.

With the seed bed prepared in the manner afore mentioned, the seeds were then planted in 4 inch rows made by a hand drag. In the main drag bar of the device used

as a drag were wooden spikes which left impressions or rows in the soil when pulled across the area. In these small rows the seeds were deposited by hand and covered with one-half to one inch of soil by again dragging the area with the smooth side of the main bar downward or on the surface.

This procedure resembles closely planting with a drill which is probably the most widely adapted method yet used; however, other machinery and modifications of the drill have been employed. The rate of seeding of these strains was not measured in this experimental work, but the work of others (29, 17) establishes the practicability of seeding with a drill and other modifications, and the rate of seeding is there known. Therefore, it is the opinion of the author that seeding is wholly practicable and the recommended rates (25) may be used and expected to give the same results as observed in this experiment.

The credit for establishing the grass seeded in this project rightfully goes to K. D. Price, L. G. McLean and B. F. Kiltz, and the plant selections were made by Mott and many other ardent and faithful workers interested in the development of better grass land. It is L. G. McLean to whom I am indebted for the above information relative to the procedures employed in establishing the grass plots.

OBSERVATIONS

The observations of the grass plantings were made in the winter of 1940-41. The results, and estimates of each species and strain are presented in table 13, 14, 15, 16, and 17, but to have a more thorough understanding of the subject each species and conditions accompanying its growth will be discussed herein.

As shown by the above mentioned tables, I have estimated each plot, on the basis of 100% as the perfect stand, and given it a percentage score. I based my scoring system on forage growth, ability of the stand to cover the ground, and arrived at a score to signify its desirability as a pasture stand. To substantiate this scoring, however, the height of forage and diameter of the bunches in some cases will be given. It must be remembered that the observations were made in the winter while the plants were very mature and presented dense swards of forage, but they were in a state of dormancy.

In most cases the seeds were completely gone, but there is evidence presented by their growth which of the species produced seed. The state of maturity, at which these grasses were observed, answers favorably for studying seed production, but less favorably for studying possibility of hay yield or ground cover. The bunch grasses have more of a tendency to occur in large clusters and maturing from this point of origin gives little rise to new plants filling in the ground area because the tall

dense forage smothers new seedlings out when they occur the following spring. Gernert (14) in his experimental work with native grass species shows that hay yield is not increased enough in the fifth year to pay for the labor of clipping more than twice annually. He also reports that as the clippings are increased the hay production is decreased. The project discussed here has had no organized treatment in this manner, but was subject to occasional mowing. Had this been done systematically in the early stages of establishment, it is altogether possible that the stands would appear thicker in some cases and more of the ground would have been covered. Judging from the availability of forage on these plots when observed, it is estimated that hay yields from them, at the time haying would have been done, would have been desirable. Therefore, the appearance of the stands and likewise the scores given may be considered by some to be under adverse conditions as far as pasture is concerned, since the plots have received little attention or care in the last 3 or 4 years. A relation between the strains and species can be established, however, and the scores given are considered by the author as significant of their desirability.

Andropogon furcatus

Andropogon furcatus, Muhl. (A. provincialis Lam.),Big Bluestem, is reported by Featherly (11) as an important constituent of wild prairie hay, and grazed by all classes of livestock. The species is found in the open prairie and

flowers in the summer and fall. The states from which the seeds were imported for this project may be considered its general distribution, (17), i. e. Texas, Oklahoma Kansas, Nebraska, and North Dakota. However, in the western parts of these states where climatic conditions are very severe it occurs only in scattered stands. The plant is tall, leafy and has a bunch habit of growth, with an extensive root system which penetrates deeply into the soil. During favorable seasons, seed crops may be expected if the mother plants have sufficient space to develop.

Savage and Smith (29), recommend seeding reasonably early in the spring. The fall planted seed enters dormancy early in the fall, and develops slowly in the winter months. The fall and winter seedings are not recommended, because the seeds germinate in warm periods and the young seedlings are killed by oncoming frosts. Late spring seedings experience hot dry weather and torrential packing rains. In some years grasshoppers may be an enemy if planting is done at this time.

Hoover (17) recommends 15 to 20 pounds of seed per acre if the seed is to be broadcast, and 6 to 8 pounds if seeded in rows suitable for cultivation. The seed can be readily harvested with a small grain combine, and will yield 75 to 100 pounds of field run material averaging 25% pure seed by weight.

The yield of prairie hay per season, of which this species is a major constituent, may be expected to average

1 ton per acre or slightly more on very desirable stands.

The general recommendations above mentioned for establishing this species were followed rather closely in this experiment, so we may expect that the results obtained were from no error made in preparing the seed bed or planting the seeds.

In both the larger plots and the two foot rows the seed of southern origin produced a greater amount of forage and a more desirable stand than the northern strains. The former, in each instance and likewise in the duplicate series C3b and in the two-foot rows, presented a dense stand of grass and an abundance of forage covering the ground in excess of 90% in many cases.

In the order of their desirability, the Texas strain ranked first, Oklahoma second, Kansas third, Nebraska fourth, and North Dakota, fifth. In the two-foot rows with seed of Oklahoma, Kansas, and Nebraska strains, the desirability of stand was in that order. Seed from Mays and Payne Counties, Oklahoma, produced the most forage and ground cover in the two-foot rows. The height of the stems varied from 4 and 5 feet for the southern strains to 4 and 5 inches for the northern strains. Percentage of ground covered ranged from 100% to 15% and the diameter of bunches from 14 to 2 inches. The southern strains excelled in each instance. The northern strains grew in small bunches with few stems as high as 3 and 4 inches, falling over and sparsely covering the ground. The southern strains showed

evidence of producing an abundance of seed while the northern strains could maintain only a sparse growth.

Little is to be said about palatability of the forage in this discussion. Each species having substantial growth was very coarse and exhibited the type of forage one would expect to find where the grass had not been clipped or pastured and had been allowed to mature to this stage. Each species discussed herein is considered desirable as a pasture grass. A plant utilization list, table 12, prepared by the Extension Service of Oklahoma Agricultural and Mechanical College is given below. (6)

TABLE 12

PLANT UTILIZATION LIST
Based on percentage of 100

Agropyron smithii	Western Wheatgrass	65
Andropogon furcatus	Big Bluestem	75
Andropogon scorparius	Little Bluestem	80
Bouteloua curtipendula	Side-oats Grama	75
Bouteloua gracilis	Blue Grama	85
Bouteloua hirsuta	Hairy Grama	75
Buchloe dactyloides	Buffalo Grass	85
Cynodan dactylon	Bermuda Grass	75
Elymus canadensis	Wild-rye	30
Panicum virgatum	Switch Grass	50
Sorghastrum nutans	Indian Grass	65
Sorghum halepense	Johnson Grass	70

Clover in Oklahoma did not exceed the above scores

The hay production from these plots is not known as no data is available at this time. The strains from this locality and southern regions produced an abundance of forage as compared to the sparse growth of the northerly strains, and it is expected that a greater yield of hay would be secured from the southern strains.

Only in a few instances will it be noted that there is a decided difference in the strains from the same areas, which were expected to yield as well as the others. For example, plot C3a9, collected in Texas, yielded poorly as compared to C3a7, collected in Oklahoma.

The date the seed was harvested from the mother plant of these respective strains will possibly account for the difference in their growth. C3a9, harvested in 1936, was a very poor year, reviewing weather conditions, as compared to 1937 when C3a7 was harvested.

The seed collected in 1936 was, therefore, due to adverse weather conditions, much less viable, and did not retain the germinative powers of that seed collected in 1937 which was a much more favorable year. The respective strains of grass from each region may vary due to climatological, and ecological conditions which affect their adaptability, but in this study the source of seed is the major factor to be considered and will be discussed more in detail.

Andropogon scoparius

Like Big Bluestem, Andropogon scoparius, Michx., Little Bluestem gave similar results and showed a distinct advantage in stands obtained with seed of southern or local origin.

The species is described by Featherly (11) as an important grass of the prairie and one of the major constituents of prairie hay along with Big Bluestem. It furnishes good grazing for livestock and will flower in the summer and fall.

Hoover (17), gives this species a general distribution throughout Nebraska, Kansas, Oklahoma the black land belt of South-central Texas, Northern New Mexico, Northern Arizona, Utah, and Western Colorado.

Little Bluestem is a perennial bunch grass and occurs in abundance on fertile soil, preferably light pervious soils, (29), especially in the drier parts of the region where a lack of moisture retards growth on heavier soils. It occurs only in scattered clumps on unfavorable sites, but may be expected to do well in most of this state. It is most palatable in the early stages of its growth, but when it reaches maturity in some regions it is not grazed readily.

The seed can be harvested with power strippers or small grain combines, threshed with an ordinary small-grain separator, and cleaned with a fanning mill. The seed usually contains mixtures of Big Bluestem, Indian Grass, Switch Grass and Grama. On semi-heavy soils, it is found mixed with more drought resistant species of Grama and Buffalo. These mixtures are desirable to use in re-seeding, because they represent the natural association of grasses which occur in this region. Spring seeding is recommended and the rates are 6 to 8 pounds per acre if planted under nursery conditions, and are to be cultivated between the rows. If drilled or broadcast for a pasture stand, 20 pounds per acre is advisable.

