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Tractor and Horse Power in the Wheat Area of South Dakota

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PART I

Costs and Standards of Performance

A study of farm operations and farm management was made on 48 farms in Potter county during 1930, through the method of accounts kept daily by farm operators, assisted at regular monthly intervals by a resident field agent. During 1931 thirty other farmers within the spring wheat area of the state kept records of their tractors; and a survey by visits to farmers in the same area was made in 1931 and 1932, in which additional information about tractor and horse uses, performances, and costs was secured.

The results of the Potter county study are being published as preliminary reports, of which this is the second. A part of the information secured during 1931 and 1932 is included in this report for the purpose of giving more reliable standards of performance of horses and tractors. **The purpose of the report is to make available information which will aid farmers in deciding under what circumstances it is the more economical to use tractors or horses or a combination of both.**

The farms from which tractor records were secured ranged in size from a quarter section farm to 2,500 acres of crop land. The soils on the farms studied are practically all loams and not difficult to work. Weed infestation is light. The topography of the cropped land ranges from level to only slightly rolling. The annual rainfall is about 15 inches in the western part of the area and increases to 25 inches or more in the eastern part. The normal frost-free days range from 120 to 130.

The rainfall and yield of crops were slightly below normal in 1930 and the frost-free period was slightly longer than usual. Prices paid for farm products at the farm until July of 1930 were slightly below the average for the last five preceding years; after July prices declined sharply and are still low. (October, 1932.) Late frosts in the spring of 1931 made it necessary to replant flax once or twice on many farms. Drought and hot winds that summer caused considerable abandonment of crops, or at least rendered it uneconomical to harvest them for grain. Grasshopper attacks also reduced the acreage harvested in some sections of the area studied. All of these factors influenced to some extent the amount farm power was used.

Tractors

Description of tractors.—The 227 tractors studied during the three years ranged in age from new to nine years old, and in size from 10-20 horse power to 22-36 horse power. Eleven per cent of them were in operation for their first season, 18 per cent for their second season, 21 per cent for their third, 22 per cent for their fourth, 10 per cent for their fifth, 9 per cent for their sixth season, and 9 per cent were older. Fifty-nine per cent of the tractors were 10-20 horse power rating, general purpose type, 24 per cent were 15-30 horse power, and 17 per cent were rated above 15-30 horse power. Only a few tractors were equipped with lights for night work. Careful daily records of costs and performance for all of the year 1930 were kept on only 40 tractors owned by 27 farmers. The records of these 40 only are used in most of the discussions of costs of tractors and fuel and oil consumed; all of the 227 were included in rate of performance records.

Use of tractors.—Table 1 shows that the 10-20 tractors of the 1930 Potter county study were used an average of 59 ten-hour days at drawbar work and 3 days at belt work, total 62 days. The 15-30 tractors were used an average of only 39 days at drawbar work but were used 7 days at belt work, making a total of 46 days. The 10-20 tractors were used an average of only one day during the year for custom work, while the 15-30's averaged five days of custom work.

Where two tractors were owned the average number of crop acres[1] was 710, or almost 75 per cent more than on one-tractor farms, and the average number of work horses was five. The one-tractor farms had an average of 408 crop acres and an average of four work horses. The total days of tractor work performed on the two-tractor farms was 114, or about twice as many as on the one-tractor farms. Practically all of the custom work done off the farm was done by the operators of the two-tractor farms.

TABLE 1.—Average use of tractors by size of tractor, and by number of tractors per farm, Potter county, 1930

	Size of tractors		No. of tractors per farm	
	10–20	15–30	1	2
Number of records	25	15	14	13
Number of crop acres per farm			408	710
Number of horses per farm			4	5
Number of 10-hour days of work:	*Per tractor*		*Per farm*	
Drawbar work	59	39	51	107
Belt work	3	7	4	7
Total	62	46	55	114
Per cent of time at:				
Drawbar work	95	85	93	94
Belt work	5	15	7	6
Days of custom work	1	5	0	9
Per cent of time at custom work	2	11	0	8

[1] Crop acres includes all crop land except native hay.

The term "ten-hour day" as used in this circular, means 10 hours of work as reported by the tractor operators or drivers of teams. It includes short periods of time when no work was being accomplished by the tractor or horses, also slight inaccuracies in estimating or measuring time. Idle periods of 15 or more minutes were not included as time working. The authors recognize that exactly 10 hours is not a farmer's work day, but discussion requires that the term "day" be limited or defined, and 10 hours was chosen as the limiting time.

The use of 10-20 tractors varied from 37 ten-hour days to 108 days during 1930. The range in use of 15-30 tractors was from 10 days to 117 days. The range in total days of tractor work done on one-tractor farms was from 39 to 65; on two-tractor farms, from 72 to 194.

The information secured in 1931 was from farms which were of smaller average size than those studied in 1930. A direct comparison of the total number of hours tractors were used on these farms in the two years is not significant, so the hours of work performed per 100 acres of crops is presented in table 2. On the one-tractor farms a total of 134 hours of tractor work was done per 100 crop acres in 1930 and 81 hours in 1931. On the two-tractor farms 160 hours of tractor work was done

TABLE 2.—Comparison of tractor use, 1930 with 1931, Wheat Area of South Dakota

	1-tractor farms		2-tractor farms	
	1930	1931	1930	1931
Number of crop acres per farm	408	350	710	551
Hours of tractor work performed	547	282	1,136	737
Total hours of work per 100 crop acres	134	81	160	134
Hours of drawbar work per 100 crop acres	124	71	150	121
Hours of belt work per 100 crop acres	10	10	10	13

per 100 acres in 1930 and 134 acres in 1931. The amount of belt work per 100 acres was not less in 1931 than in 1930, so the smaller total amount of tractor work done in 1931 was due to less work in the fields. The smaller amount of tractor work done in 1931 may have been on account of one or more of the following circumstances: Some of the smaller farms were of a different type from the average of those from which records were taken in 1930, requiring less field work. Dry weather and grasshoppers reduced the yields in 1931 to such an extent that many fields of grain were not harvested mechanically, and low prices of grain also caused more harvesting by livestock than usual. The prices of fuel and lubricants were relatively higher than prices of farm products.

Fuel and Oil Consumed.—The 10-20 tractors used an average of 22 gallons of fuel per 10-hour day for the heavier field operations including plowing, disking and harrowing; and 18 gallons per day for belt work and for lighter field work including corn planting, grain harvesting, and mowing. (Table 3.) The 15-30 tractors used an average of 30 gallons of fuel per day for the heavier work and 27 gallons per day for belt work.

The range in fuel consumption for 10-20 tractors at heavy work was from 20 to 24 gallons, and at belt work and lighter field work, from 17 to 20 gallons. The range for 15-30 tractors was from 28 to 34 gallons for heavy work and from 25 to 28 gallons for belt work per 10-hour day. The oil consumption averaged 3 quarts per 10-hour day for the 10-20 tractors and 5 quarts for the 15-30 tractors.

TABLE 3.—Average consumption of fuel and oil by tractors per 10-hours of operation, 40 tractors 1930, 27 tractors 1931, Wheat Area of South Dakota

Kind of work	Size of tractor	
	10–20	15–30
Gallons fuel used for:		
Plowing, disking, harrowing, drilling, 4-row and high speed cultivating	22	30
Corn planting, 2 and 3-row cultivating at low speed, lighter harvesting operations	18	
Belt work	18	27
Gallons oil used for all work, average	¾	1¼

Kerosene and distillate were not used enough in the tractors studied so that reliable conclusions could be drawn concerning their economy as fuel.[2]

Tractor Costs.—The annual costs of a tractor may be divided into the following three classes:

1. Those which vary directly with the number of days the tractor is used; they include lubricants and wages of the tractor operator.
2. Those which vary with the days of use, but not in direct proportion to use. Repair costs are in this class, also depreciation due to use.
3. Those which remain the same regardless of the number of days of use. Interest on the investment, taxes, shelter, insurance, and depreciation due to the passing of time are in this class; these are frequently called "fixed charges".

The costs of fuel and oil, and of repairs also vary with speed of the tractor, amount of the load, kinds of fuel and oil used and condition of the tractor. All costs vary with prices paid for each item of expense.

