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Suitability of South Dakota Locations for Straw Pulping Plants

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SUITABILITY OF SOUTH DAKOTA LOCATIONS FOR STRAW PULPING PLANTS

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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CHAPTER I

INTRODUCTION

An improved pulping process has been developed by the USDA which uses straw as the basic ingredient in the production of boxboard and corrugating paper. 1/ If a plant or plants using this pulping process could be built in the state, a use would have been found for a product produced by farmers that has very limited commercial value to them at present.

The Northern Utilization Research Branch of the Agricultural Research Service, U. S. Department of Agriculture, has selected the Experiment Station of South Dakota State College to undertake a research contract to determine availability of surplus wheat, rye, and flax straw in South Dakota for industrial utilization. This is a very timely study in South Dakota where the dominant industry is agriculture and a need has been felt for the "balancing of agriculture with industry" and especially in view of the recent industrial conference at Huron, April 13 and 14, 1955, which launched a program to encourage all industrial development in South Dakota.

Purpose of the Study

The purpose of this study is to determine whether any area or areas in the state have all the necessary requirements for the operation

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1/ Atchison, Joseph E., The Mechano-Chemical (M-C) Process Gives New Impetus to Production of Pulp From Straw, Bagasse and Other Vegetable Fibers, a report reprinted from "Paper Trade Journal", August 13, 1954.

of a plant. From experience with the Peoria laboratory, it was found that the following information would be needed. More discussion of these aspects will be taken up in later chapters.

1. The harvested acreage of wheat, rye, and flax by counties.

2. The amount of surplus straw by counties.

3. The present off-farm use of surplus straw by counties.

4. The area or areas in which it is possible to collect 50,000 tons of straw per year in an area having a radius of approximately 50 miles as local conditions warrant. In this connection it is necessary to determine:

   a. Crop practice prevalent in these areas that have a bearing on the utilization of the straw, including the yield and quality of the straw.

   b. Areas affected by extensive rust, weeds, and similar contaminants, and their severity.

   c. Amounts of actual surplus straw not needed on the farm or for soil fertility purposes.

   d. History of wheat production showing how frequently crop failures or other factors affect the quality and availability of straw.

   e. Estimates of maximum and minimum quantities of straw available for industrial use over a period of years, representing at least one normal cycle of maximum and minimum production.

   f. Value of straw for purposes of soil fertility.

5. For any areas in which approximately 50,000 tons of straw can be collected and baled for industrial utilization, information must be obtained on the additional requirements for location of a hypothetical paper mill producing 70 tons a day of board (boxboard or insulating board) or 59 tons per day bleached paper or straw pulp. This requirement includes the following:

   a. Water requirement of approximately 3,000,000 gallons per day.

b. Provisions for disposal of mill effluents: 300,000 gallons per day alkaline cooking liquors, highbiological oxygen demand (BOD) and about 2,000,000 gallons of water containing spent bleach liquors and some filler.

(1) Ponding.

(2) Sewage disposal facilities.

c. Electric power required; for example, 25,000 kilowatt hours per day.

d. Fuel for steam.

(1) Coal availability.

(2) Gas availability.

e. Labor requirement. (It is estimated that 660 farm labors are required 2 weeks for straw collection, etc. and 90 men full time for pulp and paper mill operation, or a total equivalent of 115 men full time.)

(1) Availability of farm, mechanical and common labor in accordance with the above requirements.

(2) Wage rates for the above requirements.

f. Transportation facilities.

(1) Hard roads, trucking rates and available farm trucks.

(2) Railroads.

g. Community conditions.

(1) Other industries and skilled labor pool.

h. Costs of straw collection in the location.

(1) Costs of mowing and baling.

(2) Costs of loading and trucking 25, 50, and 100 miles from the site.

Method of the Study

This study was carried on in two phases. The first phase was to determine, from secondary sources, the amount and distribution of the straw produced in the state. This included determining the harvested acres and grain production by counties, the conversion factor that would translate the grain production into straw production, the straw production by counties, the straw production per square mile by counties, the frequency of crop failures; and finally the effects of adding fertilizer on straw production.

The second phase of the study was to determine the areas in which straw production seemed to be great enough to warrant establishing a plant. Sites within these areas are discussed from the standpoint of their feasibility in terms of the availability and cost of water, electricity, sewage, fuel, labor and transportation needed for pulp production.

Before beginning the second phase of the study, the Northern Regional Research Laboratory at Peoria, Illinois was visited to determine problems of the straw pulping industry. Particular attention was given to how the improved pulping process would affect the existing pulping straw market. After reviewing the problem at the laboratory, a visit was planned with representatives of the Central Fiber Manufacturing Company at Quincey, Illinois. Here industry problems were discussed and the improved pulping process was viewed on a commercial scale.

The second phase was accomplished by mailed inquiries to power companies, Chambers of Commerce, county agents and others. The results of these inquiries were followed up by informal personal interviews with individuals and organizations in towns where plants might be located. The information received from interviews was required to determine the communities' attitudes toward an industry of this kind.

CHAPTER II

STRAW PRODUCTION

Harvested Acres

The first step to determine the amount of surplus straw available for industrial use in South Dakota was to calculate the amount of straw produced. No statistics are available on straw production. The South Dakota Crop and Livestock Reporting Service, however, reports the annual harvested acres and grain production by counties. 1/ These data were assembled for the years 1934 through 1954.

The harvested acres of wheat, rye and flax was prepared from IBM cards. However, harvested acres do not give reliable data for straw production because of the wide straw yield variation from year to year. It was decided, in conference with the Agronomy Department of South Dakota State College, that a grain-straw ratio would yield more reliable results as to the actual straw production. This ratio would still have a margin of error which would probably be greatest in years of extremely low yields or crop failures. In these years straw may be produced in greater quantities than the ratio would portray.