Hoover (17), cites similar work done at the Kansas Experiment Station on plant selection. He states that several of these selections developed "have outstanding merit because of uniformity in habit of growth and abundance of leafy foliage." From my observations it appears that the same results may be obtained from selections at this station, but as stressed in later discussions, it is not desirable to make selections from remote regions. Many of the selections from this region exhibit superior qualities of leafiness and possibly a more vigorous root system to support the excess vegetation.

Seeds of this species were obtained and planted from Texas, Oklahoma, Kansas, Arkansas, Nebraska, and North Dakota. The ratings I have given these stands for desirability is exactly in that order. The Texas strain was better than any of the rest, producing an abundance of forage and covering the ground nicely. Oklahoma ranked second and Kansas and Arkansas strains exhibited similarity in appearance and adaptability. Here again, the southern strains show a decided promise of success over the northern strains.

The height of Little Bluestem from the northern seed was only 3 to 6 inches and the clusters measured only 2 to 3 inches in diameter and less. The southern strains produced forage 3 and 4 feet high with the plant crown often measuring 8 to 10 inches in diameter. The ground covered by the species was again in favor of the southern

strains which often covered the ground 100% as compared to 20% for the northern strains.

Palatability and hay production are not known; however, they were considered to be represented by the forage present when the observations were made. In each case the southern strains were most desirable. None of the stands obtained from seed originating north of Kansas showed evidence of having produced seed, and the yield of the Kansas strain was no doubt very light as compared to those yields from Oklahoma and Texas.

Bouteloua curtipendula

Bouteloua curtipendula, (Michx.) Torr., Side-Oats Grama, is the most widely distributed of all the Gramas, (Hoover, 17), but possibly reaches its highest development in the Rocky Plains region, (Featherly 11), "It is found generally throughout the United States east of the Rocky Mountains." (17)

It affords considerable grazing, and flowers in the summer and fall. The species is a perennial with scaly rootstocks, although it assumes the bunch habit of growth. It is very palatable; however, the stems are not eaten by livestock readily and often remain standing after the leafy foliage has been eaten.

Hoover (17), states that "for seed production, Side-oats Grama is one of the most promising native grasses that have been grown under cultivation in the nurseries, particularly because its upright growth habit facilitates

harvesting." In the nursery yields of 400 pounds per acre of seed have been obtained, and the seed obtained in this manner is of much higher quality than that collected from native stands. The seed from native stands is usually low in viability and often gives less than 20% germination.

The experience obtained from nursery planting by other workers and the observations and results of this experiment indicate that desirable stands may be obtained by bringing this grass into wide use. Seeding is recommended in early spring, and rates of 20 pounds per acre if broadcast or 8 to 12 pounds per acre if drilled in rows suitable for cultivation.

The seed was introduced from Arizona, New Mexico, Texas, Kansas, Nebraska, and North Dakota, and planted alongside the Oklahoma strain.

In this instance, the Oklahoma seed produced a much better stand on the larger plots with New Mexico ranking second. In the two-foot rows, the Arizona strain came to the lead with 100% desirability. (No Arizona seed was planted in the larger plots.) The adaptability of strains to Payne County conditions, as shown by the present condition of the stand after 3 years survival, are in this order: Arizona, Oklahoma New Mexico, Texas, Kansas, Nebraska, and North Dakota. It becomes evident that the farther north we go for our seeds, the less adapted that strain is for local conditions.

Side-oats Grama appears to be one of the grasses from which we could well afford to harvest seed in this

community, as none of the southern strains imported to the region excelled our native strain, except that obtained from Arizona. It will prove interesting to find out more about the Arizona strain.

Side-oats Grama assumes the bunch habit of growth; however, it appears to have a tendency to close in and cover the soil more desirably than the two species afore mentioned, A. furcatus, A. scoparius. No measurements were taken on the diameter of the clusters, because in the desirable stands the ground was thoroughly covered. The stems stood erect to a height of 3 feet, and the leafy clusters attained a height of 18 to 24 inches or more.

As mentioned in the discussion of the other species, the southern strains again were far better than the northern strains, but Oklahoma and Arizona species produced plants of leafy character and heavy stems which were superior.

The desirability of stands of this grass derived from seed of southern and local origin is considered extremely advisable and promises optimum results.

Bouteloua gracilis

The seed of Bouteloua gracilis, (H.B.K.), Lag., Blue Grama, was introduced from New Mexico, Texas, Nebraska, North Dakota, and Kansas. The results of comparative plantings of this species are again in favor of the southern and local strains.

Texas, New Mexico, Kansas, Oklahoma, Nebraska, and North Dakota is the order in which the strains rank for

desirability and adaptability. The Texas and New Mexico strains are very nearly the same and show good stands, while Kansas and Oklahoma are next in line with the Kansas strain slightly more desirable than that of Oklahoma in the first series of plots. This is not the case in the duplicate plots, however, as the Oklahoma strain was much more desirable, and offered a high percentage of forage and ground cover. The duplicate series, however, showed that Texas and New Mexico strains were also desirable. It is unexplainable why the Oklahoma strain did not hold up its rating in the first plot of C3a, but weather and other factors make this difference logical.

The desirable stands of Blue Grama in C3a, C3b, and the two-foot rows indicate that it may be, along with Side-oats Grama, a very desirable grass to harvest seed from in Oklahoma. The stands obtained from Oklahoma seed, except in C3a, as mentioned above, were in every respect very desirable, and no doubt this grass will become very valuable in this county and others.

Featherly (11) states that, "This is one of the most important grasses of the plains. It cures well on the ground and furnishes good winter pasture."

Blue Grama occurs generally throughout the Great Plains, and is often found associated with Buffalo Grass on undisturbed soil. Savage (29) reports that it is best adapted to heavy and semi-heavy soils, but it is found growing on sand and will grow well when seeded there.

In general it is sod forming in habit (Hoover 17); however, this growth characteristic varies with the region in which it is found. In the northern part of the region it is reported to be more inclined to form sod than in the southern region. Savage (29) states that it is the slowest grass in the great plains to thicken by natural re-seeding, and the turfs enlarge very little. The strains of southern and local origin observed at this station however, appear to be sod forming, and have a tendency to spread rather than become taller and assume a more vigorous bunch habit of growth. The stands obtained from Canadian County, Oklahoma, seed produced 100% ground cover and the forage and stems reached a height of 1 to 2 feet.

Blue Grama has a shallow root system, but it is very dense, and it is adapted to a wide variety of soils and climate. In some cases this species has been planted in double six-inch rows spaced thirty inches apart to permit cultivation. Hoover (17) states that, "Under these conditions the seed has been observed to show complete emergence within 48 hours after planting." He also cites an experiment at Lincoln, Nebraska, similar to the one discussed herein. Seed of each species was collected from Oklahoma, Colorado, New Mexico, and Nebraska. The southern strains, he states, "Tend to mature later and to be more vigorous in comparison with those obtained from northern sources."

Field seeding practices vary with the environmental conditions and purpose of the planting. The seed bed needs

to be carefully prepared, firm, and free from weeds. In areas subject to excessive wind it is advisable to seed in stubble or other crop residue. The seeds are very small, and cannot be covered deeply with much success. Good stands have been obtained by seeding broadcast 5 to 8 pounds per acre, and much less if for nursery planting.

Panicum virgatum

Panicum virgatum, L., Switch Grass, gave the same results as the other species cited. The southern strains of the species were much better adapted to Payne County conditions; however, the Oklahoma seed produced superior stands.

The stands obtained from Oklahoma seed were very high, dense, and covered practically all of the ground. In some cases they reached a height of 6 feet and protruded from huge bunches which covered the ground completely. Because of a lack of care and early maturity the forage was very coarse; however, the forage produced by this species in its earlier growth is very palatable and of great value as a pasture. Kansas was next to the Oklahoma strain in adaptability, and Nebraska was next. No seed was obtained for planting from a more southerly origin than Oklahoma. Both Oklahoma and Kansas strains showed signs of producing an abundance of seed.

Switch Grass, as stated by Featherly (11), is found on a variety of soils. It is grazed closely by livestock in the spring, and in many localities it forms an important

constituent of wild prairie hay. It flowers in summer and fall.

Savage (29) states that Switch Grass and Indian Grass occur sparingly on sandy upland, but prefer the lighter sandy bottom land where they receive an excess of moisture. Both species are recommended for use in hay meadows and mixtures on sandy upland. Switch Grass is a perennial characterized by deep and vigorous rootstocks. It is widely distributed throughout the United States, but occurs more generally in the Great Plains region.

The grass plots observed would have made a very acceptable hay crop had it been cut at the proper time, but as a result of maturity the excess foliage is considered very unpalatable, however, it supplies abundant ground cover. The stems and leaves of this species occur in greater abundance than other species observed. The fact that the foliage stands through the winter will make it very desirable for areas subject to excessive wind.