Fuel and oil costs.—Tables 4 and 5 give the costs of fuel and oil at varying rates of consumption and at different prices. They are summarized in table 6. Sixty-two days was selected for the length of season of 10-20 tractors, and 46 days for the 15-30 tractors because those were the average number of days, respectively, that the tractors were used.

Using the 1930 averages of 20 gallons of fuel and 3 quarts of oil per day for 10-20 tractors, a difference of 2 cents per gallon for fuel amounted to $24.80 for the season, and a difference of 10 cents per gallon for oil amounted to $4.65 for the season. A difference of 2 gallons of fuel consumed per day amounted to $18.60 per season with fuel at 15 cents per gallon, or $13.64 with fuel at 11 cents per gallon. A difference of one quart of oil consumed per day amounted to $9.30 per season with oil at 60 cents per gallon, and $10.65 with oil at 70 cents per gallon.

2 Minnesota Agricultural Experiment Station Bulletin 280, p. 28, The Farm Tractor in Minnesota, reports no difference in amounts of gasoline and distillate consumed per hour at the same kind of work.

TABLE 4.—Cost of fuel and of lubricants at various prices for 10–20 tractors using 20 gallons of fuel and three quarts of oil per 10 hours*

	Cost per 10-hr. day	Cost per 62-day season
Net price of gasoline per gallon:		
11c	$2.20	$136.40
13c	2.60	161.20
15c	3.00	186.00
17c	3.40	210.80
Price of cylinder oil per gallon:		
50c	.38	23.25
60c	.45	27.90
70c	.53	32.55
80c	.60	37.20
Average cost of other lubricants	.08	4.96
Average cost of fuel and lubricants 1930	3.61	223.51

* The average prices of gasoline and cylinder oil in 1930 were 15 and 70 cents respectively.

TABLE 5.—Cost of fuel and oil at various rates of consumption and with fixed prices for fuel and oil

	Cost per 10-hr. day	Cost per 62-day season	Cost per 46-day season
Fuel used per 10-hours @ 15c per gal:			
16 gallons	$2.40	$148.80	
18 gallons	2.70	167.40	
20 gallons	3.00	186.00	
22 gallons	3.30	204.60	
24 gallons	3.60	223.20	
26 gallons	3.90		$179.40
28 gallons	4.20		193.20
30 gallons	4.50		207.00
32 gallons	4.80		220.80
Oil used per 10-hours @ 70c per gal:			
3 quarts	.53	32.55	
4 quarts	.70	43.40	
5 quarts	.88	54.25	40.25
6 quarts	1.05		48.30

TABLE 6.—Differences in cost of tractor operation due to variations in prices and rates of consumption of fuel and oil

Item	Variation	Consumption or price	Difference per day	Difference per 62-day season
Fuel	2c per gallon	20 gallons per day	40 cents	$24.80
Oil	10c per gallon	3 quarts per day	7½ cents	4.65
Fuel	2 gallons per day	15c per gallon	30 cents	18.60
Fuel	2 gallons per day	11c per gallon	22 cents	13.64
Oil	1 quart per day	60c per gallon	15 cents	9.30
Oil	1 quart per day	70c per gallon	17½ cents	10.65

Various tractor operators made substantial savings either by contracting for, or buying fuel and oil in large quantities. The consumption of fuel and oil per tractor was reduced in numerous cases by slight adjustments on the tractor, by overhauling and repairing, by using proper hitches and by using a different grade of oil.

Repair costs.—Cash repair costs depend largely on the amount of work done by a tractor but are not directly proportional to it. The costs vary widely between tractors for any one calendar year and for that reason the records for only one year are not very reliable as a guide. Annual repair costs for individual tractors vary due to age, condition, care and previous use, to accidents, and to whether necessary repairs are made within the year of record, or just previous to, or just following the year of record. The average cash costs of repairs in 1930 for all 10-20 tractors was $47.74. This made an average of $1.13 per day for the tractors used less than 55 days during the year, 77 cents per day for those used from 55 to 65 days, and 54 cents for those used more than 65 days per year. (Table 8.)[3]

Charges for interest, depreciation and taxes.—Charges for interest, depreciation and taxes are commonly called "fixed charges" because they are considered as a fixed annual cost, regardless of the number of days a tractor is operated. The charge per day, however, varies with the number of days the tractor is used. Fixed charges for 10-20 tractors based on days of use are shown in table 7.

TABLE 7.—Charges per day for interest, depreciation and taxes on 10–20 tractors, Potter county, 1930

	Number of 10–hour days used		
	Under 55 Average 42	55–65 Average 62	Over 65 Average 89
Number of tractors	6	13	6
Interest	$1.24	$ .90	$ .70
Depreciation	3.33	2.42	1.89
Taxes	.24	.16	.11
Total fixed charges*	$4.81	$3.48	$2.70

* No charge is included for housing or for insurance.

Interest charges were made against tractors at the rate of eight per cent of their average 1930 value. The average was calculated by using the inventory value at the beginning and at the end of the year. Interest charges averaged $1.24 per 10-hour day for 10-20 tractors operated less than 55 days during the year, 90 cents per day for those operated from 55 to 65 days per year, and 70 cents per day for those operated more than 65 days per year. Likewise the depreciation charges averaged $3.33, $2.42 and $1.89 per day respectively; and the taxes averaged 24, 16 and 11 cents respectively. The interest, depreciation and tax charges on 15-30 tractors averaged $1.10, $4.80 and $.28 per day respectively. The calculated total annual fixed charges averaged $225 for 10-20 tractors and $284 for 15-30 tractors.

Depreciation charges were determined by the farmers' own valuation of the tractors at the beginning and at the end of the year. Taxes were calculated on the first inventory value at the rate of 24 mills, the aver-

3 A study of 314 tractors of various sizes, reported in Minnesota Experiment Station Bulletin 280, p. 28, gives average repair costs as 60 cents per day.

age tax rate of Potter county in 1930. No charges were computed for housing or for insurance. The fixed charges listed in table 7 are probably higher than for all tractors in the same class in 1930, since the average age of the tractors studied was about three years, and the average estimated life of the tractors was eight years.

Summary of costs.—A summary of the costs, including fixed charges, discussed in the foregoing pages is given in table 8. The costs of fuel and oil were the same per 10-hour day regardless of the number of days the tractors were used. Among the 10-20 tractors the costs of repairs and the fixed charges were greatest per day for the tractors which were used least. The total calculated costs per day averaged $9.55 for the 10-20 tractors which were used an average of 42 days per year, $7.86 for those used an average of 62 days per year, and $6.85 per day for those used an average of 89 days per year. The average total costs per day for 15-30 tractors was $12.72.

TABLE 8.—Summary of operating costs of tractors, Potter county, 1930

	Cost per 10-hour day				Total annual costs	
Size of tractor	10–20	10–20	10–20	15–30	10–20	15–30
Number of days used	42	62	89	46	62	46
Number of tractors	6	13	6	15	25	15
Fuel and lubricants	$3.61	$3.61	$3.61	$5.40	$223.51	$248.40
Cash for repairs*	1.13	.77	.54	1.14	47.74	52.44
Total fixed charges†	4.81	3.48	2.70	6.18	225.31	284.28
Totals	$9.55	$7.86	$6.85	$12.72	$496.56	$585.12

* Based on all tractors.
† No charge is included for housing or for insurance.

The use of 15-30 tractors varied from 10 days during the year to 117 days. The average total cost per day for the tractor which was used only 10 days was $24.40, while it was only $7 per day for the tractor which was used 117 days. These figures all indicate the desirability of a large amount of profitable work for a tractor. The average total costs computed for the 10-20 tractors for 1930 was approximately $496; for the 15-30 tractors it was $585.