Grain-Straw Ratio

To determine the amount of straw produced the data on grain production was multiplied by the conversion factor or grain-straw ratio. This ratio was calculated by the Agronomy Department from experiments

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1/ South Dakota Wheat 1926-1943 and South Dakota Agriculture 1944 thru 1954, South Dakota Crop and Livestock Reporting Service, Sioux Falls, South Dakota.

conducted by them on the amount of straw that could be associated with each bushel of grain produced.

Table I The Relationship Between Grain and Straw Production

Type of Grain	Total Straw in lbs. Per Bushel of Grain	Less 20% left by Windrower	% of a ton	Conversion Factor Bushels to Tons
Rye	109	87.2	4.36	.0436
Wheat	138	110.4	5.52	.0552
Flax	80	64.0	3.20	.0320

Wheat and rye results were computed from experiments conducted in 1943, 1945, 1948, 1949 and 1952. These years were selected because the Agronomy Department felt that they would more nearly represent grain-straw production due to the introductions of new varieties during this period. Unfortunately data on flax straw production was only available for 1952; however, the Agronomy Department considered 1952 a representative year.

Total straw production was reduced 20 per cent (column II) to allow for the difference between the total straw produced and the stubble usually left in the field by the windrower. This 20 per cent may vary with straw prices and/or harvest conditions of the straw, but was considered by the Agronomy Department to be average.

Total Straw Production

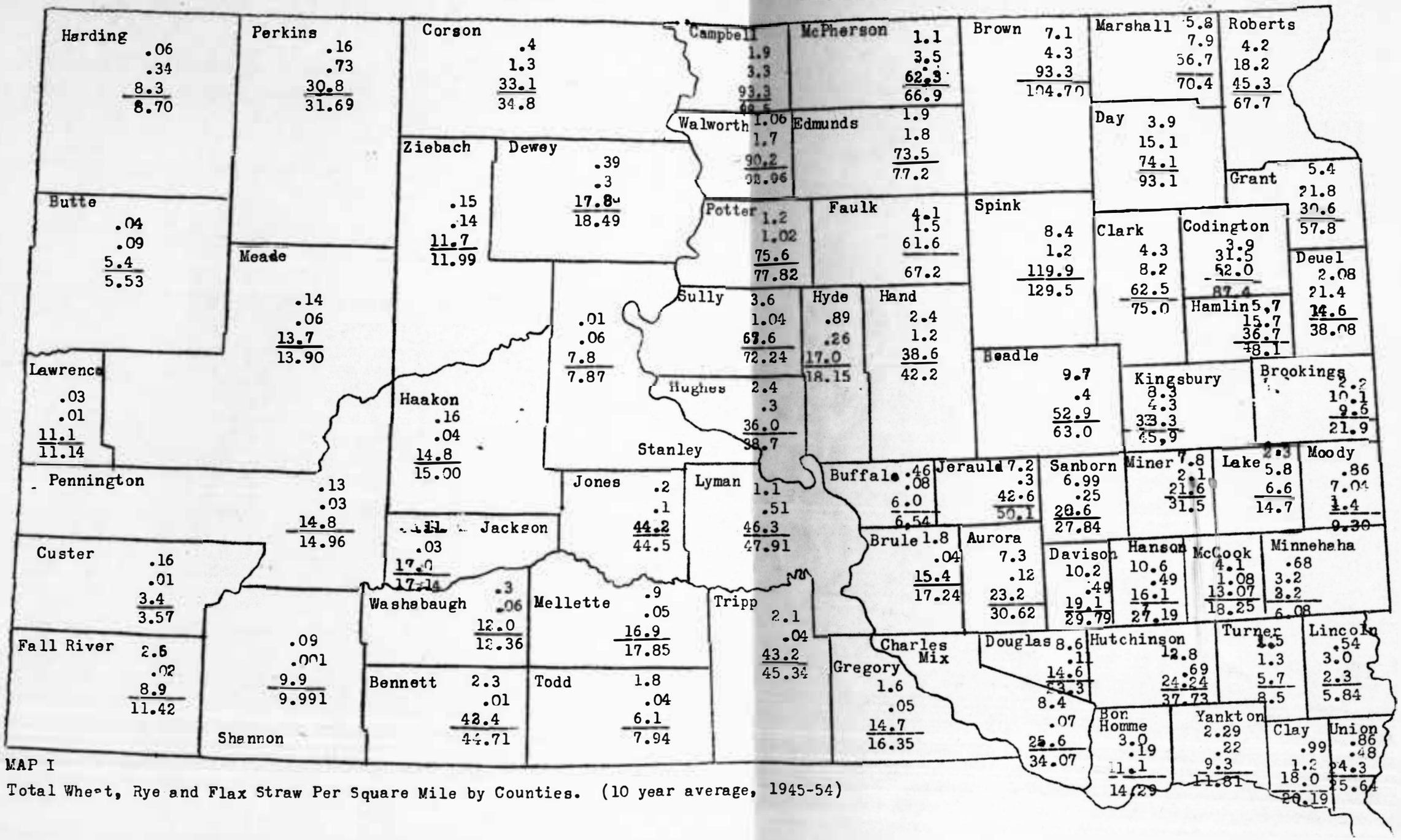
The conversion factor was applied to grain production in each county in the state for the years 1934-1954. Twenty-one years were used to reflect maximum and minimum production or frequency of straw-crop failures.

The past 10 years, those used for the grain-straw ratio, were used for obtaining average straw production. If variety changes and changes in fertility level and soil management practices would make prior years non-typical for the grain-straw ratio, it was felt they should not be used for determining average straw production. The years 1934-1944 were calculated in the same way as those from 1945-1954, but were used only in calculating the number of straw-crop failures.

Straw Density

The average production of wheat, rye and flax straw by counties was calculated for the 10 year period, 1945-1954. Since the size of the counties is not uniform, this has little meaning in determining whether the density of straw production is heavy enough to support a plant. The average production in each county was divided by the number of square miles in the county to arrive at straw production per square mile.