The seed of this species has been collected by various methods, and is generally found occuring in mixture with other taller grasses such as Indian Grass and Big Bluestem. To secure stands of Switch Grass it is recommended to sow 15 to 18 pounds per acre broadcast or drilled. Nursery planting requires only 6 to 8 pounds per acre. (17)

Sorghastrum nutans

Only three strains of Sorghastrum nutans, (L.), Nash. (Andropogon nutans L.), Indian Grass, were studied. This

species was introduced from Arkansas, Texas and Kansas. No seed was planted that was known to be from Oklahoma.

The adaptability of the strains is exactly in the order above mentioned. The Arkansas strain produced a rank thick growing type of forage which covered the ground nicely. Arkansas and Texas strains produced seed; however, those strains obtained from Kansas showed little signs of having done more than survive. The seed from Arkansas and Texas produced a desirable stand of forage which in some cases stood 6 and 7 feet above the ground, and furnished good cover for the soil.

Featherly (11) states that,

> "Sorghastrum nutans is found on prairies and in open woods. It is grazed by all classes of livestock, and often forms a constituent of prairie hay, and flowers in late summer and fall."

Savage (31) states that,

> "Indian grass is a tall palatable, tufted grass sparingly distributed over sand-hill pastures in the southern Plains, but it seldom occurs in pure stands except on fairly moist bottom land. Cattle relish this grass so much that they have nearly eliminated it, except in the protection of rank-growing shrubs. The large tawny-haired seeds are easily broadcast but difficult to drill, except with special mechanism. The prompt germination and strong seedling vigor of this species are noticeably helpful in establishing stands. This grass continues active growth later in the fall than the Bluestems and other closely related species but is equally slow in renewing growth in the spring."

Buchloe dactyloides

In contrast to the tall bunch grasses previously discussed, four plots of Buchloe dactyloides (Nutt.) Engelm. (Bulbilus dactyloides Raf.), Buffalo Grass, were observed.

These plots were established by sodding the area in checks. The size of the squares of sod and measurements used in checking the sod are not known. The sod was taken from Alfalfa and Payne Counties and in each instance produced a desirable and thick stand of low growing forage which covers the ground. This species is a short grass; however, since it is one of the major pasture plants of the Plains Region, it is extremely desirable to conduct much research toward increasing this species.

Gernert (13) states in his article on variation of Buffalo Grass, that the seed or caryopsis-bearing spikelet is borne so close to the ground that it is not practicable to harvest it as yet, because no method has been proved applicable. Therefore, the standard method of establishing this species to give the most desirable results is that of sodding. Some seeds have been collected by hand and by using a vacuum method, however, the latter is not perfected and hand picking is a slow and tedious job. Of the seed collected he reports as high as 86% was infected with fungi such as Cer cospora, Helminthosporium and Ustilago. Of the remaining seed only a small percent were found to be viable.

In 1935, he found some rank growing female plants in the Arbuckle Mountains of southern Oklahoma. These plants displayed an elevated spikelet, and appeared to be capable of producing seed that could be harvested with a farm mower. Several rooted runners were propagated, and produced an abundance of dense forage through two drought years. Two

clippings taken from the plots produced in air dry hay, per acre, the following yields-

First clipping	August 8, 1936	3.08 tons per acre
Aftermath	November 2, 1936	2.40 tons per acre
	Total one season	5.48 tons per acre

This plot was composed of all pistillate grass; however, he reports that a plot of staminate grass of this strain could be expected to produce greater returns. The pistillate spikelets shatter easily after maturity; therefore, its chief value is in forage production.

Buffalo Grass occurs on dry tight lands; however, it has a wide range of soil and climatic adaptations. If Big and Little Bluestem and the taller pasture grasses are overgrazed and the stands become thin, Buffalo Grass will replace it. However, in sandy land, or in ravines and bottom land where moisture may occur in excess, the Buffalo Grass will not appear, but weeds and less desirable grasses will take its place. It is considered one of the most drought resistant species, and much unlike Bermuda, another stoloniferous grass used as pasture in some areas, it is easily subdued by shallow cultivation, and it never becomes a weed.

Another interesting fact presented by Gernert (13), is the type of plant which becomes infested with nematodes, and is often mistakenly recognized as another grass by exports. The grass under these circumstances is very short and

dwarfed, and produces pistillate spikes on prostrate surface runners with no elevated stems. This has not been observed by the author of this thesis, but it is deemed a very interesting study for workers who may consider looking further into the problem.

TABLE 13

SOURCE OF SEED AND DESIRABILITY OF GRASS STAND

Location in Nursery	Species	Source of Seed	Harvested	Planted	Estimated on 100% Basis		
					Forage	Ground Cover	Desirability of Stand
C3a1	Andropogon furcatus	Logan Co., Okla.	1935	6/3/38	60%	70%	65%
C3a2	Andropogon furcatus	Holt Co., Nebraska	1937	"	40%	40%	40%
C3a3	Andropogon furcatus	Cannonball, N. Dak.	1937	"	15%	15%	15%
C3a4	Andropogon furcatus	San Antonio, Texas	?	"	90%	90%	90%
C3a5	Andropogon furcatus	Anderson Co., Kansas	1937	"	50%	50%	50%
C3a7	Andropogon scoparius	McCurtain Co., Okla.	1937	"	80%	80%	80%
C3a8	Andropogon scoparius	Amarillo, Texas	?	"	70%	70%	70%
C3a9	Andropogon scoparius	Collected in Texas	1936	"	70%	65%	65%
C3a10	Andropogon scoparius	Holt Co., Nebraska	1937	"	30%	30%	30%
C3a11	Andropogon scoparius	Tower, N. Dakota	1937	"	20%	20%	20%
C3a12	Andropogon scoparius	San Antonio, Texas	?	"	100%	100%	100%
C3a13	Andropogon scoparius	Aldous Sel., Kansas	1937	"	70%	70%	70%
C3a14	Bouteloua curtipendula	Canadian Co., Okla.	1936	"	80%	70%	75%
C3a15	Bouteloua curtipendula	Vaughn, N. Mexico	1936	"	70%	70%	70%
C3a16	Bouteloua curtipendula	San Antonio, Texas	?	"	60%	70%	65%
C3a17	Bouteloua curtipendula	Columbus, Nebraska	1937	"	30%	30%	30%
C3a18	Bouteloua curtipendula	Cannonball, N. Dak.	1937	"	10%	10%	10%
C3a19	Bouteloua curtipendula	Saline Co., Kansas	1937	"	20%	20%	20%
C3a20	Bouteloua gracilis	Canadian Co., Okla.	1937	"	50%	50%	50%
C3a21	Bouteloua gracilis	Mosquero, N. Mexico	1936	"	60%	60%	60%
C3a22	Bouteloua gracilis	Lovington, N. Mexico	1937	"	70%	70%	70%
C3a23	Bouteloua gracilis	Amarillo, Texas	?	"	60%	60%	60%
C3a24	Bouteloua gracilis	Holt Co., Nebraska	1937	"	30%	20%	25%
C3a25	Bouteloua gracilis	Center, N. Dakota	1937	"	10%	10%	10%
C3a26	Bouteloua gracilis	San Antonio, Texas	?	"	70%	70%	70%
C3a27	Bouteloua gracilis	McPherson Co., Kan.	1937	"	60%	65%	65%
C3a28	Panicum virgatum	Canadian Co., Okla.	1937	"	80%	80%	80%
C3a29	Panicum virgatum	Holt Co., Nebraska	1937	"	30%	30%	30%
C3a30	Panicum virgatum	Manhattan, Kansas	1937	"	40%	50%	45%

TABLE 14

SOURCE OF SEED AND DESIRABILITY OF GRASS STAND

Duplicate series of species in table 13 planted in adjacent plots

Location in Nursery	Species	Source of Seed	Date Harvested	Date Planted	Estimated on 100% Basis		
					Forage	Ground Cover	Desirability of Stand
C3b18	Andropogon furcatus	Logan Co., Okla.	1935	6/3/38	80%	70%	75%
C3b19	Andropogon furcatus	Holt Co., Nebraska	1937	"	20%	20%	20%
C3b20	Andropogon furcatus	Cannonball, N. Dak.	1937	"	20%	20%	20%
C3b21	Andropogon furcatus	San Antonio, Texas	?	"	90%	90%	90%
C3b22	Andropogon furcatus	Anderson Co., Kansas	1937	"	60%	60%	60%
C3b24	Andropogon scoparius	McCurtain Co., Okla.	1937	"	30%	30%	30%
C3b25	Andropogon scoparius	Amarillo, Texas	?	"	40%	40%	40%
C3b26	Andropogon scoparius	Collected in Texas	1936	"	35%	35%	35%
C3b27	Andropogon scoparius	Holt Co., Nebraska	1937	"	15%	15%	15%
C3b28	Andropogon scoparius	Tower, N. Dakota	1937	"	10%	10%	10%
C3b29	Andropogon scoparius	San Antonio, Texas	?	"	70%	70%	70%
C3b30	Andropogon scoparius	Aldous Sel., K.S.C.	1937	"	60%	50%	55%
C3b1	Bouteloua curtipendula	Canadian Co., Okla.	1936	"	70%	65%	65%
C3b2	Bouteloua curtipendula	Vaughn, N. Mexico	1936	"	80%	80%	80%
C3b3	Bouteloua curtipendula	San Antonio, Texas	?	"	40%	40%	40%
C3b4	Bouteloua curtipendula	Columbus, Nebraska	1937	"	30%	30%	30%
C3b5	Bouteloua curtipendula	Cannonball, N. Dak.	1937	"	20%	20%	20%
C3b6	Bouteloua curtipendula	Saline Co., Kansas	1937	"	70%	70%	70%
C3b7	Bouteloua gracilis	Canadian Co., Okla.	1937	"	80%	80%	80%
C3b8	Bouteloua gracilis	Mosquero, N. Mexico	1936	"	40%	30%	35%
C3b9	Bouteloua gracilis	Lovington, N. Mex.	1937	"	70%	70%	70%
C3b10	Bouteloua gracilis	Amarillo, Texas	?	"	60%	60%	60%
C3b11	Bouteloua gracilis	Holt Co., Nebraska	1937	"	20%	20%	20%
C3b12	Bouteloua gracilis	Center, N. Dak.	1937	"	20%	20%	20%
C3b13	Bouteloua gracilis	San Antonio, Texas	?	"	70%	70%	70%
C3b14	Bouteloua gracilis	McPherson Co., Kan.	1937	"	70%	70%	70%
C3b15	Panicum virgatum	Canadian Co., Okla.	1937	"	100%	100%	100%
C3b16	Panicum virgatum	Holt Co., Nebraska	1937	"	50%	50%	50%
C3b17	Panicum virgatum	Manhattan, Kansas	1937	"	65%	65%	65%