TABLE 9.—Average costs per 10-hour day of 10–20 tractors when performing 62 days of work per year, and of 15–30 tractors when performing 46 days of work per year, Potter county, 1930

	10–20 tractors		15–30 tractors	
	Light work	Heavy work	Light work	Heavy work
Gallons of fuel consumed (Table 3)	18	22	27	30
Quarts of oil consumed (Table 3)	3	3	5	5
Cost of fuel @ 15c per gallon	$2.70	$3.30	$4.05	$4.50
Cylinder oil @ 70c per gallon	.53	.53	.88	.88
Other lubricants	.08	.08	.13	.13
Total for fuel and lubricants	$3.31	$3.91	$5.06	$5.51
Average repair costs	.77	.77	1.14	1.14
Fixed charges (Table 8)	3.48	3.48	6.18	6.18
Average total cost per 10-hour day	$7.56	$8.16	$12.38	$12.83

Comparison of 10-20 and 15-30 tractors. *Cost per day.*—Table 3 shows the average amount of fuel used by 10-20 tractors was 18 gallons per 10-hour day for belt work and lighter field work, and 22 gallons for heavy field work. The 15-30 tractors consumed an average of 27 gallons per day when doing belt work and 30 gallons when doing heavy field work. They also used respectively three quarts and five quarts of cylinder oil per day. The average number of 10-hour days worked by the 10-20 tractors was 62, and that of the 15-30's was 46. Using these figures as standards, and including fixed charges, calculations show the average total cost per day for 10-20 tractors without operator was $7.56 when performing lighter work and $8.16 when doing heavy work. (Table 9.) The average total costs per day for 15-30 tractors were $12.38 for lighter work and $12.83 for heavy work. Even if the total costs for 15-30 tractors had been computed on the basis of 62 days there would still be considerable difference per day in favor of the smaller tractor. The 15-30 tractor, however, can perform certain field operations more cheaply per acre.

TABLE 10a.—Average* acres covered per 10 hours by 10–20 and 15–30 tractors performing different operations with different sizes of implements, Wheat Area of South Dakota, 1930–1932

Operation and size of implement	Acres per 10-hour day			
	10–20 tractor		15–30 tractor	
	Most common	Range†	Most common	Range†
Plowing:				
4 14-inch bottoms			16.5	13– 20
3 14-inch bottoms	11.5	8– 13	13.5	10– 15
2 14-inch bottoms	9.0	7– 11		
Disking:				
10-foot tandem	33	30– 37	40	30– 50
9-foot tandem	32	30– 35	35	30– 40
14-foot single	50	40– 60	70	60– 80
10-foot single	40	30– 50		
9-foot single	35	30– 40		
Harrowing:				
7-section spike tooth	105	100–110	140	125–150
6-section spike tooth	105	90–110	115	100–120
5-section spike tooth	95	80–100	100	80–110
4-section spike tooth	85	75– 90		
Seeding:				
14-foot drill	45	40– 50	45	40– 50
12-foot drill	42	40– 45		
11-foot drill	38	35– 43		
10-foot drill	36	30– 40		
10-foot drill, disc and harrow	31	25– 35	35	30– 45
4-row planter, second gear	40	35– 45		
2-row planter, second gear	24	20– 28		
Cultivating:				
4-row, second gear	43	40– 45		
2-row, high gear	32	27– 37		
2-row, second gear	23	15– 30		

* Average here means the most common rate or modal performance.
† Unusual extremes were not included in the range.

Rate of tractor performance.—The most common rates at which tractors performed various kinds of field work with implements of various sizes are given in table 10a,b,c. The rates on different farms as recorded by the operators varied somewhat. Size of fields, condition of soil, yield of crops, trouble with the tractor or the implement it pulled, and bias of the operator were some of the factors responsible for the variations. Acre variations from the most common rates of performance were small for implements of narrow widths and greater for the wider implements. The per cent of variation from the common rates, however, was not large for the different implements. The large variations between plows was due mostly to sod and stubble ground and to depth of plowing. Performance records below the most common rate indicate some maladjustment which, if corrected, should improve the efficiency of labor and possibly reduce cash costs.

Best size of implements.—The best widths of implements for the tractor as indicated by the data are given in table 11. These figures should not be interpreted as final however, especially for the 15-30 trac-

TABLE 10b.—Average* acres covered per 10 hours by 10–20 and 15–30 tractors performing different operations with different sizes of implements, Wheat Area of South Dakota, 1930–1932

Operation and size of implement	No. Men	Acres per 10-hour day			
		10–20 tractor		15–30 tractor	
		Most common	Range†	Most common	Range†
Mowing and raking:					
7-foot mower, and rake	1	20	18–22		
2 6-foot mowers, and rake	1	30	25–35		
Harvesting grain:					
8-foot binder	1	23	20–26		
10-foot binder	1	26	22–30		
12-foot push binder	1	29	25–33	34	30–38
2 8-foot binders	2-3			42	40–45
12-foot foot header and 2 boxes‡	4	27	25–31		
12-foot header and barge	2–3			33	30–40
12-foot windrower	1	32	30–33		
16-foot windrower	1	40	36–43		
12-foot pick-up	2	32	30–33		
16-foot pick-up	2			38	34–40
8-foot combine	1	23	20–25		
12-foot combine	2	32	30–33	37	36–40
16-foot combine	2			45	40–50
1-row corn binder	1	9	8–10		
1-row corn picker§	2	10	9–11		

*Average here is the most common rate or modal performance.
† Unusual extremes were not included in the range.
‡ Four horses were used to draw the header boxes.
§ Two horses were used to draw the grain wagon.

TABLE 10c.—Average* belt work performed per 10 hours by 10–20 and 15–30 tractors for different operations with different sizes of implements, Wheat Area of South Dakota, 1932

Operation and size of implement	No. men‡	No. 2-horse teams	Quantities per 10-hour day		Acres for 1932 all crops
			10–20 tractor	15–30 tractor	
			Range†	Range†	Range†
			Bushels of wheat§		*Acres*
Threshing from shocks:					
22-inch separator	5– 7	4–5	500–700		20–40
28-inch separator	7– 8	4–6		700– 800	30–50
28-inch separator	8–10	6–8		800–1000	40–65
32-inch separator	8–12	6–8		900–1100	45–80
36-inch separator	8–12	6–8		1000–1200	50–90
Threshing from header stacks:					
28-inch separator	4			1000–1300	
Threshing from barge stacks:					
28-inch separator	4			700–1000	
Threshing from bucker piles:					
28-inch separator	6	¶		600– 800	
			Tons of silage		
Silo filler from shocks:					
10 or 12-inch cutter	4– 7	3–4	35– 45		7–14
14 or 16-inch cutter	10–12	7–9		70– 90	

* Average here is the most common rate or modal performance.

† Unusual extremes were not included in the range.

‡ Number of men and teams includes bundle haulers, spike pitchers and men at the machine, but not grain haulers for threshing or men and teams for cutting corn in the field for silo filling.

§Usually 50 to 75 per cent more oats and barley can be threshed per day than the standards given above for wheat.

¶ Bucker piles were hauled to the separator with a 10–20 tractor and sweep rake.

tors, since there was not sufficient information on larger loads for the 15-30 tractors. According to other studies which have been made, the most economical load for a tractor is one which is slightly less than the upper limit of its capacity.[4] The fixed charges are the same whether a tractor is developing 10 or only 5 horse power, therefore they are lower per horse power when the tractor is being used at its full capacity. Data

TABLE 11.—Desirable size of implements for tractors, indicated by 1930–1932 data, Wheat Area of South Dakota

Implement	10–20 tractor	15–30 tractor
Tandem disk harrow	9-foot	10-foot
Single disk harrow	14-foot	
Spike tooth harrow	6-section	7-section
Grain drill	12 or 14-foot	
Corn planter	4-row	
Corn cultivator	4-row	
Grain binder	10-foot	
Combine		16-foot

4 The Farm Tractor in Minnesota. Minnesota Agricultural Experiment Station Bulletin 280, p. 63, 1931.

obtained by the Montana Agricultural Experiment Station[5] indicates the optimum load for a 10-20 tractor under Montana conditions is about: two 14-inch bottom plows in sod, three in stubble, 11 feet of tandem disk, 23 feet of single disk harrow, 25 feet of spike tooth harrow, 21 feet of drill, and a four-row corn planter. The optimum load for a 15-30 tractor under similar conditions was about: three 14-inch bottom plows in sod, four in stubble, 16 feet of tandem disk, 33 feet of single disk harrow, 35 feet of spike tooth harrow, and 30 feet of drill.