The requirements for a plant using straw for industrial use are 50,000 tons of straw within a 50 mile radius. When converted to production per square mile this amounts to 6.36 tons per square mile. If all the wheat, rye and flax straw produced were surplus straw (less 20 per cent left as stubble) all the counties in the state with the exception of Butte, Custer, Minnehaha and Lincoln counties produce enough straw to support a plant of the prescribed size. (See map I)



MAP I

Total Wheat, Rye and Flax Straw Per Square Mile by Counties. (10 year average, 1945-54)

The first figure refers to rye straw production, the second refers to flax straw production, the third to wheat straw production, and the fourth to total rye, flax and wheat straw production per square mile.

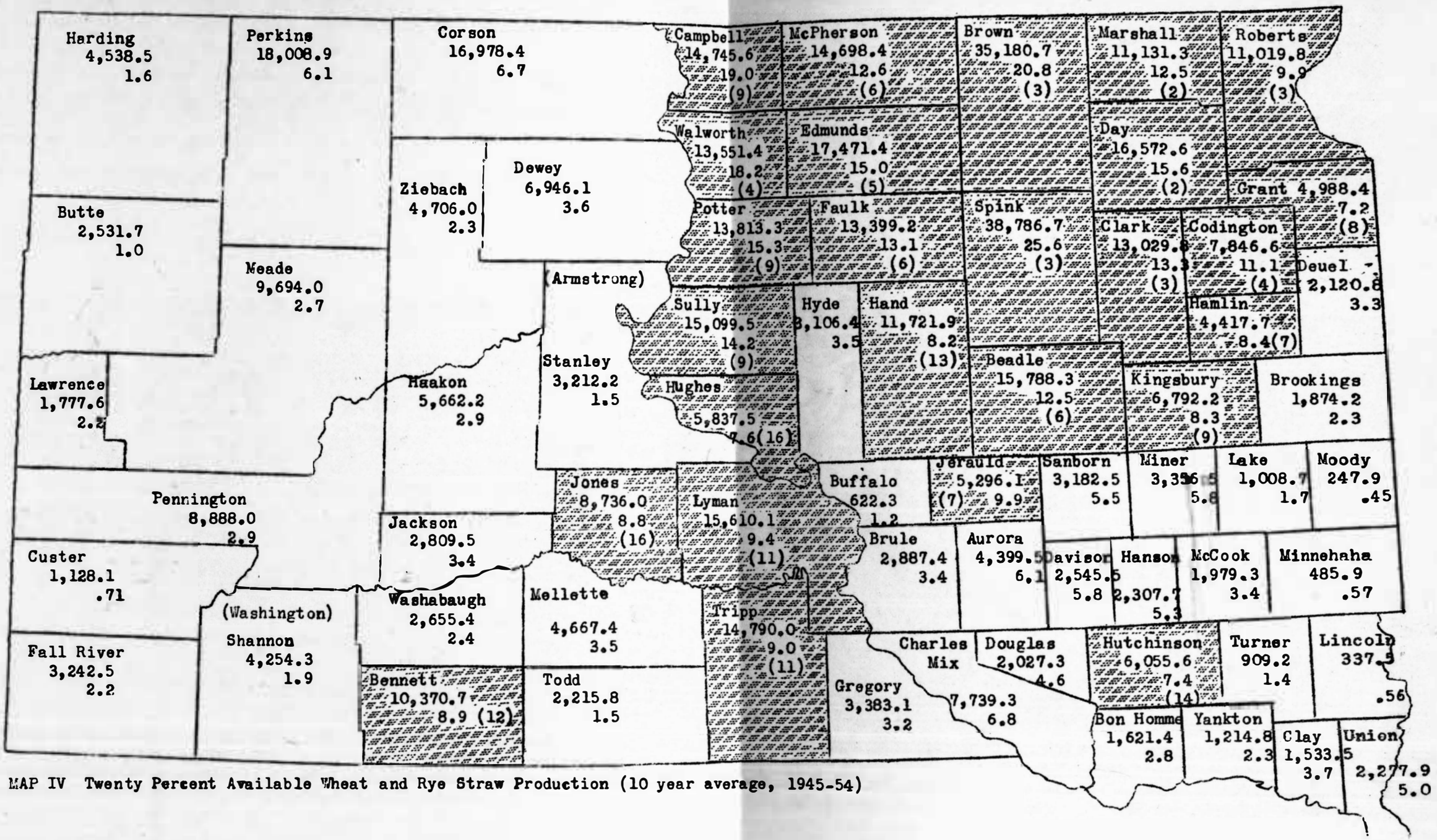
Concentrated Production Areas

The assumption that all straw produced is available is unrealistic. Flax straw, however, which cannot be worked back into the soil satisfactorily is probably all or nearly all surplus straw. For this reason flax straw was singled out to determine whether any area in the state produced enough flax to supply a plant with flax straw only. Ten counties in northeastern South Dakota produce a flax straw density to meet this requirement. (See map II)

Since all wheat and rye straw produced cannot be classified as surplus straw, assumptions were made as to the amount of straw that might be considered surplus. Assumptions of 10, 20 and 30 per cent availability of the total wheat and rye straw were tentatively considered and maps were prepared to illustrate each. On maps illustrating each assumption all counties with over 7 tons available wheat and rye straw per square mile for a 10 year average were shaded. This served to illustrate locations of concentration and to pin point areas which would be most desirable for plant location from the density and stable production standpoint. (See maps III, IV and V)