TABLE 15
SOURCE OF SEED AND DESIRABILITY OF GRASS STAND
Seeded in two foot rows

Location in Nursery	Species	Source of Seed	Date Harvested	Date Planted	Estimated on 100% Basis		
					Forage	Ground Cover	Desirability of Stand
C4a47	Panicum virgatum	Vernon, Texas	1935	1935	70%	80%	75%
C4a49	Panicum virgatum	Ft. Smith, Ark.	1935	1935	50%	50%	50%
C4a50	Panicum virgatum	Savannah, Okla.	1935	1935	50%	50%	50%
C4a59	Sorghastrum nutans	Liberal, Kansas	1935	1935	20%	20%	20%
C4a60	Sorghastrum nutans	Temple, Texas	1935	1935	60%	40%	50%
C4a61	Sorghastrum nutans	Ft. Smith, Ark.	1935	1935	70%	70%	70%
C4a79	Andropogon furcatus	Payne Co., Okla.	"	"	90%	90%	90%
C4a80	Andropogon furcatus	Garden City, Kansas	"	"	60%	60%	60%
C4a81	Andropogon furcatus	Pittsburg Co., Okla.	"	"	20%	20%	20%
C4a82	Andropogon furcatus	Pittsburg Co., Okla.	"	"	20%	20%	20%
C4a83	Andropogon furcatus	Henrietta, Oklahoma	"	"	40%	40%	40%
C4e70	Andropogon furcatus	Mayes Co., Oklahoma	1937	4/30/38	100%	100%	100%
C4e71	Andropogon furcatus	Anderson Co., Kansas	1937	"	40%	40%	40%
C4e72	Andropogon furcatus	Maxwell, Nebraska	1937	"	30%	20%	25%
C4e73	Andropogon furcatus	O'Neil, Nebraska	"	"	30%	30%	30%
C4e74	Andropogon furcatus	Ravaina, Nebraska	"	"	30%	30%	30%
C4e75	Andropogon furcatus	Columbus, Nebraska	"	"	00	00	00
C4a86	Andropogon scoparius	Garden City, Kansas	1935	1935	60%	60%	60%
C4a87	Andropogon scoparius	Liberal Kansas	"	"	40%	40%	40%
C4a88	Andropogon scoparius	Wilbarger, Texas	"	"	80%	80%	80%
C4a93	Andropogon scoparius	Dardanelle, Ark.	"	"	60%	60%	60%
C4a95	Andropogon scoparius	San Antonio, Texas	"	"	80%	80%	80%
C4e78	Andropogon scoparius	Cherokee Co., Texas	1937	5/13/38	100%	100%	100%
C4e79	Andropogon scoparius	Wilberger Co., Texas	"	"	100%	100%	100%
C4e80	Andropogon scoparius	Carmen, Texas	?	4/30/38	100%	100%	100%
C4e81	Andropogon scoparius	Fayetteville, Texas	?	"	100%	100%	100%
C4e82	Andropogon scoparius	LaWard, Texas	?	"	100%	100%	100%

TABLE 16
SOURCE OF SEED AND DESIRABILITY OF GRASS STAND
Seeded in two foot rows (cont.)

Location in Nursery	Species	Source of Seed	Date Harvested	Date Planted	Estimated on 100% Basis		
					Forage	Ground Cover	Desirability of Stand
C4e83	Andropogon scoparius	Logan Co., Okla.	1937	4/30/38	100%	100%	100%
C4e84	Andropogon scoparius	Pittsburg Co., Okla.	"	"	80%	80%	80%
C4e85	Andropogon scoparius	Mayes Co., Oklahoma	"	"	80%	80%	80%
C4e86	Andropogon scoparius	Okmulgee Co., Okla.	"	"	90%	90%	90%
C4e87	Andropogon scoparius	McClain Co., Okla.	"	"	90%	90%	90%
C4e42 to C4e44	Andropogon scoparius	McCurtain Co., Okla.	1937	9/2/38	70%	70%	70%
C4e88	Andropogon scoparius	McCurtain Co., Okla.	"	1937	90%	90%	90%
C4e89	Andropogon scoparius	Garvin Co., Oklahoma	"	"	100%	100%	100%
C4e91	Andropogon scoparius	Anderson Co., Kansas	"	"	60%	60%	60%
C4e92	Andropogon scoparius	Manhattan, Kansas	"	"	70%	70%	70%
C4e93	Andropogon scoparius	O'Neil, Nebraska	"	"	20%	20%	20%
C4c6	Bouteloua curtipendula	Altoona, Kansas	1935	1935	70%	70%	70%
C4c20	Bouteloua curtipendula	Waynoka, Oklahoma	"	"	70%	70%	70%
C4c21	Bouteloua curtipendula	Whitsett, Texas	"	"	100%	100%	100%
C4d29	Bouteloua curtipendula	Alva, Oklahoma	"	"	90%	90%	90%
C4e96	Bouteloua curtipendula	Bexar Co., Texas	1937	4/30/38	80%	80%	80%
C4e97	Bouteloua curtipendula	Bexar Co., Texas	"	"	90%	90%	90%
C4e98	Bouteloua curtipendula	O'Neil, Nebraska	"	"	30%	30%	30%
C4e99	Bouteloua curtipendula	Saline Co., Kansas	"	"	50%	50%	50%
C4e100	Bouteloua curtipendula	Platt Co., Nebraska	"	"	40%	40%	40%
C4e101	Bouteloua curtipendula	Tucson, Arizona	?	?	100%	100%	100%
C4e102	Bouteloua curtipendula	Deaf Smigh Co., Texas	?	?	80%	80%	80%
C4c22	Bouteloua gracilis	Dalhart, Texas	1935	1935	50%	60%	50%
C4d36	Bouteloua gracilis	Las Vegas, N. Mexico	1935	1935	10%	10%	10%
C4e48	Bouteloua gracilis	Canadian Co., Okla.	1937	9/2/38	100%	100%	100%

TABLE 17

BUFFALO GRASS
SOURCE OF SOD AND DESIRABILITY OF GRASS STAND

Location in Nursery	Species	Source of Seed	Date Harvested	Date Planted	Estimated on 100% Basis		
					Forage	Ground Cover	Desirability of Stand
C7a12	Buchloe dactyloides	Alfalfa Co., Okla.	1935	4/13/37	100%	100%	100%
C7a13	Buchloe dactyloides	Payne Co., Oklahoma	"	"	100%	100%	100%
C7a14	Buchloe dactyloides	Payne Co., Oklahoma	"	"	100%	100%	100%
C7a15	Buchloe dactyloides	Payne Co., Oklahoma	"	"	100%	100%	100%

PICTORIAL STUDY

PLATE I

Big Bluestem stands obtained with seed from San Antonio, Texas, (Left) and Anderson Co., Kansas, (Right). The plots pictured here are C3a4 and C3a5 from Left to Right. It is interesting to note the height of forage produced by the southern strain as compared to the short growth of the northern strain.

PLATE II

Little Bluestem plots C3a10, C3a11, and C3a12 are pictured from Left to Right. The seed was obtained from Holt Co., Nebraska, Tower, North Dakota, and San Antonio, Texas, respectively. Plots of Blue Grama can be seen in the foreground. The Bluestem plots begin where the yard-stick is standing.

PLATE III

Little Bluestem plots C3a9 and C3a10 are pictured from Left to Right. The seed was obtained from Texas and Nebraska. The percentage of ground cover, afforded by the two strains, is clearly seen in this picture. The Texas strain is much more desirable in this respect.