Many of the cooperators added a second or even a third implement to the tractor's load in order to obtain the greatest efficiency from both the tractor and the time of the operator. The attachment of one section of spike tooth harrow behind a 15-30 tractor and 3-bottom plow did not reduce the acreage plowed per day. The same load for a 10-20 tractor reduced the rate of plowing only one-half acre per day. A 15-30 tractor was slowed up only about four acres per day when a two-section harrow was attached behind either a 10-foot tandem disk or a 10-foot drill.

Cost per acre.—The average tractor cost per acre in 1930 for performing different field operations is shown in table 12. The direct cash costs of operation—fuel and lubricants—are given in the first two columns. They were computed from tables 9 and 10. The cash costs for fuel and lubricants and wages for the operator are shown in the middle two columns. A charge of $2.50 per day was allowed for hired labor. This was a common farm wage in 1930. The last two columns give the total costs of fuel, lubricants, repairs, operator and fixed charges. The chief purpose of the table is to serve as a guide to owners of tractors of two sizes when they are choosing which tractor shall be used for an operation. **Economy of operation, rather than mere speed should determine the choice.** If the table is used as a guide for custom work rates, a charge for the use of implements should be added; the owner of the outfit is also entitled to a profit on his investment.

The table indicates that plowing, disking and harrowing can be done at about the same cash cost with 15-30 tractors as with 10-20's, especially if the latter draw a load less than optimum. If the larger tractors were to draw the optimum load indicated for them by the Montana agricultural experiment station[6] they would compare more favorably with 10-20 tractors than they do in table 12. The large tractors compared more favorably with the smaller when wages were included in the cash costs, because the large ones complete the work on an acre in less time. If the work is performed by unpaid labor there is no cash outlay for wages, and the only gain by using the larger tractor is timeliness of performance, for which there is no measure. Wages add greater cost per acre for slow operations like plowing or cutting corn, than for fast operations like harrowing or drilling. For example: an operator's wage of $2.50 per day adds 22 cents to the cost of plowing an acre with a 10-20 tractor and 3-bottom plow, and 15 cents with a 15-30 tractor and 4-bottom plow. The same wage adds only 2 cents per acre to the cost of harrowing with a 7-section harrow.

5 Mechanical Tests on Tractor Farming Equipment. Montana Agricultural Experiment Station Bulletin 243, p. 19, 1931.

6 See p. 12 of this circular.

The 15-30's compared less favorably with the smaller tractors when fixed charges were included in the costs because the fixed charges are greater for the larger, more expensive tractors, and the larger tractors were used fewer days per year on the average. If the 15-30 tractors had been used as many days during the year as the 10-20's, the fixed charges per day would have been about $1.60 less than they were. This would

TABLE 12.—Average tractor cost per acre for performing different operations with 10–20 tractors used 62 days per year, and 15–30 tractors used 46 days per year, Potter county, 1930

Operation and size of implement	Cost per Acre					
	Fuel and lubricants		Fuel, lubricants and wages*		Fuel, oils, wages, fixed charges‡, repairs	
	10-20	15-30	10-20	15-30	10-20	15-30
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Plowing:						
4 14-inch bottoms		33		48		93
3 14-inch bottoms	34	41	56	60	92	113
2 14-inch bottoms	44		71		118	
Disking:						
10-foot tandem	12	14	19	21	32	39
9-foot tandem	12	16	20	23	33	43
14-foot single	8	8	13	12	21	22
10-foot single	10		16		26	
9-foot single	11		18		30	
Harrowing:						
7-section spike tooth	4	4	6	6	10	11
6-section spike tooth	4	5	6	7	10	13
5-section spike tooth	4	6	7	8	11	15
4-section spike tooth	5		8		11	
Seeding:						
14-foot drill	9	13	14	18	24	34
12-foot drill	9		15		25	
11-foot drill	10		17		28	
10-foot drill	11		18		30	
10-foot drill, harrow and disk	13	17	21	24	34	44
4-row planter, second gear	7		13		22	
2-row planter, second gear	14		24		41	
Cultivating:						
4-row, second gear	7		13		22	
2-row, high gear	12		20		33	
2-row, second gear	14		25		43	
Harvesting:						
12-foot binder		15		22		43
10-foot binder	11	16	19	24	34	48
8-foot binder	14	18	24	27	41	53
12-foot header	12	16	21	23	37	46
16-foot combine†	7	12	13	16	22	31
12-foot combine†	8	13	15	19	25	37
1-row corn binder	37		65		112	
2 mowers, 7 and 5-ft.	10		17		29	
7-foot mower	13		23		40	

* Wages of $2.50 per day for labor was included in calculating the costs shown in the last four columns of this table.

† Costs for auxiliary motors were not included.

‡ Fixed charges include interest, taxes and depreciation.

have reduced the costs per acre, shown in the last column, about 10 cents for plowing, 1 cent for harrowing and 4 cents for disking, drilling and harvesting. This indicates the greater economy of large tractors on large farms than on small farms. The tractor should fit the size of the farm if the low cost per acre is to be secured.

The various operations were performed more economically with the larger implements listed in the 10-20 tractor columns than with the smaller implements. Likewise the 15-30 tractors operated more economically when used with larger implements. Tandem disking was more economical than disking twice with a single disk.

Cost of belt work.—There was not a sufficient number of separate records kept of different kinds of belt work to provide reliable information as to the amounts of fuel used for each kind. Table 9 shows the cost of fuel and lubricants for 10-20 tractors averaged $3.30 per 10-hour day for light work, and $3.90 for heavy work. The corresponding costs for 15-30 tractors were $5.00 and $5.50. These figures indicate the 10-20 tractor is cheaper for belt work when it has sufficient power to perform the work well.

Reducing tractor costs.—Operating costs may be reduced several cents per acre in some instances by better bargaining for fuel and oils, slight adjustments on the motor, overhauling the motor, less time idling the motor, having implements in proper adjustment, adding another section to a harrow, using tandem hitches, etc. Over a period of years more reductions in costs per acre may be made by replacing implements of narrow width by those which have greater capacity for work; or by increasing the number of crop acres per farm. Table 13 shows the favorable effect on cost per acre of greater crop acreages. This indicates again the desirability of having a large number of crop acres as a means of reducing the production cost per acre. The actual number of crop acres and the tractor cost per acre are shown for all farms studied which had two horses and one 10-20 tractor. The table indicates much greater economy of operating a tractor on the farms which had a comparatively large number of crop acres.

TABLE 13.—Effect of number of crop acres on cost per acre of 10–20 tractors, on farms having one tractor and two horses, Potter county, 1930

Crop acres per farm	Total cost per acre*	Cost of fuel and oil	All other costs*	Farm No.
530	$ .96	$238	$269	31
468	1.21	235	332	17
442	1.04	253	210	37
397	1.31	283	237	55
327	1.39	242	214	42
264	1.60	200	224	11
232	1.68	191	199	72
209	1.87	186	205	65

* No wages, insurance or housing included.

Horses

Number of horses on farms.—The number of work horses on the 48 farms studied in 1930 varied from two to twelve per farm. Eleven of the farms having tractors had only two work horses per farm, and one had 10 horses. The seven farms having no tractors averaged nine horses per farm. Table 14 shows the number of horses and the average crop acres per farm for the 1-tractor and for the 2-tractor farms. For the most part, farms with greater crop acreage had the more power, but there were some exceptions. Saddle horses and colts are not included in this discussion. There were auto trucks on nine of the 2-tractor farms and on seven of the 1-tractor farms, but none on any of the horse power farms.

TABLE 14.—Number of horses and average crop acres per farm on 1-tractor and 2-tractor farms, Potter county, 1930

One-tractor farms			Two-tractor farms		
Number horses	Average crop acres	Number farms	Number horses	Average crop acres	Number farms
2	359	8	2	642	3
4	294	1	4	639	5
6	464	3	6	776	5
10	756	1	8	941	1

Feed consumed by horses.—Twenty-eight reliable records were kept of feeds fed to horses and days the horses were on pasture. Table 15 shows the horses were fed an average of about one ton of grain each per year: those which were on pasture about one-half of the time were fed about two tons of roughage per year, and those which were on pasture but little were fed about three tons of roughage per year.