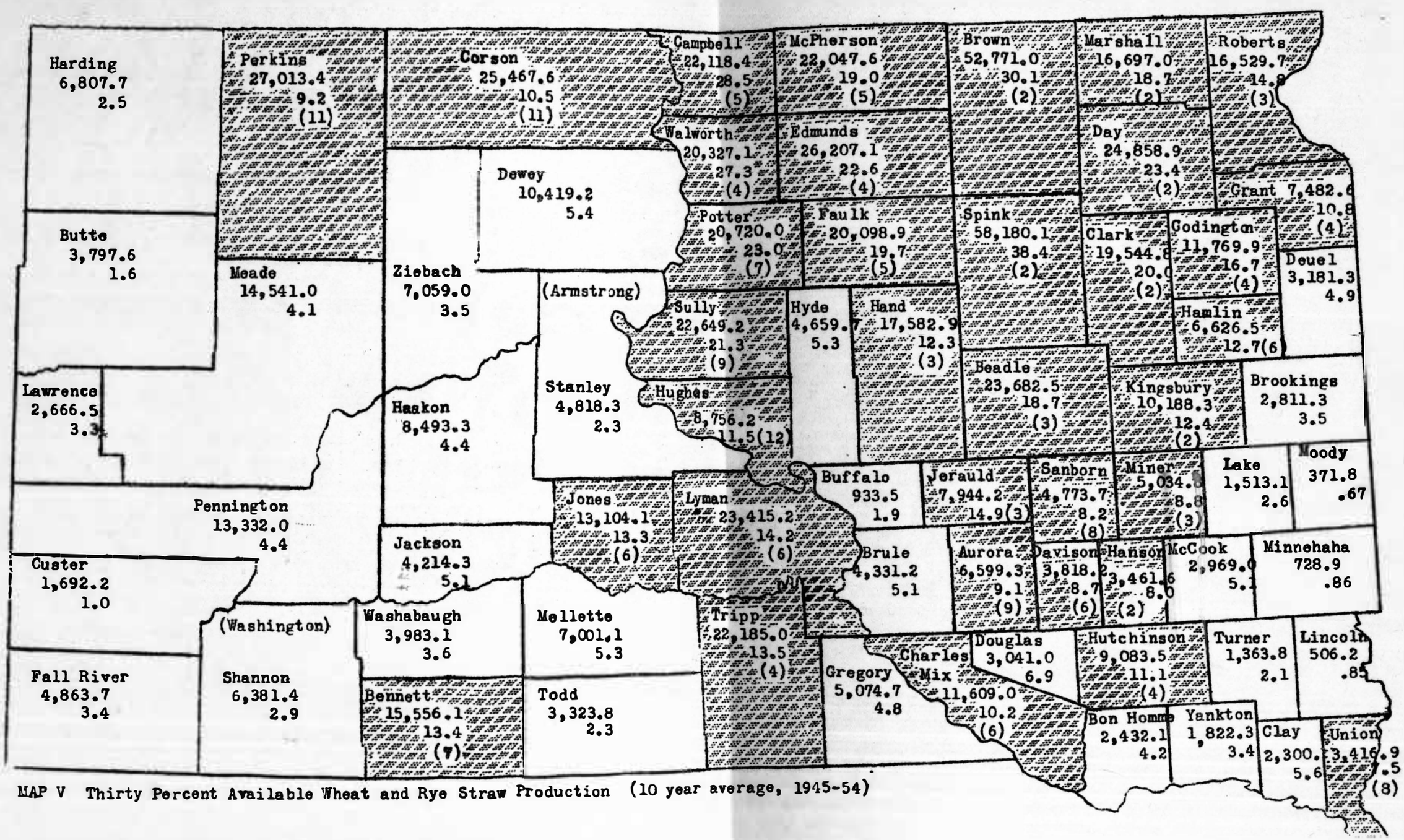
Frequency of Straw Failure

The number of years within the past 21 when straw production fell below 7 tons available straw per square mile was listed within each shaded county. These years, in a broad sense, might be considered years of straw failure. Sufficient straw was produced, but under the rigid assumption of 10, 20 and 30 per cent surplus straw such an amount would



MAP IV Twenty Percent Available Wheat and Rye Straw Production (10 year average, 1945-54)

The first figure represents 20% of the 10 year average wheat and rye straw production. The second figures give available wheat and rye straw per square mile at 20% availability. The shaded areas indicate available straw over 7 tons per square mile. The bracketed figures are the number of years in the last 21 available straw fell below 7 tons per square mile.



MAP V Thirty Percent Available Wheat and Rye Straw Production (10 year average, 1945-54)

straw production. The second figures give available wheat and rye straw per square mile at 30% availability. The shaded areas indicate available straw over 7 tons per square mile. The bracketed figures are the number of years in the last 21 available straw fell below 7 tons per square mile.

not be available. It is logical to assume that in years of low farm income a larger percentage of the total straw production would be available than normally. In years of extremely low grain yield the grain-straw ratio would also have the greatest margin of error in favor of straw production.

CHAPTER III

FACTORS AFFECTING AVAILABILITY OF STRAW

The data which have been collected indicate that sufficient wheat, rye and flax straw is produced to supply a pulping plant at nearly every location in South Dakota except the southeastern counties and a few of the extreme western counties. However, not all the straw produced would be available for paper production. It is of prime importance to determine what factors might affect the straw availability.

Present Farm Use

It was determined from visits with county agents and farmers in the area that most of the wheat and rye straw is spread and remains in the field. Where any straw is collected, it does not exceed 5 or 10 per cent of the farmer's production. For livestock purposes, oats straw is usually preferred where it is available as it may also substitute for some livestock roughage. Wheat, rye or flax straw does not break up and become dusty as readily as oat straw. This characteristic makes these straws especially desirable for hog bedding.

Existing Industrial Straw Use

Although sales barns, stockyards, and small packing plants buy some straw from farmers for livestock bedding, the only straw now used industrially in South Dakota in significant amounts is flax straw. Brookings, Deuel, Grant and Roberts counties have exported flax straw to Minnesota in the past for paper production. County agents of these counties estimate that the amount sold has ranged from 65 to 85 per cent

of the total flax straw production. Only limited amounts of flax straw in Clark county have been sold in prior years. This can be attributed to the added moving and handling cost to transport and process straw from other than the extreme eastern counties of South Dakota. 1/

An experimental portable flax tow mill which processes flax straw out of the windrow has operated the past two years in eastern South Dakota counties. If this machine is further perfected, flax straw processing can be a mobile industry capable of moving to the most desirable production areas. This machine makes a compact wire tied bale weighing about 200 pounds from processed flax straw. Currently this product is then shipped to New York for further processing. 2/

Crop Practices Prevalent in the Area

Within the areas considered for wheat straw pulping in South Dakota, wheat is the major revenue crop. It has a comparative advantage over other grains and therefore commands the first priority on land use. As a consequence, it represents the largest acreage grain crop in these areas. 3/

1/ Information received from the Watertown Chamber of Commerce indicates that a flax straw processing plant is being encouraged to locate at Watertown, South Dakota. If a plant locates there, it will undoubtedly increase the size of the South Dakota area supplying flax straw.