PLATE IV

Side-oats Grama plots C3a18, C3a17, and C3a16 are pictured from Left to Right. The seed was obtained from Cannonball, North Dakota, Columbus, Nebraska, and San Antonio, Texas. The height of forage and percentage of ground cover are both represented in the picture. The southern strain produced a very desirable stand in every respect.

PLATE V

The poor growth and small percentage of ground cover produced by northern strains is readily seen in this picture. Left to Right are plots C3a17 and C3a18. The stands were obtained with seed from Columbus, Nebraska, and Cannonball, N. Dakota. (Left to right)

PLATE VI

Three plots of Blue Grama pictured from Left to Right are C3b10 from Amarillo, Texas; C3b11 from Holt Co., Nebraska; and C3b12 from Center, North Dakota. The southern strain produced forage 12 to 14 inches high which furnished very desirable ground cover.

PLATE VII

Thickness of stand and percentage of ground cover produced by Blue Grama is shown in this picture. Plots C3b10 and C3b11, obtained with seed from Texas and Nebraska are pictured from Left to Right.

PLATE VIII

Switch Grass plots C3b16 and C3b15 are pictured from Left to Right. The stand pictured on the left was obtained with seed from Holt Co., Nebraska, while that on the right was obtained with seed from Canadian Co., Oklahoma.

PLATE IX

Indian Grass obtained by planting seed of local origin. As shown by this picture, the species is found growing 5 and 6 feet high.

PLATE X

Buffalo Grass plots C7a13 and C7a12 are pictured from Left to Right. The sod used in establishing these plots was obtained from Payne and Alfalfa counties, Oklahoma, respectively. Both plots illustrate the desirability of this grass in affording ground cover and producing a dense and palatable forage.

DISCUSSION

From the observations, discussed in the preceding paragraphs, of native grass seeded with seed from New Mexico, Texas, Oklahoma, Arkansas, Arizona, Kansas, Nebraska, and North Dakota, we see readily that the local strains are more productive and desirable as a pasture stand, and the northern strains do not so much as flower or produce seed in most cases. The stands obtained from southern strains, when planted here, produce rank vegetative growth and seed rather late in the season. The northern strains are considerably dwarfed, produce only slight vegetative growth, and seldom produce seed.

The reasons for this are yet to be definitely established. It is not believed by the author that the plants have an inherent characteristic which is carried in the seed to make them unadaptable to this region. For example, each of the species from remote regions grown in their home environment develop nicely, and present on their home site as desirable and rank a growth as our local strains present when grown here in their home region. The northern strains grown in Oklahoma produce sparce growth as shown in the observations. Likewise, it is reported by McLean, that our local strains planted in Nebraska and North Dakota produced only scant growth while the local strains of that region, grown on their home site, were rank and very desirable. (22)

Since it is not proved that there are inherent characteristics which make these facts true, this behavior

must be attributed to other causes. There is a combination of factors, as shown in the results presented by other workers, to indicate along with my observations, that it is not advisable or practicable to import seed from remote regions. Our knowledge of what has been done with other species of the plant kingdom will indicate that the same results may be expected with species of the gramineae family.

Forest Planting Investigations

Toumey and Korstian (37) have devoted their attention to seeding and planting in the practice of forestry, and their work is therefore centered about trees and not grasses. They report, however, that the underlying fundamental principles of seeding and planting are generally the same, but in each locality the conditions vary so profusely that local conditions must be taken into consideration, and the application of seeding principles varied accordingly.

In their experience with ash and other forest species from remote regions, they report that one cannot expect to practically acclimatize a forest tree. The requirements of trees cannot be expected to be modified appreciably when grown in a new region where conditions are different from those found in their natural habitat. Strains imported from remote regions is done so at the sacrifice of more desirable local strains which are neglected. (20) If a species is removed to a new region from other localities and produces desirable results, as many of the grass species observed have done, it is

not because of acclimatization, but because it experiences conditions which are similar to those of its original habitat.

At the North Dakota Experiment Station, seeds were obtained of Green Ash and planted in the fall of 1934, and survival counts were made in 1935 and 1936. (18) There is a regular reduction in survival, as shown in table 18, as the seed source progressed from North to South. They state that the loss was no doubt due to the inability of the seedlings from southern origin to withstand the cold climate of North Dakota in 1935 and 1936. (3)

TABLE 18

RESULTS OBTAINED WITH GREEN ASH
(After two growing seasons)

State	No. lots of seeds	Total No. of trees	Ave. Survival %
North Dakota	25	294	67
South Dakota	12	532	62
Nebraska	21	913	48
Kansas	8	243	43
Oklahoma	3	132	7

Again it is apparent that some definite factors are adversely effective in transplanting of seed and seedlings, and the seed of local origin will produce stands of considerable advantage.

Grass Planting Investigations

These viewpoints are also shared by Savage and Smith as a result of their study on native grass stands from seed of remote regions when planted in Oklahoma. (29)

Northern strains are reported lower in yield and earlier in maturity than strains from this locality or more southern origin. They state that all local native grass seed may be expected to give better results than seed from other sections. It is believed that northern strains in all probability become more susceptible to the high temperatures and drought of this region. More forage has been obtained by introducing seed from southern origin if weakness such as susceptability to cold and drought can be avoided. (17,29) The strain moved too far north may not produce seed before frost, because of its late maturity, and in the experiment at the Nebraska station, similar to the one discussed herein, this was found to be true.

Effect of Climate and Soil on Mineral Composition of Grasses

Daniel has studied certain factors which affect the mineral composition of prairie grasses.(8) It is his belief that grass plants are higher in calcium and phosphorus when grown on fertile soil; however, the data indicates that the kind of plant grown has more effect on the amount of mineral present than climate or soil.

Since the same species of grasses, in this case, are grown in each region from which the seeds were obtained for this experiment, it is again logical to believe that climate and soil have little effect on the results obtained. The fertility of the soil is an important factor, however, which limits the rapid development of the climax grasses.(15)

The mineral composition of several native grass species, collected in Oklahoma, is found on the following page.

TABLE 19

THE AVERAGE COMPOSITION OF SOME COMMON OKLAHOMA GRASSES (15)

Scientific name	Common Name	No. Samples	Average Composition in % N	P	Ca
Aristida oligantha	Triple Awned Grass	5	.605	.059	.189
Andropogon furcatus	Big Bluestem	26	.515	.086	.276
Andropogon scoparius	Little Bluestem	43	.614	.072	.269
Andropogon torreanus	Silver Beard Grass	2	.718	.100	.328
Buchloe dactyloides	Buffalo Grass	14	.987	.126	.339
Bouteloua gracilis	Grama Grass	8	.933	.108	.314
Cynodan dactylon	Bermuda Grass	14	1.294	.179	.659
Paspalum dilatatum	Dallis Grass	4	1.109	.137	.186
Sorghastrum nutans	Indian Grass	6	.827	.085	.291
Syntherisma sanguinalis	Crab Grass	5	1.460	.190	.353
	Average all		.893	.119	.319

The influence of rainfall on the composition of grasses is cited by Murphy and Daniel, who believe that high rainfall is associated with low calcium and high phosphorus content in the forage, and that low rainfall produces a greater amount of calcium and a lesser amount of phosphorus. (24) The short grasses are reported richer in calcium and contain one-half again as much protein and phosphorus as the tall grasses. Soil composition, as it has been stated, has some affect on the mineral content of the forage, but the ability of the plant to remove the nutrients from the soil varies. Weeds, for example, are often heavier feeders than our native grass. The grasses discussed here evidently require very little available plant food nutrients (9), since much of the soils on which they occur contain as little or less than 10 p.p.m. of easily soluable phosphorus, are low in exchangeable calcium, and are slightly to strongly acid. (15, 24)

Therefore, it is logical to conclude that the variations in stands obtained in this experiment were not wholly a result of soil or climate.

Site Factor Studies

Bates and Pierce (3), in disucssing forestation, state that,

> "The site factors which have a more or less direct bearing upon forest vegetation are so numerous and so intimately related and complex that precise methods of study are very difficult. In accordance with their nature they relate to the atmosphere, to the soil, and to plant and animal life. The atmospheric factors which influence forest vegetation are temperature,

> light, humidity, precipitation, and to a lesser extent wind, lightning, and atmospheric impurities. The soil factors are water content, soil composition, soil temperature, soil gases, and indirectly altitude, slope, exposure, and surface. The life factors refer to the plants and animals in every environment which react upon the forest vegetation. There is no habitat which escapes the influence of these factors."

As mentioned before, it is not believed that there is a wide variation of site factors in the regions from which the grass seeds were obtained. (Figures II and III) (2) Therefore, aside from the general affects of these factors, no appreciable difference in the stands can be attributed to them.