TABLE 15.—Average number of horses, tractors, crop acres, and feeds fed to horses on 28 farms using various power units, Potter county, 1930

Power used	Number farms	Number horses	Number tractors	A. corn and small grain	Pounds fed per horse			Days on pasture†
					Grain	Hay	Fodder	
Horses only	7	9	.0	347	1,790	4,045	726	155
Horses and tractors*	11	6	1.4	611	1,980	3,737	829	137
2 horses and tractors	10	2	1.5	469	2,123	5,269	1,308	46

* More than two horses per farm.
† Pasture includes stubble and corn fields.

On tractor farms with only two horses, the horses were let to pasture only 46 days during the year and consequently consumed more grain and rough feed per head than the horses on other farms. Where horses were the only draft power, they averaged 155 days per year on pasture.

Horse costs.—The cost of keeping a horse for a year varies mostly on account of the kinds, amounts and quality of feeds fed, the prices of the feeds, the value of the horse, the age of the horse, the number of horses on the farm and the amount of work performed. The cost per horse for each day of work performed by horses depends on the annual cost of keeping a horse and the number of days of work done. The cost per acre for work performed with horses varies with the cost per day per horse, the number of horses used and the number of acres covered per day. The total costs of horses are discussed in connection with table 17.

The average cash costs for medicines, veterinary services and shoeing were approximately $1 per horse. Taxes averaged $1.20 and repairs on harness averaged 50 cents per year. This made a total cash outlay of $2.70 per horse per year. The non-cash costs were: depreciation in value of horses and harness were estimated at $5.00 and 50 cents respectively, and interest calculated at the rate of eight per cent on an average value of $50, or $4.00 per year. This was a total of $9.50 non-cash costs. The sum of the cash and non-cash costs listed above was $12.20 per horse per year. The depreciation charges were calculated by using the farmers' own estimates of values of colts and of horses of different ages. No charges were estimated for housing, insurance, and chore labor on horses, and no credit was given for manure produced. Costs of implements drawn by horses are discussed in connection with table 20.

Reducing horse costs.—The cost of horse power may be reduced somewhat on many farms by several methods. The first and most important is to maintain the horses as economically as possible. Other methods are to raise colts, and to use young horses for most of the horse work, selling them before they begin to depreciate because of their age. In this way the charge for depreciation is transferred to someone else. Some of the cooperators reduced maintenance costs by pasturing the horses as much as was practical, by feeding much cheap roughage and little grain, and by feeding unthreshed grain.

The cost per acre and per day worked averaged less on farms where there was a large acreage of crops, where the horses were used a great deal, where "big teams" were hitched to implements of considerable capacity, and where a minimum of time was needed for resting the horses. Fast walking horses, usually young ones, also reduce the cost per acre and per hour because of their ability to cover ground more rapidly.

Rate of horse performance.—The average number of acres commonly covered in 10 hours when doing various kinds of farm work with horses is given in table 16a,b,c. The variations in rates usually found on different farms is also given. Variations in rates are due largely to length of rest periods for the horses, age and weight of horses, depth of tilling, soil conditions, and crop yields, and perhaps also to differences on the part of the operators in judging the acreage covered and the number of hours worked per day. The average amount of work done indicates what may be accomplished by anyone under fair conditions. Good performance is that which is somewhat above the average.

TABLE 16a.—Acres covered per 10 hours by horses performing different operations with different sizes of implements, Wheat Area of South Dakota, 1930–1932

Operation and size of implement	Number horses	Acres per 10-hour day	
		Most common	Range*
Plowing:			
3 14-inch bottoms	8	8.5	8– 9
2 14-inch bottoms	6	6.5	5– 8
	5	6	4– 7
Disking			
10-foot single	6	30	25– 35
	4	25	20– 30
9-foot single	6	25	23– 27
	4	22	18– 25
8-foot single	4	20	18– 24
Harrowing:			
6-section spike tooth	8	90	80–100
	6	75	60– 90
5-section spike tooth	6	65	50– 80
	4	50	40– 80
4-section spike tooth	6	45	30– 60
	4	45	30– 60
Seeding:			
12-foot drill	6	30	25– 35
11-foot drill	6	26	22– 30
	4	23	20– 25
10-foot drill	6	24	20– 30
	4	22	15– 30
2-row corn planter	2	17	14– 23
Cultivating:			
2-row	4	17	13– 20
1-row	2	8	6– 12

* Unusual extremes were not included in the range.

TABLE 16b.—Acres covered per 10 hours by horses performing different operations with different sizes of implements, Wheat Area of South Dakota, 1930–1932

Operation and size of implement	No. men*	No. horses	Acres per 10-hour day	
			Most common	Range†
Mowing:				
5-foot mower	1	2	11	8–15
6-foot mower	1	2	13	10–15
Raking:				
10-foot rake	1	2	23	20–25
12-foot rake	1	2	24	20–25
Harvesting grain:				
8-foot binder	1	4	19	17–20
12-foot header and 1 box	2–3	‡4–6	22	18–25
12-foot header and 2 boxes	4–5	‡4–6	29	25–35
1-row corn binder	1	3	7.5	7– 8
1-row corn picker	2	‡6	8	7– 9

* Additional men for shocking or topping off not included.
† Unusual extremes were not included in the range.
‡ Two additional horses were used per box.

TABLE 16c.—Hay stacked per day using horses with different equipment and sizes of crew, Wheat Area of South Dakota, 1932

Operation and implement	No. men	No. horses	Length of day	Stacks per day	Tons per stack
Stacking from windrows:			*Hours*		
1 sweep rake	3	2	8	1	8–10
			10	2	7– 9
1 sweep rake, 1 stacker	3	4	8	2	6– 8
			10	2	8–10
2 sweep rakes, 1 stacker	4–5	6	8	3	6– 8
3 sweep rakes, 1 stacker	5	8	10	3	8–10

Comparison of Horses and Tractors

Horses and tractors may be compared directly in various ways such as: Cash costs, total costs, costs per acre, and time saved. None of the direct comparisons will ever satisfy both the defender of horses and the defender of tractors. The reason lies in the fact that certain items of cost, and certain advantages of each kind of power over the other kind cannot be measured accurately and they differ on different farms. For examples: Unsalable feed has no market value, or it might be fed to different animals securing different economic results in each case. Actual values of horses, and depreciation charges on both horses and tractors must be estimated. Empty horse stalls are a cost which cannot be easily allocated, and time saved by using a tractor cannot be evaluated if it is not used for productive work. The only fair comparison is one that shows which kind of power will return the greatest net income to the farmer and his family. Such a comparison is made in Part II of this circular.

Current cash costs compared.—A comparison is made in table 17 of the annual current cash costs of horses on horse farms and of all 10-20 tractors studied in 1930. The average total amount of cash costs of horses and harness on the seven farms which were operated with horses on-

TABLE 17.—Average annual current cash operating costs of horses and of 10–20 tractors, Potter county, 1930

	All horse farms, average 9 horses	Average all 10–20 tractors
Average acres per farm	347	469
Fuel and oils (Table 8)		$223.51
Taxes	$10.80	9.92
Repairs on harness	4.50	
Repairs on tractor		47.74
Veterinary, shoeing	9.00	
Total cash cost per year	$24.30	$281.17

ly was $24.30 or $2.70 per horse. Taxes, repairs on harness, shoeing and medical attention were the only cash costs; no horse feed was purchased. The average cash costs of 10-20 tractors for the year 1930 was $281.

If the comparison of cash cost of power to operate a farm is carried to completion, the cash cost of horses used on a tractor farm should be added to the cash cost of the tractor; and if horses are sold from the farm because of the purchase of a tractor, the value of the feed crops formerly used by the horses sold should be subtracted from the total cost of power on the farm, giving a "net cash cost" of the power. If the cash cost of two horses, $5.40, is added to $281.17, the average cash cost of a 10-20 tractor; and the estimated 1930 cash value of the feed for six horses, $200*, be subtracted from the total, the average "net cash cost" of the power on the tractor farms recorded in table 17 would be

* The value of the feed and the number of horses assumed sold are arbitrary figures, some farmers sold more and some less than six horses after purchasing a tractor, and many of the tractor owners kept no record of feed and pasture used by horses.

approximately $86. If less labor was hired because of using a tractor instead of horses, wages saved by operating the tractor should also be deducted from the total cash cost.