2/ This information is based on an interview with the flax tow mill operator.

3/ South Dakota Agriculture 1954, South Dakota Crop and Livestock Reporting Service, Sioux Falls, South Dakota.

Wheat is combined from the windrow rather than as standing grain as is common in Illinois, Nebraska and other states. The height of cut varies with the height of grain and the quantity necessary to make a continuous ribbon for uniform feeding into the combine. It is preferred when possible to leave sufficient stubble to keep the grain off the ground and in good condition. Normally when the straw is tall, the stubble is cut taller to lessen the straw load on the combine cylinder. Straw may be spread or left in a windrow for baling as the combine operator chooses.

Straw Contaminants

The most common contaminants of straw are broad leafed weeds and the grass type weeds. The broad leaf weed problem has been almost eliminated in wheat and rye by the use of 2-4-D weed sprays and good management practices. The grass types, when serious in wheat and rye, are of a local nature. Flax straw suffers more contamination from both grass type and broad leaf weeds. Sprays are effective on flax; however, more damage results to the flax. Weed contaminants are the major cause for rejecting flax straw for the present industrial use. 4/

County agents were concerned about the extensive straw movement spreading noxious weeds. One county agent cited examples of new Leafy Spurge patches bordering the roads leading to flax straw storage sites. If the transportation of straw contaminated with noxious weeds is con-

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4/ Based on interview with county agents.

tinued, some regulatory measures may be imposed by those enforcing the state weed law.

Rust has been a serious problem in the durum wheat area, which is also the concentrated flax area, of South Dakota. Because of the extensive rust damage in recent years, farmers there are eliminating durum wheat from their cropping system. This recent shift should be considered more closely if straw plants are depending on durum wheat straw from Roberts, Marshal, Grant, Codington, Hamlin and Deuel counties. 5/

If rust resistant varieties of durum are developed, this situation will be reversed again. However, the effect of rust, without available resistant varieties, is to reduce drastically the acreages planted to wheat. Within the spring wheat area rust resistant varieties are available and more resistant ones are in prospect. Rust in this area is not a local problem and the effect is largely dependent on the seasonal weather and winds which bring the rust spores up from southern United States where they are wintered over.

Labor Requirement

Seasonal labor for straw collection is required in rather large amounts. It is not felt that this will present any problem if the harvest wage is equaled. Current harvest help is receiving $1.00 to $1.25 per hour, plus room and board, and according to county agents,

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5/ Ibid.

there is ample migratory labor following the harvest to meet any straw collecting need.

Collection Equipment

Existing farm equipment can handle the majority of the straw collection. If movements of flax straw and flax straw collection methods can be used as guides, farmer's wagons and trucks are used extensively for hay and straw movement over a 10 to 12 mile radius. Flax straw buyers now buy and store flax straw at decentralized points for later movement to the plant. This practice makes the best use of existing equipment, reduces the number of handlings, and makes it possible to use more efficient trucks for delivery to the plant as straw is needed. This practice also greatly reduces the fire hazard. A new practice, along this line, has been to buy flax straw on large producers' farms, baled and stacked according to prescribed specifications. 6/

Twine tie balers are extensively used by farmers. These balers are preferred for livestock feeds. Wire disposal and livestock loss because of wire in the hay and straw dictate this. Wire tie balers are available and represent about 5 per cent of the balers in use. Wire bale ties cost more and would also contribute to the low percentage of wire tie balers. Additional balers, if required for wheat straw baling, could be wire tie balers if a premium payment was established for wire tied

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6/ Ibid.

bales. There is an almost universal custom rate of 10 to 12¢ per bale charged for twine baling. Bales were estimated at 40 to 45 pounds. The wire tie rates run from 14 to 16¢ per bale. This higher rate is offset by a stronger and slightly heavier bale. 7/

Miscellaneous Factors

Nuisance factors have also influenced straw availability. Flax straw, which presents a disposal problem to farmers, has sometimes been available to buyers on the field for taking it away. Wheat straw has often been burned when tall growth must be turned under, to avoid inconvenience in plowing the ground. This practice is disappearing and is found only in the western areas which have not been cultivated long enough to feel the reductions in organic matter and fertility level. The nuisance or disutility value of wheat straw, however, is much less than with flax straw.

Straw choppers are now available which attach on combines. These attachments chop and spread the residues thus eliminating the problem. These are quite numberous in the eastern flax counties. County agents recommend using choppers rather than burning or selling for less than fertility value. This may have been a factor in the higher price now being paid farmers for flax straw. Currently flax straw is bringing $12.00 per ton at decentralized buying points or baled stacked on the

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7/ Ibid.

field of large flax producers. 8/

Price Factor

If straw does not present a disposal problem to farmers or otherwise have disutility, it must bring a net return to farmers to encourage its sale. Straw at a paper plant and straw on the field are different products. Raking, baling, handling and hauling of straw in amounts necessary for paper production would represent cash outlays for the farmer. Less tangible costs would be fertility and organic matter loss. Without compensation for all of these, it is doubtful if a constant supply could be assured over the long run. Where the straw yield is light it is usually raked before baling. The custom raking rate varies from 80¢ to $1.00 per acre for this service. 9/ The raking cost per ton would vary, depending on the straw yield. In heavy yielding years, this service may not be necessary and on light straw yielding years it may limit grain fields which are profitable to harvest due to the high raking cost per ton.