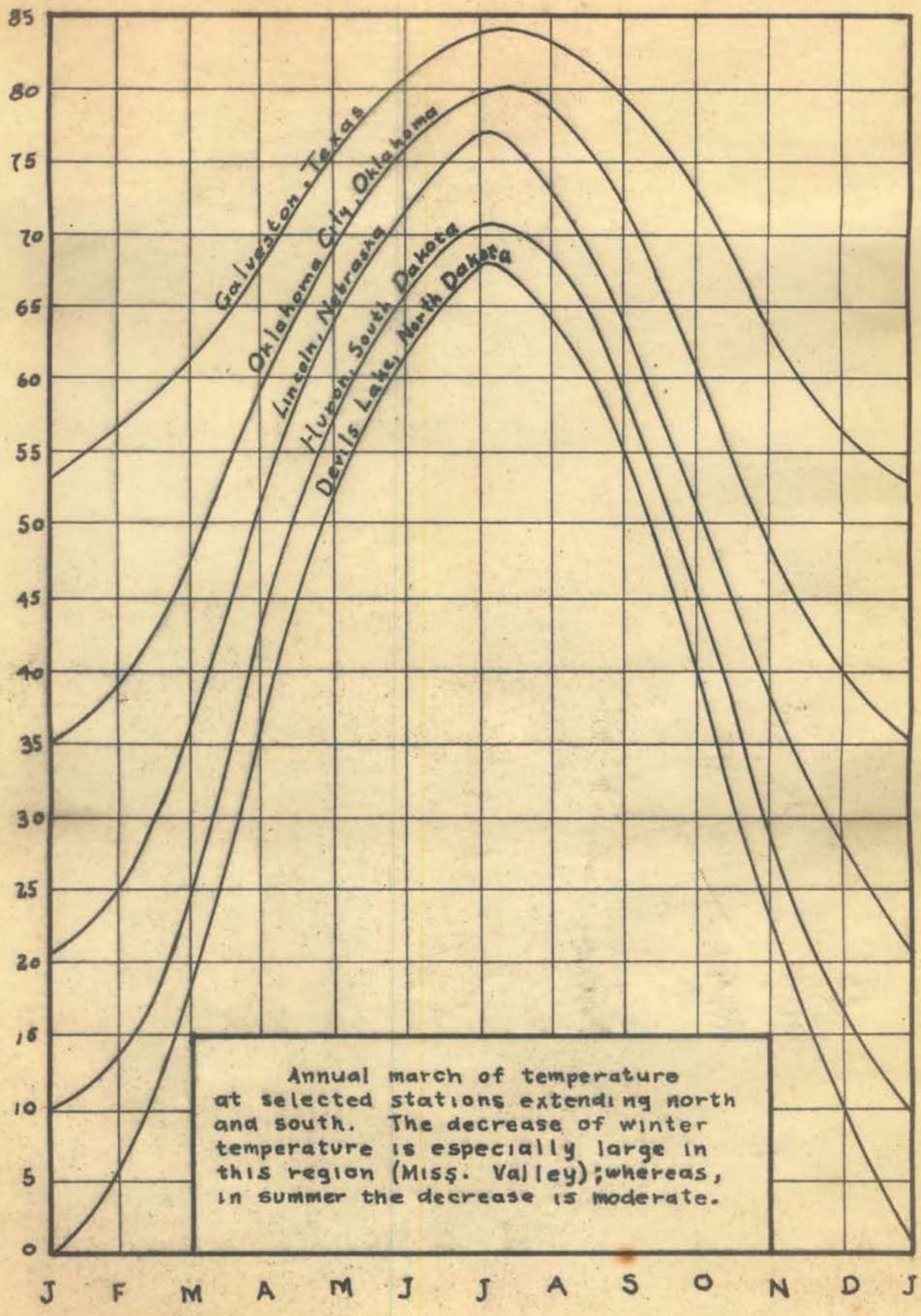
Effect of Length of Day on Plant Growth

In reviewing the above information and observations we find it is not advisable to import strains from remote regions, and those which are imported fail to produce as desirable a stand as local strains. We cannot satisfactorily account for the great difference by claiming that ecological factors produce these effects entirely. Therefore, a very interesting factor which may enter into the field of discussion is the work of Garner and Allard (12) on length of day, and the affect of day length on plant growth.

> "Plants which attain their most successful floriferous expression on an increasing length of day have been termed long-day types of plants. Plants which attain flowering on a decreasing length of day have been termed short-day types."(12)

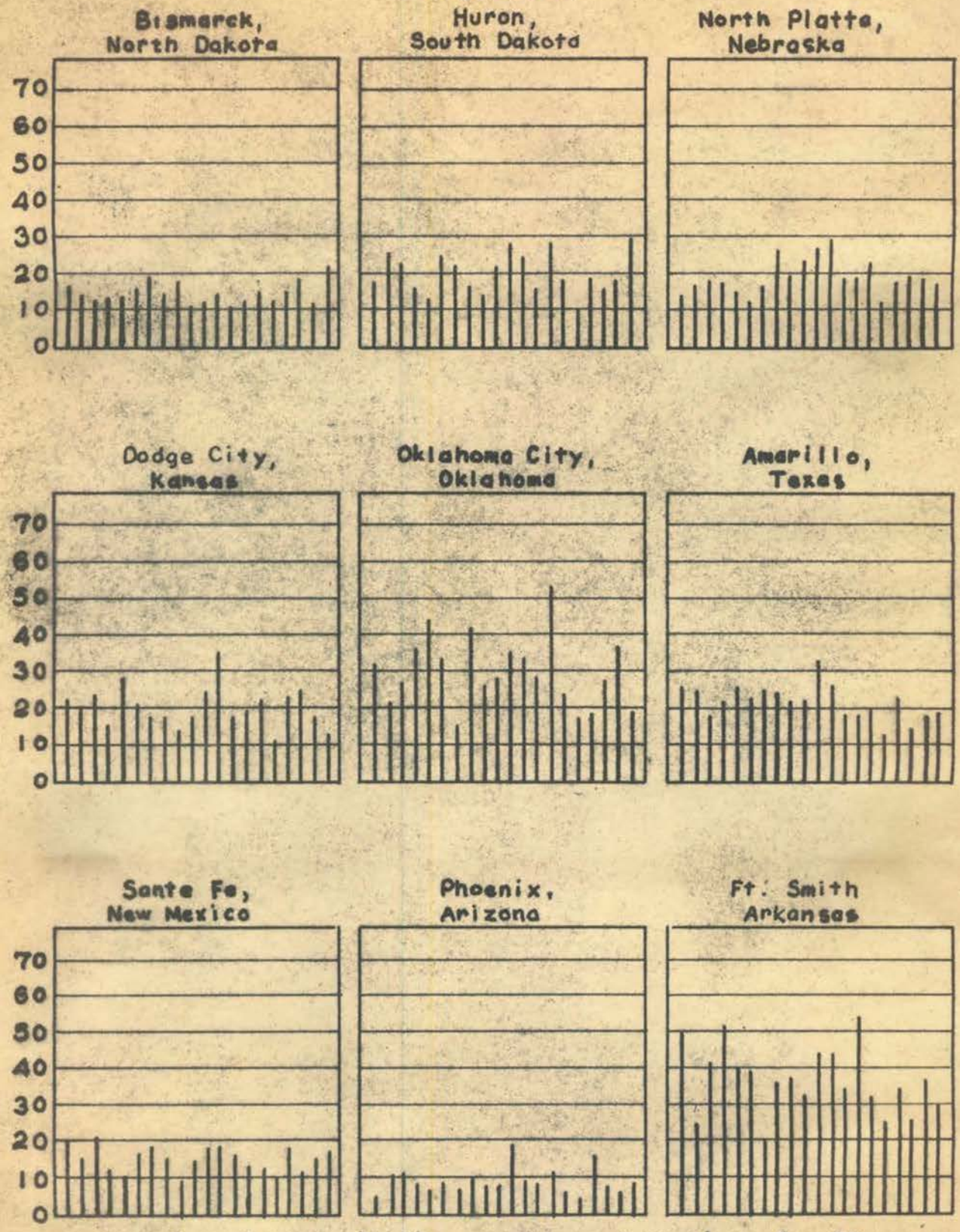
Therefore, the length of day may possibly be a factor which affects the adaptability of these grasses.

Figure II



Annual march of temperature at selected stations extending north and south. The decrease of winter temperature is especially large in this region (Miss. Valley); whereas, in summer the decrease is moderate.

Figure III



Annual precipitation at selected stations for 20 year period, 1895-1914. Each vertical line represents the precipitation for one year.

It is understood without question that the days are longer in regions north of this locality; however, the sun's rays are not so direct. Also, the strains from a more southern origin, when moved to this locality, experience a slightly longer day during the growing season than that of their home site, but the difference in length of day is not so great between Texas and Oklahoma as it is between Oklahoma and North Dakota.

The length of day in each of the regions from which seeds were obtained is given in table 20. (2) An interesting contrast is shown by the variations of winter and summer day length, and the increasing length of day during the growing season as we progress northward from Oklahoma.

The grasses of northern origin, therefore, are to be considered adapted to a long day because, when subjected to the shorter days of Oklahoma they do not flower, or if so, show a less successful floriferous expression. During this time, however, our own local strains were developing satisfactorily. The strains obtained from regions south of this locality, experience a longer day; however, the difference in length of day is only slight. The southern strains flowered nicely and produced a rank vegetative growth, so therefore should be considered as adapted to a short day, because when these plants were moved northward they behaved in the same capacity as northern plants when grown here.