The average number of crop acres per farm on the horse farms was 347; it was 469 on the tractor farms. Using these acreages for calculation, the average current cash costs per crop acre for power was approximately seven cents on the horse farms, and 60 cents for a 10-20 tractor and two horses. The "net cash cost" for the tractor and two horses was approximately 18 cents.

If a farmer has enough horses, feed, and cheap labor to operate his farm effectively, his cash expenses for power for one single year would be cheaper with horses than with a tractor; in the long run, however, costs other than the current cash costs must be considered.

Total annual costs compared.—As previously stated, the amounts and values of feed fed to horses vary a great deal. This makes it difficult to compute total costs of horses which will be fair for comparison with tractors, the costs of which can be more accurately calculated. However, because there is considerable demand for such a comparison, table 18 is offered as a guide for a farmer to use in making a similar comparison on his own farm. Computations for this table were based on the amounts of feed consumed as shown in table 15, and on prices which were carefully selected as being representative for Potter county in 1930. The prices used were: 70 cents per hundred pounds for grain, $7.60 per ton for hay, $4.00 per ton for fodder, and $5.00 for six month's pasture. Chore labor, bedding and housing costs were not included in the calculations. The averages of the seven farms using horses only, are compared with the averages of five farms, each of which had two work horses and a 10-20 tractor. The average total costs of nine horses were $413, and for a 10-20 tractor and two horses they were $612.80 for the year 1930. The average number of crop acres per farm was 365 on the horse farms and 383 on the tractor farms. Using these acreages for calculation, the average costs per crop acre were approximately $1.20 on the horse farms, and $1.60 on the tractor farms.

TABLE 18.—Computed costs of power on horse farms and tractor farms, Potter county, 1930

	7-horse farms, average 9 horses	5 farms with a 10–20 tractor and 2 horses
Feed and pasture	$303.20	$71.00
Taxes on horses	10.80	2.40
Harness repairs and depreciation	9.00	2.00
Veterinary, shoeing	9.00	2.00
Interest on investment in horses	36.00	8.00
Depreciation in value of horses	45.00	10.00
Total charges on horses	$413.00	$95.40
Average cost of 10–20 tractor		517.40
Total cost of power	$413.00	$612.80
Average crop acres per farm	347	383
Cost per crop acre for power	$ 1.19	$ 1.60

This table outlines a method of comparing the total costs of horses and tractors. A similar comparison on any farm would give different results due to variations in the number of horses per farm, costs of horse feed, gasoline, depreciation on the tractor, and other factors which would make considerable change in the total costs per horse or per tractor, or in the costs per crop acre or per hour. Also, changes in the number of crop acres per farm would change the costs per acre, and changes in the total number of hours the horses worked per year would change the costs per hour.

TABLE 19.—Comparison of rate of performance of horses and tractors, Wheat Area of South Dakota, 1930–1932

Operation and size of implement	Number horses	Acres covered in 10 hours			Hours required per 100 acres		
		Horses	10-20 tractor	15-30 tractor	Horses	10-20 tractor	15-30 tractor
		Acres	*Acres*	*Acres*	*Hours*	*Hours*	*Hours*
Plowing:							
2 14-inch bottoms	5	6.	9.		166	111	
3 14-inch bottoms	8	8.5	11.5	13.5	118	87	74
4 14-inch bottoms				16.5			61
Disking:							
10-foot single	6	30	40		33	25	
14-foot single			50	70		20	14
10-foot tandem			33	40		30	25
Harrowing:							
5-section spike tooth	6	65	95		15	10	
9-section spike tooth	8	90	105	115	11	10	9
7-section spike tooth				140			7
Seeding:							
10-foot drill	4	22	35		45	29	
12-foot drill	6	30	42		33	24	
14-foot drill			45	45		22	22
2-row planter	2	17	24		59	42	
4-row planter			40			25	
Cultivating:							
1-row cultivator	2	8			125		
2-row cultivator	4	17	32		59	31	
4-row cultivator			43			23	
Harvesting:							
6-foot mower	2	13			77		
7-foot mower			20			50	
12-foot, 2 mowers			30			33	
8-foot binder	4	19	23		53	44	
10-foot binder			26			38	
12-foot binder			29	34		34	29
16-foot binder				42			24
12-foot header and 1 box	8	22			45		
12-foot header and 2 boxes	4		27			37	
12-foot header and barge				33			30
8-foot combine			23			44	
12-foot combine			32	37		31	27
16-foot combine				45			22
1-row corn binder	3	7.5	9		133	111	
1-row corn picker and wagon	8	*6.	10		125	100	

* Two additional horses were used to draw the wagon.

This cost comparison should not be construed to mean that the use of horses as the only power on the farm is more profitable than the use of a tractor and horses. Total net income to the farm business is more important than saving small amounts in one phase of the business. Every farm is a problem in itself and the most profitable power combination on one farm might be unprofitable on another farm.

Rate of performance compared.—The common acreage covered by horses and by tractors in 10 hours is compared in table 19; also the hours required per 100 acres for different operations. The purpose of the table is to serve as a guide for choosing, from the standpoint of time, which power to use on farms where more than one kind of power is available and time is the deciding factor. Time saved may be the basis of choice when help is to be hired at high wages, or when the time for doing a certain work is limited, but net returns to the farm should be the final basis for choosing. If the labor is performed by unpaid family workers or by men paid by the month, labor time saved can be valued only by what the workers accomplish with the time saved.

If power units are to be purchased, rate of performance is important since slow performance would limit the number of crop acres one could farm, or would necessitate duplication of power, machinery and laborers to accomplish the work on a large acreage of crops. On the other hand, high rate of performance on a small number of crop acres usually causes a high cost of production per acre because of the high fixed charges of large units of power and equipment. These considerations and the cash outlay required for labor and belt work influence the net farm returns.

Machinery and equipment compared.—Some special tractor equipment is necessary if the greatest advantages possible are to be secured from the use of a tractor. This increases the equipment investment per farm, and the equipment investment per acre unless the area of the farm is increased. Table 20 shows the value of equipment averaged $1,547 per farm on horse power farms and $2,073 per farm on tractor farms. The average value of all equipment and horses was $2,109 on horse power farms; the average value of all equipment, tractors and horses on tractor farms was $3,283. The large total investments in power and equipment of the tractor farms were, however, not much larger per acre than

TABLE 20.—Value of equipment* and power per farm and per acre on horse power and on tractor farms, Potter county, 1930

	Horse farms	2 horses 1 tractor	Average all tractor farms
Number of farms	8	8	39
Number horses per farm	8	2	5
Crop acres per farm	364	359	491
Value of equipment per farm	$1,547	$1,574	$2,073
Value of tractors per farm		588	810
Value of horses per farm	562	181	402
Value of equipment and power per farm	2,109	2,343	3,283
Value of equipment per acre	4.25	4.30	4.22
Value of equipment and power per acre	5.79	6.52	6.68

* Autos, trucks and small tools were not included in the valuation of equipment.

on the horse power farms because the former were larger farms. The tractor farms had a total equipment and power investment averaging $6.68 per acre, the horse farms' average was $5.79 per acre. The equipment of the tractor farms included all threshing rigs, combine-harvesters, and other machinery operated by the tractor. If threshing rigs and other belt driven machinery which operate from a stationary position were omitted from the total, the investment per acre on tractor farms would be about $5.75, or approximately the same as on horse power farms.

There was little difference in equipment investment between the horse power farms and the tractor farms with two horses, because the horse farmers owned various implements in duplicate. The value per acre, however, was about 75 cents more on the small tractor farms because the tractor and two horses had a higher value than the horses alone, and the number of crop acres was about the same.

Studies made by the Iowa agricultural experiment station[7] indicate the annual cost of depreciation, repairs, housing and interest of machines bought for tractor use averages about 16 per cent of the purchase price, other machinery 14 per cent. On this basis the total annual cost of the equipment represented in table 20 would be about $400 for horse power farms and $640 for tractor farms, or $1.10 per acre on horse power farms and $1.30 on tractor farms.