Ninety to ninety-five per cent of balers now in use are twine tie balers. 10/ The per bale rate leaves the baling cost per ton rather undertermined as there is a wide difference in weight per bale. With an average of 11¢ per bale and an average of 45 pound bales the

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8/ Ibid.
9/ Ibid.
10/ Ibid.

per ton cost would be $4.90 per ton. There would likely be a range due to condition of the straw from $4.75 to $5.25 per ton. Straw bales are usually lighter than hay bales. With the cost per bale constant, straw would cost more per ton to bale than hay.

Custom trucking costs are set by the public utilities commission and are graduated by distance hauled. The current rates are as follows: $2.00 per ton up to 25 miles, $3.00 per ton up to 50 miles, $4.20 per ton up to 75 miles and $5.20 per ton up to 100 miles. Minimum total charges are established also. These become very important when considering straw hauling as straw is extremely bulky. It is difficult for standard livestock and grain trucks to haul sufficient loads of straw to surpass the minimum charge. The minimum charges are $6.25 for up to 25 miles, $12.50 up to 50 miles, $18.75 up to 75 miles and $25.00 up to 100 miles. 11/

Since the yields of wheat and straw vary from year to year, and since some of the costs are on a ton of straw basis and others on an acre basis, absolute cost cannot be given. If, however, average yields and costs are applied, a guide may be obtained. In computing these costs, custom charges were used; if farmers are able to utilize time and equipment which would otherwise be idle some straw may be received at less than these costs.

The 10 year average wheat yield is 12 bushel for the North Central district. 12/ When converted to equivalent straw yield, the average

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11/ Regulation #7 South Dakota Public Utilities Commission.
12/ South Dakota Agriculture 1954, op. cit., p. 13.

straw produced would be 1,325 pounds of straw per acre or 66.25 per cent of a ton. Based on a 90¢ per acre charge for raking, the raking cost per ton would be $1.35. An average baling charge is $5.00 per ton. The trucking cost would vary by distance hauled from $2.00 to $3.00 within the 50 mile supply area and might be considered to average $2.50 per ton. A handling charge estimate used frequently for flax straw is $1.50 per ton. 13/ This would total $10.35 custom handling and collecting charges on an average at a storage site. If this practice of selling straw is to remain on firm basis, an additional $1.96 must be paid for the nitrogen and phosphorus fertilizers in the straw based on current prices. Thus a cost of $12.31 should be used if all costs are allowed.

Value of Straw for Purposes of Soil Fertility

Work has been done by the Agricultural Experiment Station at Fargo, North Dakota on the soil depleting power of flax as compared with that of hard spring wheat and other small grain. The chemical constituents of the straws and grains were determined, beginning in 1947, at Fargo and Minot, North Dakota. 14/

13/ Based on interview with county agents.

14/ Clagett, C.O.; Stoa, T.E.; Klosterman, H.J.; Kingsley, A.F.; Sisler, W.W., The Soil Depleting Power of the Flax Crop Compared With That of Hard Red Spring Wheat, Oats and Barley, Bulletin 378, North Dakota Agricultural Experiment Station, North Dakota Agricultural College, Fargo, North Dakota, August 1952.

The North Dakota study included all elements removed. It is felt, that for the purpose of this study, which is to determine the monetary value of the fertility loss in the straw, that only nitrogen, phosphorus and organic matter should be considered. The addition of nitrogen and phosphorus fertilizers has given significant yield increases on small grain in South Dakota. Agronomists agree that organic matter is vital and essential for maintaining physical and chemical fertility. 15/ Potassium is not being considered as a cost item here, however, since it is not a limiting factor in South Dakota crop production. South Dakota soils were derived from parent material high in potassium and it is unlikely a shortage of this element will be experienced in the foreseeable future. 16/

Straw analysis at North Dakota disclosed a relatively low nitrogen and phosphorus content though the variation was greater for straw than for grain. Wheat straw at Fargo, North Dakota averaged .66 per cent nitrogen and approximately .07 per cent phosphorus. 17/ In other words a ton of wheat straw contains 13.2 pounds of nitrogen and 1.4 pounds of phosphorus. Flax straw contained .79 per cent nitrogen and .09 per cent phosphorus. 18/ This would be 15.8 pounds of nitrogen and 1.8 pounds

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15/ Puhr, Leo F. and Worzella, W.W., Fertility Maintenance and Management of South Dakota Soils, Circular 92, South Dakota Agricultural Experiment Station, Agronomy Department, South Dakota State College, Brookings, South Dakota, p. 5.

16/ Ibid., p. 10.

17/ Clagett, et. al., op. cit., pp. 10 and 11.

18/ Ibid.

phosphorus per ton of flax straw. No data was available on rye straw.

Ammonium nitrate is currently selling for $85.00 per ton. Since this form is 33.5 per cent nitrogen, 670 pounds of nitrogen costs $85.00 or approximately 12.7¢ per pound. Phosphorus fertilizer in the 0-45-0 form costs $78.00 per ton. Phosphorus fertilizers percentages are determined on the percent of P_2O_5 rather than phosphorus. The conversion factor for 0-45-0 fertilizer would be 19.6 per cent. This would net 392 pounds of phosphorus for $78.00. At this price replacement phosphorus would cost almost 20¢ per pound (19.8¢).

Using these costs for nitrogen and phosphorus in wheat straw, the element replacement cost of wheat straw would be $1.96 per ton. The element replacement cost in flax would be 2.37¢ per ton. This does not include application cost as it is assumed that a continuous grain cropping system would require, sooner or later, some application of fertilizers.

Organic matter loss presents a different problem as it is not available as a commercial product in quantities large enough for general distribution. It is usually replaced by the addition of grasses or legumes in the rotation and this would involve the curtailing of grain acreages. While this practice may be good from the soil conservation standpoint, it is not felt that the price paid for straw would encourage this change and it would be a costly practice for the farmer at the current grain price. It is extremely difficult, therefore, to place a value on organic matter. Some soils have ample supplies, others are

lacking in organic matter.