TABLE 20

LENGTH OF DAY

Dec. 22

LOCATION			TIME OF		TOTAL
Lat. &	Long.	State	Sunrise	Sunset	Length of Day
47.5	100-95	N. Dakota	7.46	4.12	8.26
45.0	100-95	S. Dakota	7.36	4.22	8.46
42.5	100-95	Nebraska	7.27	4.31	9.03
40.0	100-95	Kansas	7.19	4.38	9.19
35.0	100-95	Oklahoma	7.05	4.53	9.48
32.5	100-95	Central Texas	6.58	4.59	10.01
27.5	100-95	S. Texas	6.47	5.11	10.24

LENGTH OF DAY

June 21

LOCATION			TIME OF		TOTAL
Lat. &	Long.	State	Sunrise	Sunset	Length of Day
47.5	100-95	N. Dakota	4.02	8.61	16.00
45.0	100-95	S. Dakota	4.13	7.50	15.37
42.5	100-95	Nebraska	4.23	7.40	15.17
40.0	100-95	Kansas	4.31	7.32	15.01
35.0	100-95	Oklahoma	4.46	7.17	14.31
32.5	100-95	Central Texas	4.53	7.10	14.17
27.5	100-95	S. Texas	5.05	6.58	13.53

The experiments performed by Garner and Allard (12) were with Sedum Woodwardi N. E. Br., Sedum spectabile Bor., and wild senna, Cassia marilandica L.

It is found that unfavorable length of day will not only inhibit flowering, but will also keep the plant from flowering as long as the short day is experienced. This appears to be exactly what has happened on the sites where seed from regions having a longer day has been sown. It has been shown, that these plants returned to their home environment resume normal growth in that region.

In studying native grasses, however, it appears that not only the flowering characteristic is affected unfavorably by a shorter day, but the plant also suffers vegetatively. A poor development of vegetative stems, and in some cases death, occurs in the species and strains subjected to a shorter day. The workers afore mentioned found like results with the wild senna and report that,

> "In this particular plant (Wild Senna) the attainment of flowering and seed production is accompanied by rapid and vigorous stem growth, where long days are experienced, resulting in an effecient photosynthesis and an active translocation of reserve material to the underground storage parts to support the next year's growth."(12)

In the grass strains studied it appears to be true that effective photosynthesis does not take place, because of the shorter day to which the northern strains are subjected and, therefore, the reserve material stored in the roots is only enough to maintain life the next season, and the plant does not produce seed or show any evidence of

vigorous growth. This continuous short day, in some cases, has led to abnormal dwarfing and death of the plant, because sufficient reserves have not been accumulated for growth the next season.

In studying these grasses from various sources, it is logical to assume, therefore, that the reason for their poor development is due to the lack of effective photosynthesis which is effected by length of day.

These native grasses, which may spread from their original center of occurance by natural means, or man, are subject to the length of day during the growing season as well as other conditions. The plants discussed herein, with the exception of Buffalo Grass, depend on reseeding or seed production for their distribution. As a result of this characteristic in these species, the plants have gradually become adapted to such change, and eventually have spread from one end of their range to the other without perceptive differences. Therefore, their limits of distribution are affected by summer day length which must be favorable for the production of fertile seed.

These species may survive in any region where day length is not favorable to seed production, providing the length of day does not also affect effecient photosynthesis, and the plant can maintain itself by vegetative methods. This may be the case with the native grasses herein discussed, but they could be expected only to maintain growth and would not furnish desirable forage, ground

cover, pasture, or produce seed. The attainment of these qualities in our grass stands is our ultimate purpose, which can be achieved by wise choice in selection of our seed.

It is advantageous, therefore, in view of the above information, to use seed of local origin entirely. May we do so to solve the present problem.

SUMMARY

The need for a greater extent of grass land is evident, and its merits are understood. It can be and is profitable, and the beneficial effects upon the soil cannot be underestimated for this region.

Many problems are presented when considering establishment of native grass, among which are socio-economic, agronomic, climatic, and geographic. As a result of the diligent work and effort on the part of scientific men, however, these problems are rapidly being solved for the greater part, and great strides in that direction can be made.

Some native grass species were established by the Soil Conservation Service at the Oklahoma Agricultural and Mechanical College Experiment Station in the years 1935, 1936, 1937, and 1938. These species were Big Bluestem, Little Bluestem, Blue Grama, Side-oats Grama, Indian Grass, Switch Grass, Buffalo Grass, and others not discussed at length in this study. Seed and individual plants of these species were obtained from North Dakota, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Arizona, and Arkansas, and sod of Buffalo Grass was obtained from counties of this state. Each strain was planted in a manner prescribed by other workers.

From the observations made of these grass plantings, the practicability of re-establishing native grass by seeding, the effect of source of seed on resulting stand,

and desirability of stand for forage and ground cover can be determined.

It is believed that superior grass stands may be obtained with the progeny of individual plant selections, and some work was done along this line; however, it is not discussed in great detail, as this work is still in progress.

The data summarized and presented in tables 13,14,15, 16, and 17 thoroughly establish the fact that it is practicable to establish native grass in this area by seeding. Excellent stands were obtained from seed of this locality; however, it is pointed out that stands and growth obtained from southern strains were far superior in every respect to those obtained from northern strains. The grass stands steadily decreased in desirability as we went from south to north, from Texas and New Mexico to North Dakota. In most cases, Texas and Oklahoma strains were superior, with Texas qualities for desirability matching those of Oklahoma in most cases.

The desirability of stands and adaptability was evaluated in terms of percent, basing the percentage scores on forage, ground cover, and finally arriving at a score to signify its desirability as a pasture stand for this region. The native grasses obtained from local and southern strains produce desirable stands of forage. They produce excellent ground cover, and may be termed very adaptable to the region, and of great value in occupying the open prairie, once cultivated fields, or lands to be retired from cultivation.

For the benefit of interested parties a list of commercial sources of seed of native grass is presented in table 22, as prepared by the U.S.D.A., and information relative to these seed and recommendations for rates of seeding mixtures is found in tables 23 and 24, as prepared by Savage. (29) It is not my purpose here to make recommendations relative to date of seeding; however, it is my belief that better results can be obtained by spring seeding and in some cases sowing in crop residue or sorghum stubble. Spring plowing and preparation of the seed bed is also recommended by other workers.

The climatic conditions in the area during this experiment are summarized in table 21.

TABLE 21

CLIMATOLOGICAL DATA FOR YEARS 1935-1938 INCLUSIVE (40)
Stillwater, Oklahoma

Year	Ave. Temp.	Total ppt.	Snow-fall	Days Clear	Days Cloudy	Days Partly Cloudy
1935	59.3°	33.59"	3.0"	168	106	91
1936	61.9°	18.29"	1.5"	225	79	62
1937	60.1°	25.49"	5.7"	171	108	86
1938	62.4°	35.29"	12.4"	188	81	96
Ave.	59.4°	33.84"				

The four years on which the grasses have occupied the area present both optimum and adverse weather conditions; however, the soil or climatic conditions show little in-

fluence on actual results, but they are of considerable general importance and do have some relation on the success of establishment and seeding. The soil is chiefly Vernon and Kirkland types, and is typical of the upland region of the county.

The work of others with flowers and forest plantings indicate that it is not advisable to import seed or plants from remote regions, if the new habitat is not greatly like the original home conditions, as they do not become acclimatized. Soil and climate do have their effect, but it is clearly shown that the poor development of plants in the new home or habitat cannot be attributed to this fact alone, although susceptability to hot or cold weather and drought sometimes produces adverse effects.

It is believed by some that length of day is the main factor promoting favorable growth, and this is tenatively acceptable. As a result of the differences in the length of day which occur in North Dakota, Nebraska, Kansas, Oklahoma, and Texas, the seeds imported from these regions carry with them the characteristics of the mother plant. Oklahoma may be considered beyond the range of extremely abnormally long days as experienced farther northward. Therefore, a plant of northern origin planted in Oklahoma is subject to a shorter day. The results of this short day in the new habitat affects the flowering habit and vegetative growth of the species which are discussed.

The short day, experienced by the grasses of the northern origin in their new habitat, does not facilitate

effective photosynthesis so that a sufficient quantity of plant nutrients can be stored in the underground parts of the plant as reserve food to promote seed development, or support substantial growth the following year. Therefore, stands obtained from seed or sod of remote regions may not be expected to produce seed and the vegetative qualities will be most undesirable.

For optimum results to be obtained from seeding, it is advisable to secure seed only of local or southern origin. The stands produced from these strains exhibit an abundance of forage and ground cover, and the goal we should strive to attain by securing the greatest possible desirability as a pasture stand, has then been reached.

ACKNOWLEDGMENTS

It is with deep gratitude that I express my appreciation to Dr. W. B. Gernert and Dr. H. F. Murphy for their suggestions and criticisms in the progress of this thesis. The previous work of others in allied subjects has been of inestimable value. An indebtedness to Mrs. Marie Hatcher and L. G. McLean for their loyal assistance is also gratefully acknowledged.