Quality of work compared.—The opinions of farmers in various states as to the effects of tractors on yields, and as to quality of work of tractors when compared with horses, has been secured in connection with studies of farm power[8]. Among 1,196 cooperating farmers only one per cent reported that they believed the tractor did poorer work than horses, or caused a decrease in yields; 16 per cent believed the work was better, or the crop yields were increased.

Other comparisons of horses and tractors.—Data given in the foregoing pages of this circular plus other information secured from farmers warrant the following general statements in favor of tractors and in favor of horses as farm power.

The tractor has a higher capacity for work both per hour and per day. It travels with greater speed and can be operated continuously regardless of heat, insects or time of day. This advantage enables a farmer to accomplish work in better season. It also enables him to farm more land with a chance for greater total net income. It provides power for belt work. Sometimes the costs of operating a tractor are lower than for horses.

Horses are better adapted to various kinds of work, to certain types and conditions of soil, to rough land and to small fields. Horses are necessary on most farms and the costs of an added tractor may be greater than the income added because of more work done, and on account of

7 Life, Service and Cost of Service of Farm Machinery, Iowa Agricultural Experiment Station Bulletin 260, p. 275, 1929.

8 Cornell University Agricultural Experiment Station Bulletin 405, p. 126, 1921, N. Y. U. S. Department of Agriculture Bulletin 1202, p. 49, 1924. Oklahoma, Kansas, Nebraska. Farmers' Bulletin 719, p. 18, 1916. Illinois.
U. S. Department of Agriculture Bulletin 1447, p. 13, 1926. Oregon.
Minnesota Agricultural Experiment Station Bulletin 280, p. 71, 1931.

savings caused by reducing the animal power. Horses furnish power at lower cash costs on South Dakota farms, and sometimes at lower total costs including interest on investment and depreciation in value. Horses sometimes increase in value. A given area of land on a farm will supply enough feed for a horse regardless of prices of feeds; but an area which will produce enough grain to buy a season's supply of fuel and oil when prices of grain are high, will not produce enough to buy a like supply when grain prices are low and the prices of fuel and oil remain unchanged. Horses can be managed by laborers who have no mechanical ability.

CONCLUSION.—The matter of comparative costs, rate and quality of work is not the final consideration. Although tractor power may mean a somewhat higher cost per unit of work done, it may in the long run add more to the net income of the farm than a cheaper source of power. This is brought about by increasing the farmer's capacity to handle a larger business[9] which may have a greater total net income, although the income per unit of production is less. Small farms cannot expect this advantage.

9. Larger business does not necessarily mean a larger acreage, it may mean the same number of acres farmed more intensively by adding legumes, more cultivated crops, more livestock, or better livestock, or by some other method whereby a greater earning power is secured.

PART II

Applying the Information Presented in Part I

Part I of this circular gives the costs and rates of performance of tractors and horses on farms in the wheat area of South Dakota in 1930, 1931 and 1932. Part II is an attempt to illustrate how this information may be used on individual farms in determining what power should be used under varying circumstances. Our first problem deals with an adjustment from one kind of power to another, a change which involves a period of several years, the investment of capital, and changes in the farm organization. The second problem deals with a choice of which power to use when various units of power are available and are not all needed at one time; this problem involves a choice for each season and each farm operation, for the purpose of reducing cash costs.

Adjustments on a Potter County farm

The first problem will be that of substituting a 10-20 tractor for a part of the horses on Farm No. 86, Potter county. The organization of the farm in 1930 is given in table 21. Two able-bodied men operated the farm. The children were too young for farm work, and there was no work outside the farm for either of the men if the use of a tractor were to reduce their working time on the farm. They had sufficient command of capital to make any desirable changes; there is plenty of land nearby that could be rented on the one-third crop basis and the soil and topography of the land is suitable for tractor use.

TABLE 21.—Organization of farm Number 86, Potter county, 1930

Crops	Acres	Livestock	Number
Wheat	35	Cows milked	8
Other small grain	168	Stock cows	4
Flax	19	Calves	10
Corn	153	Other young cattle	10
Alfalfa	14	Bull	1
Hay and pasture	347	Sows	30
Other land	16	Pigs raised	150
		Hens	200
Total	752	Horses	12

Ninety-eight acres of corn were husked, 35 acres cut, and 20 acres pastured. Threshing was hired done by a custom thresherman. Machinery, fencing, water system and buildings were all in good repair, and sufficient for the needs of the farm. Pasture and feed on the farm were sufficient to maintain the livestock and build a reserve for possible years of crop failure. The livestock and crops kept both men fully employed practically all of the year.

The time required with teams during 1930 for producing the grain and flax grown on Farm 86 is shown by months in table 22. During April and May 665 hours of time were required with teams for field

work on the grain crops and only 410 hours were available for one man because of short and rainy days. The second man was needed in the fields with a team for more than half time during those two months. During June 383 hours of work was performed with teams, requiring the full time of both men; and during the fall the second man and team were

TABLE 22.—Time required and time available for draw-bar work in producing grain and flax on Farm Number 86, 1930*

	April, May	June	July	Fall	Total
Man hours required:					
With horses	665	383	102	490	1,640
If tractor had been used	345	168	61	156	730
Hours available in 1930 for 1 man for field work with:					
Horses	410	195	185	470	1,260
Tractor†	450	260	270	470	1,450

* Shocking and threshing small grain, harvesting hay and other work for which the tractor is not commonly used were omitted from calculations, since they would be the same if the tractor were used on the farm without increasing the acreage.

† More hours are available for tractor performance because of its capacity to work steadily and long.

needed part time. The time which would have been required for a 10-20 tractor to perform the same work is also given in the table. If a tractor had been used instead of horses, one man could have done all of the drawbar work in connection with the crops and had time to spare each month. This indicates that if a tractor were substituted for horses on the farm, a greater area could be tilled.

Changing from horse to tractor power and increasing the size of business.—Various changes might have been made on Farm 86 to make it more profitable under 1930 price conditions, but for the purpose of making our problem easy to follow only three changes are proposed at this point of the discussion. They are: Substitute a 10-20 general purpose tractor for horses and sell eight horses. This change releases man labor time, and feed for eight horses. To use most of the time thus released, let us rent 200 acres of crop land on the one-third share basis. To use the feed and the remainder of the time let us add four milk cows to the herd. The cows should produce four calves each year, soon making about eight additional head of young cattle on the farm, or a total of 12 additional head. The remaining four horses would be needed during hay harvest, and two horses would be used frequently throughout the year.

After adding the 200 acres it might be best to grow more legumes or feed grains, to plan for a systematic rotation of crops, or to add more livestock; but for simplicity let us grow an extra 200 acres of wheat. The time required with the tractor for producing the increased acreage of crops is given in table 23.

By using the tractor one man could do all of the necessary drawbar work, and after the seeding was finished he would have time in season to help with harvesting hay, shocking grain, threshing, and corn harvesting. And the time released from caring for horses would be more

TABLE 23.—Time required and time available for tractor work in producing grain and flax on enlarged farm*

	April, May	June	July	Fall	Total
Tractor hours required for:					
Original acreage (Table 22)	345	168	61	156	730
Additional 200 acres of wheat	100		60		160
Totals	445	168	121	156	890
Hours available for 1 man and tractor working 10-hour days	450	260	270	470	1,450

* See footnote to table 22.

than sufficient to care for the additional cattle and for servicing the tractor. All other work on the farm is ignored in this discussion since no changes were made except for wheat, cattle and power. Interest charges on the investment and cost of new machinery to make the tractor most efficient are also ignored here but are discussed on page 33.

Effect of adjustment on net income.—Using 1930 prices, the changes in farm receipts and expenses due to the proposed adjustments are shown in table 24. The cash receipts of the new plan were $1,344. In addition to the cash income about $22 cash was saved by having eight fewer horses on which to pay taxes, veterinary and shoeing bills, and harness repairs; making a total of $1,366. The cash expenses for one year due to the adjustments were $853, leaving an additional cash income to the farm of $513 due to the adjustments suggested. Since, however,

TABLE 24.—Additional receipts, expenses and income due to making adjustments on Farm 86, using 1930 prices.