The South Dakota State College Agronomy Department has found that the addition of 20 pounds of nitrogen fertilizer while increasing grain yields will increase straw yield just over 20 per cent. 19/ While these tests are inconclusive, it seems reasonable to assume that by following a fertilizer program and normal soil management practices, organic matter deficiency would not occur if not over 30 per cent of the total straw was consistently sold from the land. This amount would not be an absolute ceiling but is advanced as a safe long time average per cent if proper soil management is followed. This would allow the per cent of straw sold to vary such that with a properly planned and located paper pulp plant a consistent annual supply of straw would be received.

Summary

In view of the wide range of factors affecting the availability of straw, it should not be thought of as an exact constant percentage. If straw production varies widely as it sometimes does in South Dakota, a rigid percentage assumption is of limited use in calculating a 50,000 ton annual supply. Thirty per cent wheat and rye straw availability is being advanced as a conservative long time percentage available for industrial use. It is reasonable to assume that this can and will be exceeded in central South Dakota during early years of a plant's

19/ Based on unpublished results of the Agronomy Department, South Dakota State College, Brookings, South Dakota.

operation. If plants choose sites based on drawing their supply from a 50 mile radius, sufficient wheat straw will be available at 30 per cent availability. Much of the fluctuation in straw production can be absorbed within the area by varying the percentage above and below 30 per cent so as to average 30 per cent in the long run. In years of short straw supply, grain yields will usually be low and farmers will be willing to sell a higher percentage of their straw to keep fully employed and maintain their income. In years of abundant straw production, a considerable amount can be saved in the collection expense by drawing the year's supply from areas near the plant.

If, in selecting sites, care is taken to locate plants such that the market areas do not overlap, sufficient straw is available at a 30 per cent availability for several sites in South Dakota and a highly desirable city can be selected.

At 30 per cent availability, it is also possible through the use of normally recommended fertilizer and cropping practices to maintain the same level of fertility and organic matter in the soil. This should insure a constant straw supply indefinitely for straw pulping in South Dakota.

Thirty per cent availability assumes that in the long run the added raking, baling, handling, trucking and fertility costs are received. These have been calculated as $12.31 per ton based on current prices.

CHAPTER IV

POSSIBLE STRAW PULP PROCESSING SITES

Based on 30 per cent wheat and rye straw availability, sufficient straw density exists over the entire north half of eastern South Dakota for pulp processing plants. Local exceptions to this are Deuel and Brookings counties on the east, and Hyde county in central South Dakota. In addition, the winter wheat area surrounding Chamberlain, South Dakota could supply 50,000 tons of straw within a 50 mile radius.

The major trade centers in the area described above could supply, or could arrange to supply, all necessary services for straw pulping except water. Differences exist in the favorability of some sites over others. However, known water availability in the amount of 3,000,000 gallons daily, limit the sites which can be recommended.

Transportation System

South Dakota is served by highway, railway and airline transportation. The existing highway systems is available on any current road map of South Dakota. These highways are subject to extentions and improvements continually.

One major railroad has a main line traversing the north half of eastern South Dakota through Milbank, Webster, Aberdeen and Mobridge. Numberous other branch lines of this and other railroad companies service other trade centers of the state.

Airline service is provided by Braniff and Western Airlines. Ten cities in South Dakota are presently serviced. These include Sioux Falls,

Rapid City, Aberdeen, Huron, Watertown, Brookings, Mitchell, Pierre, Spearfish and Hot Springs. 1/

Water Requirement

Ample water is available at any point along the Missouri River. Mobridge offers the most likely Missouri River site in the northern part of the state. It is the largest city in the area and lies on the west edge of the most concentrated wheat production area of the state. Chamberlain has Missouri River water also and is almost the center of winter wheat production in South Dakota.

The James River Valley, which includes the concentrated wheat area of Brown, Spink, and Beadle counties, does not offer known water sources which are capable of sustaining a demand of 3,000,000 gallons daily. Two major cities, Aberdeen and Huron, have experienced difficulty in developing their water supply for existing and projected domestic needs. 2/ This entire area is underlaid by Artesian water supplies. These are the only dependable sources of water in periods of drought. The pressure of these Artesian wells has been decreasing and many which previously flowed have ceased to flow. It has been possible to predict when other wells will cease flowing by noting the pressure drop and the

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1/ Per interview with Western Airline station agent, Brookings, South Dakota.

2/ Water Resources of the James River Drainage Basin, Vol. II., Water Resources Committee, South Dakota State Planning Board, published by Central Office, Brookings, South Dakota, 1937, p. 76.

date and elevation of wells that have stopped flowing. 3/ In view of this finding, it is impossible to recommend sites for pulping in this area without more adequate information on water availability.

The South Dakota State Geologist expressed the belief that ample water could be obtained from the Sioux River gravel beds. 4/ Sioux Falls obtains its water supply from these gravel beds and Brookings obtains its water supply from the gravel beds of a tributory to the Sioux River. The Big Sioux has its source in the southwest corner of Roberts county where Roberts and Day county join.

Watertown is located on this water supply and is also located in the center of flax straw production. If the hydropulping process was adaptable to flax straw and could compete favorably with existing demands for flax straw, sufficient flax straw would be available at Watertown for hydropulping flax straw there.

Ample wheat straw is available within a 50 mile radius of Watertown for straw processing. Watertown could draw durum wheat straw from the north and spring wheat from the west in ample amounts if a more westerly site is not feasible from the water supply standpoint. A comprehensive report has been prepared by the State Geologist on the water potential of Watertown. 5/ This report indicates Watertown could supply ample

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3/ Ibid., p. 60.

4/ Per interview with Mr. E. P. Rothrock, State Geologist, Vermillion, South Dakota.

5/ Rothrock, E. P., Water Supplies and Geology of Lake Kampeska, South Dakota State Geological Survey, University of South Dakota, Vermillion, South Dakota, December, 1933.

water for hydropulping.

These sites (Mobridge, Chamberlain and Watertown) although they are not located in centers of the most concentrated wheat straw supply, will supply an adequate amount of straw. The Brown-Spink county area would make an ideal location from the straw standpoint, if further water studies locate sufficient water for straw pulping.