TABLE 22

UNITED STATES DEPARTMENT OF AGRICULTURE
Division of Forage Crops and Diseases,
Bureau of Plant Industry
and
Nursery Division, Soil Conservation Service
SOUTHERN GREAT PLAINS FIELD STATION
WOODWARD, OKLAHOMA

(No discrimination is intended and no guarantee of reliability is implied)

Common and scientific names and vendors

Blue Grama (Bouteloua gracilis, an excellent short bunch grass, exceedingly drought-resistant, nutritious, palatable; adapted to a wide variety of soils, particularly to heavy and semi-heavy types; responds best to spring seedings)

Barteldes Seed Company, 1521-25 14th St., Denver, Colo.
Burkett, J. H., Clyde, Texas
Chickasha Seed Growers Co., Inc., Chickasha, Okla.
Dowd & Son Seed Co., P. O. Box 743, Amarillo, Texas
Henry Field Seed & Nursery Company, Shenandoah, Iowa
Nall, L. O., Maxwell, New Mexico
Oscar H. Will & Co., Bismarck, North Dakota
Seigler, T. E., Herring Hotel, Amarillo, Texas
The Western Seed Company, 1425 15th St., Denver, Colo.

Buffalo Grass (Buchloe dactyloides, equal in value to Blue Grama, spreads by surface runners; adapted to heavy soils; an excellent pasture and lawn grass, responds best to seeding or resodding in the spring)

Anderson, Andrew; Holdrege, Nebraska
Burkett, J. H., Clyde, Texas
Chickasha Seed Growers Co., Inc., Chickasha, Okla.
Dowd & Son Seed Co., P. O. Box 743, Amarillo, Texas
Henry Field Seed and Nursery Co., Shenandoah, Iowa
Oscar H. Will & Co., Bismarck, North Dakota
Minahan, Miles J., Amelia, Nebraska

Indian Grass (Sorghastrum nutans, a tall meadow grass adapted to sandy and semi-sandy soils. Gives best results when seeded in the spring)

Burkett, J. H., Clyde, Texas
Minahan, Miles J., Amelia, Nebraska

Mixed Bluestems (Andropogon furcatus and scoparius, usually harvested as a mixture of Big and Little Bluestem, Switch Grass, Side-oats Grama, and Indian Grass, although some vendors have pure seed of Big or Little Bluestem. These sources are mainly adapted to the eastern part of the region. Should be sown in the spring)

Archer, Ed; Route 1, Meridian, Oklahoma
Braman, Maurice M., Rosalia, Kansas
Burkett, J. H., Clyde, Texas
Chaney, James; Delia, Kansas
Chickasha Seed Growers Co., Inc., Chickasha, Okla.
Clarke, R. H., Route 1, Towanda, Kansas
Dixon, Frank; Dexter, Kansas
Douglas, O. W., Route 1, Meridian, Oklahoma
Feyh, August; Route 2, Alma, Kansas
Henry Field Seed and Nursery Co., Shenandoah, Iowa
Minahan, Miles J., Amelia, Nebraska
Otis, Forest; Cannon Ball, North Dakota
Ottawa Hardware Co., Ottawa, Kansas
Peppard Seed Co., Kansas City, Missouri
Prell, Fred A., Bremen, Kansas
Puckett, G., Whitewater, Kansas
Rea, John; Williamsburg, Kansas
Stout, E. D., Route 5, Emporia, Kansas
Witherspoon, E. P., 3514 Genesee St., Kansas City, Mo.

Side-oats Grama (Bouteloua curtipendula, a palatable, nutritious, medium-tall grass, valuable in pure stands or in mixtures with Blue Grama; mainly restricted to sandy, rocky soils in western part of region, but suitable on heavier soils farther east; should be seeded in the spring)

Archer, Ed; Route 1, Meridian, Oklahoma
Badger, R. J., Mankato, Kansas
Douglas, O. W., Route 1, Meridian, Oklahoma
Feyh, August; Route 2, Alma, Kansas
Fisher, John; Bazaar, Kansas
Henry Field Seed & Nursery Co., Shenandoah, Iowa
Luff, Earl T., Lincoln Steel Works, Lincoln, Nebraska
Otis, Forest; Cannon Ball, North Dakota

Switch Grass (Panicum virgatum, a tall meadow grass on sandy bottom land and suitable for use in mixtures with other grasses on sandy upland. Spring is optimum season for seeding)

Borchardt, A. F., Route 2, Woodward, Oklahoma
Hilts, D. J., Anthony, Kansas
Minahan, Miles J., Amelia, Nebraska

TABLE 23

AVERAGE QUALITY OF SEED OF IMPORTANT NATIVE AND INTRODUCED GRASSES, AND SUGGESTED RANGE IN RATE OF SEEDING PURE STANDS, SHOWING NUMBER OF GERMINATIVE SEEDS APPLIED PER SQUARE FOOT AT DIFFERENT RATES, IN COMPARISON WITH A WELL-KNOWN CROP (Alfalfa). (29)

SPECIES		Usual seed condition	Pure seed per lb. of bulk material	Purity of bulk	Germination of pure seed	Suggested rate of bulk seed per acre	Germinative seeds per square foot	
Common name	Scientific name						At 1 lb. bulk seed per acre	At suggested rates
			No.	%	%	Lbs.	No.	No.
Western wheatgrass	Agropyron smithii	Chaffy	86,638	66.8	69.8	5 to 11	1.238	11 to 15
Sand bluestem	Andropogon hallii	Thrashy	19,232	25.3	66.6	30 to 40	.294	3 to 12
Little bluestem	Andropogon scoparius	Thrashy	42,635	20.7	61.1	30 to 40	.538	18 to 24
Side-oats grama	Bouteloua curtipendula	Chaffy	70,134**	22.7	47.0	20 to 30	.757**	15 to 23**
Black grama	Bouteloua eriopoda	Recleaned*	562,345	40.4	53.2	7 to 9	6.868	48 to 62
Blue grama	Bouteloua gracilis	Chaffy	277,456	32.8	74.4	9 to 12	4.739	43 to 57
Hairy grama	Bouteloua hirsuta	Chaffy	258,366	30.5	62.0	12 to 16	3.685	44 to 59
Buffalo grass	Buchloe dactyloides	Clean burs	35,845**	55.9	35.0	5 to 10	.280**	1 to 3**
Giant redgrass	Calamovilfa gigantea	Clean	81,590	84.5	55.0	15 to 20	1.030	15 to 21
Canada wild-rye	Elymus canadensis	Chaffy	88,452	78.9	85.0	12 to 16	1.726	21 to 28
Weeping lovegrass	Eragrostis curvula	No hulls	1,436,613	91.2	84.9	1/8 to ¼	28.000	4 to 7
Sand lovegrass	Eragrostis trichodes	No hulls	1,833,160	95.2	75.0	1 to 2	31.563	32 to 63
Galleta	Hilaria jamesii	Very chaffy	91,907**	16.0	46.0	25 to 30	.971**	24 to 29**
Vine-mesquite	Panicum obtusum	Clean	122,445	35.6	43.0	5 to 10	1.209	6 to 12
Switch grass	Panicum virgatum	Clean	503,385	80.7	71.6	3 to 5	8.274	25 to 41
Sand paspalum	Paspalum stramineum	Clean	427,030	74.0	20.0	20 to 25	1.961	39 to 49
Blowout grass	Redfieldia flexuosa	Clean		50.0	75.0	15 to 20		
Plains bristlegrass	Setaria macrostachya	Clean	283,561	48.4	27.8	10 to 15	1.342	13 to 20
Indian grass	Sorghastrum nutans	Chaffy	116,149	79.0	83.0	12 to 20	2.213	27 to 44
Sand dropseed	Sporobolus cryptandrus	No hulls	4,249,690	90.1	90.3	½	88.096	44

*Black grama usually very trashy unless thoroughly recleaned.
**No. of burs, seed cluster, or racemes, each usually containing 1 or 2 seeds.

TABLE 24

SUGGESTED GRASS MIXTURES AND RATES OF SEEDING FOR DIFFERENT SOIL CONDITIONS. (29)

Mixtures on different soils	Rate of bulk seed per acre		
	Commercially available seed	Alternative suggestions when other grasses become available	
		First	Second
	Pounds	Pounds	Pounds
Summer grasses on heavy or semi-heavy upland soils:			
Blue grama	10	9	6
Side-oats grama	5	4	3
Buffalo grass		2	2
Galleta		5	5
Weeping lovegrass			1/8
Black grama	—	—	7
Total	15	20	23 1/8
Summer grasses on sandy or semi-sandy upland soils:			
Blue grama	6	5	3
Side-oats grama	9	8	7
Sand bluestem or sand paspalum		5	5
Sand lovegrass		1/8	1/8
Weeping lovegrass		1/8	1/8
Hairy grama or plains bristlegrass	—	—	3
Total	15	18¼	18¼
Summer grasses on active sand dunes and blowouts:			
Giant reedgrass		5	5
Sand lovegrass		1	1
Sand bluestem		30	25
Blowout grass	—	—	3
Total		36	34
Summer grasses on bottom land:			
Switch grass	2	3	2
Side-oats grama	6	6	6
Indian grass	4	—	4
Total	12	9	12
Winter grasses on bottom land:			
Western wheatgrass	10	5	5
Canada wild-rye	—	5	5
Total	10	10	10

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