Sewage Disposal

State law prohibits discharging raw sewage into South Dakota rivers and streams. 6/ Mobridge is relocating its sewage system, because of the expected river rise due to the dams. They are establishing a lagoon sewage disposal system before discharging sewage into the river. This type of sewage disposal is adapted to areas where land values are low and is considered the most adapted for all classes of sewage. Chamberlain offers identical sewage possibilities to those at Mobridge. Watertown could develop a lagoon sewage system also if this method proves satisfactory. Discharges from the system might be discharged in gravel seepage beds or the Sioux River if sewage meets the state requirements. Land values at Watertown would be higher than at the western site suggested.

Electric Power

Eastern South Dakota has a U.S. Bureau of Reclamation transmission loop which serves all of eastern South Dakota. Considerable power is

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6/ Supplement to South Dakota Code of 1939, 61.0109, p. 1181.

being generated at the Missouri River dams. There appears to be an aggregate demand for hydro power greater than the supply on the existing and proposed transmission lines. Power companies also serve this area and include, Ottertail Power and Light Company, Fergus Falls, Minnesota; Northwestern Public Service Company, Huron, South Dakota; Northern States Power Company with an office at Sioux Falls, South Dakota, and Montana Dakota Utilities Company with an office at Mobridge, South Dakota.

Correspondence with these companies indicates that they will make it their business to meet any power demand in their supply area. Rates for amounts of 25,000 kilowatts a day would be a matter for negotiation. Rates would depend to a large degree on the load factor.

Fuel for Steam

An abundant supply of lignite coal is available from coal fields near Mobridge. It is currently costing $4.00 to $5.00 per ton on rail cars. 7/ Lignite coal is used by the Montana Dakota Power Company for generation at Mobridge. South Dakota coal is comparatively constant in heating value and make-up. Laboratory reports indicate the following: 8/

Moisture	36.65 per cent
Volatile Matter	25.87 " "
Fixed Carbon	28.68 " "
Ash	9.50 " "
Sulphur	0.93 " "
Heating Value	6855 B.T.U.

7/ Per information received from Mobridge Chamber of Commerce.
8/ South Dakota Coal, Mineral Resources Committee, State Planning Board, published by Central Office, Brookings, South Dakota, 1936, p. 26A.

Watertown has a petroleum pipe line terminal near the city and petroleum fuels probably would offer the lowest cost fuel at this location. Rail service could bring either lignite coal or other types of coal for steam generation. It is doubtful that lignite which is high in water content would be economical to transport this far.

Chamberlain would require rail imported fuel of either coal or petroleum. North-south rail service is not available directly and it is doubtful if lignite would be economical to use here.

Labor and Equipment Requirement

The Mobridge Chamber of Commerce felt that an abundance of harvest labor is available from the Indian reservation near there. These workers are amply qualified and able for straw collection. This is no doubt true at Chamberlain also. These areas are grain and ranch type farming areas, and an unbalanced work load is common. It was felt by the Mobridge Chamber of Commerce that many farmers would market straw in order to be employed following harvest.

Watertown is a more intensive farming area than Mobridge or Chamberlain. Watertown is a much larger city and centers a more populated area than Mobridge or Chamberlain. Labor supply should represent no problem.

Transportation Features

Mobridge is located on a hard-surfaced road, U.S. 12 and on a main line of a transcontinental railroad. There is excellent rail service east and west from Mobridge and excellent roads for truck service in or

out of Mobridge. Few other locations in South Dakota are as well serviced from a transportation viewpoint.

Chamberlain is located on U.S. 16 which traverses South Dakota east and west. It has a branch railroad line for rail service which could supply ample service if freight volume warranted.

Hard-surfaced U.S. 81 and U.S. 212 intersect at Watertown giving excellent roads in all direction. Several rail feeder lines intersect there also. Watertown has a large airport and receives airline service daily.

Community Condition

Within the areas now considered feasible, the leading trade center cities were selected. Mobridge and Chamberlain will probably experience growth resulting from the Missouri River development.

Mobridge has an active Chamber of Commerce. Assurance was given that they would cooperate in every way possible with any industry considering locating there.

The Watertown Chamber has taken steps to encourage a flax straw processor to locate at Watertown.

Cost of Straw Collection

Straw collection cost would vary little over the entire area and has been discussed elsewhere. Custom trucking rates are regulated by the South Dakota Public Utilities Commission and would be identical everywhere in the state.

Straw storage weather losses should be less in western and central South Dakota as limited rain falls following harvest. Bales and bale ties would not deteriorate as rapidly as in areas further east.

CHAPTER V

CONCLUSION

It is apparent that South Dakota produces sufficient wheat and rye straw both for agricultural use, including soil fertility, and for industrial straw pulping at several locations. No market has existed for this straw. However, from information gathered it appears that straw can be collected in sufficient quantity at reasonable rates.

Good transporation facilities, both railroad and hard-surfaced highways exist to serve a straw pulping plant.

Electric power is produced by hydro power plants on the Missouri River and power companies have asserted that they would make it their business to meet any power need of a prospective industry such as a straw pulping plant.

Based on available information on the ground water potential and the 50 mile radius for straw movement, Missouri River sites at Mobridge, Chamberlain and Watertown are at present time the only sites that can be recommended for wheat straw pulping. If sufficient water can be procured in the Brown-Spink county areas, one or two more pulping plants would be feasible depending on the availability of wheat straw in North Dakota area adjoining Brown county.

For flax straw, Watertown possesses all the major qualifications. Watertown centers the flax production area of South Dakota and is actively soliciting a flax straw processing company to locate there. Sufficient ground water would be available in gravel beds which spring feed Lake Kampeska.

Sufficient information is not available on the water potential of many South Dakota areas. The current needs are small in comparison to industrial needs. The lack of information on the availability of water within concentrated wheat production areas makes it difficult to recommend other straw pulping sites.

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