Cash receipts:		
200 acres wheat, ⅔ of 12 bu. yield, 1600 bu. @ .60	$960	
4 milk cows, 800 lb. butterfat @ .30	240	
8 young cattle, 2400 lb. growth @ .06	174	
Savings:		
Cash, 8 fewer horses @ $2.70 (see p. 20)	22	
Total cash	$1,366	
Non-cash, 8 horses, depreciation @ $5.50	44	
Total		$1,410
Cash expenses:		
89 10-hour days, tractor*, @ $4.26 (tables 7, 8)	$379	
200 bu. wheat seed @ $1	200	
2400 bu. wheat threshing @ .08	192	
600 lb. twine @ .13	78	
8 head cattle, taxes and miscellaneous @ .50	4	
Total cash	$853	
Non-cash expenses:		
Depreciation on tractor (table 7)	168	
Total		$1,021
Total additional NET income due to making adjustments		$ 389
Additional CASH farm income due to making adjustments		$ 513

* Includes fuel, lubricants, repairs and taxes.

tractors, older horses and harness depreciate in value each year, the depreciation is considered as an expense in the long run and should be listed as an expense each year. Eight fewer horses means the saving of the depreciation on that many, or $44 according to the judgment of Potter county farmers, making total credits of $1,410. The average annual depreciation on 10-20 tractors was $168. Adding $168 to the cash expenses of $853 makes total expenses of $1,021. Total receipts of $1,410 minus the total expenses leaves a net profit of $389 due to the adjustments.

Changing **kind of power but not size of business.**—If a 10-20 tractor had been purchased on Farm 86, and no other changes had been made in the farm organization, the calculated net returns to the farm for wheat, beef and butterfat, using 1930 prices, would have been about $310 (Table 25, column 3, line 10) or $410 less than by using horses only for power. This adjustment does not utilize the feed made available by the sale of eight horses or the labor made available by the use of the tractor. If these were

TABLE 25.—Calculated relative returns on Farm 86, original and adjusted plans, income prices variable, average 1930 production*

Line		Original business Column 1	Change to tractor power: Size of business: Increased Column 2	Change to tractor power: Size of business: Unchanged Column 3
1	Power costs, cash and depreciation†	$ 98	$581	$508
2	Threshing, twine and seed for wheat	82	550	82
3	Taxes on cattle	12	16	12
4	Total cost of 3 items	$192	$1,147	$602
5	Wheat @ .60	$252	$1,212	$252
6	Cattle @ .06	180	324	180
7	Butterfat @ .30	480	720	480
8	Total income from 3 items	$912	$2,256	$912
9	Total cost of 3 items (Line 4)	192	1,147	602
10	Net income of 3 items	$720	$1,109	$310
11	Wheat @ .45	$189	$ 909	$189
12	Cattle @ .05	150	270	150
13	Butterfat @ .20	320	480	320
14	Total income from 3 items	$659	$1,659	$659
15	Total cost of 3 items	192	1,147	602
16	Net income of 3 items	$467	$ 512	$ 57
17	Wheat @ .30	$126	$ 606	$126
18	Cattle @ .04	120	216	120
19	Butterfat @ .15	240	360	240
20	Total income from 3 items	$486	$1,182	$486
21	Total cost of 3 items	192	1,147	602
22	Net income of 3 items	$294	$ 35	-$116

* Average production was 12 bushels of wheat per acre, 200 pounds of butterfat per cow, and 300 pounds of beef per head of young cattle.

† Includes cash cost and depreciation of 12 horses on the original farm, and for four horses and tractor on the adjusted farms.

put to productive use or sold, the net return received thereby would be added to the net return to the farm.

Effect of price change on net income.—The prices of 1930 are now history, so we must compare the effects of lower prices on the original and on the adjusted farm business. Table 25 shows, first, a summary of the calculated expenses of the original and of the adjusted plans for the items of adjustment only. (Lines 1-4.) Then follow the calculated receipts and net income for the items of adjustment at the 1930 prices (Lines 5-10) and at two sets of lower prices for farm products. (Lines 11-16 and 17-22.) It was assumed that expenses and other features of the farm business were not affected by the adjustments.

The net returns for wheat, feeder cattle and butterfat at 1930 prices were $720 on Farm 86. (Line 10, column 1.) The returns to the increased business (Column 2) for the three items were $1,109, a difference of $389 in favor of the increased size of business and use of a tractor. If the power were changed but size of business remained the same (Column 3) the returns would be only $310, or $410 less than the original plan.

If prices were about 25 per cent lower than in 1930, the larger business and tractor would still be the most profitable of the three plans, and the smaller business and tractor would be the least profitable. (Line 16.) With prices similar to those of 1932, the adjusted farms are both at a disadvantage when compared with the original horse power farm. (Line 22.) These figures indicate the economic disadvantage of the tractor in periods when prices of farm products are low, and the prices of tractors, repairs, gasoline and oils are relatively high. This is especially applicable to farms of small business.

Effect of changes in production on net income.—If we assume the yield of wheat per acre, the rate of gain on cattle, and the butterfat production per cow to be about 25 per cent less than in 1930, and the expenses per unit the same, the net returns to the farm for those three items at various prices would be similar to those shown in table 26.

The larger business has a financial advantage of about $90 over the original plan if 1930 prices are used (Column 2, line 10) but it becomes a losing proposition if lower prices are applied to the lower production. If a tractor is substituted for eight horses and the size of business is not increased (Column 3) the plan is undesirable under each set of prices used. These figures further illustrate the disadvantage of small tractor-farms, and of large tractor-farms when prices of farm products are quite low.

The effect of adjustments on labor.—On Farm 86 no savings in wages would be made by making the proposed change from horse to tractor power and increasing the size of the business as suggested, since two men are now operating it as partners and no help is hired. If one of the men were hired by the day, however, at least a month's wages could have been saved during April and May since the field work during that time required 665 hours of man's time with teams, but would have required only 345 hours with a tractor. (Tables 22 and 23.) If the size of business were increased as suggested, one man could still do all of the field work in the spring. In June a full month's wages could be saved since the time required with horses for field work on grain was 383 hours and the tractor might have done it in 168 hours.

TABLE 26.—Calculated relative returns on Farm 86, original and adjusted plans, income prices variable, production 25 per cent below the 1930 average*

Line		Original business Column 1	Change to tractor power: Size of business: Increased Column 2	Change to tractor power: Size of business: Unchanged Column 3
1	Power costs, cash and depreciation†	$ 98	$ 581	$416
2	Threshing, twine and seed for wheat	74	504	74
3	Taxes on cattle	12	16	12
4	Total cost of 3 items	$184	$1,101	$502
5	Wheat @ .60	$189	$ 909	$189
6	Cattle @ .06	135	243	135
7	Butterfat @ .30	360	540	360
8	Total income from 3 items	$684	$1,692	$684
9	Total cost of 3 items	184	1,101	502
10	Net income of 3 items	$500	$ 591	$182
11	Wheat @ .45	$142	$ 682	$142
12	Cattle @ .05	112	202	112
13	Butterfat @ .20	240	360	240
14	Total income from 3 items	$494	$1,244	$494
15	Total cost of 3 items	184	1,101	502
16	Net income of 3 items	$310	$ 143	−$ 8
17	Wheat @ .30	$ 95	$ 455	$ 95
18	Cattle @ .04	90	162	90
19	Butterfat @ .15	180	270	180
20	Total income from 3 items	$365	$ 887	$365
21	Total cost of 3 items	184	1,101	502
22	Net income of 3 items	$181	−$ 214	−$137

* Average production was 12 bushels of wheat per acre, 200 pounds of butterfat per cow, and 300 pounds of beef per head of young cattle.

† Includes cash cost and depreciation of 12 horses on the original farm, and four horses and tractor on the adjusted farms.

When labor is hired, any wages saved by using a tractor instead of horses may be subtracted from tractor costs when comparing the two kinds of power. If unpaid labor is released by the use of a tractor and is not employed at productive work somewhere, the labor saved does not increase the net income from the farm.

Effect of adjustments on custom and belt work.—The discussion accompanying tables 23 and 24 indicates that there would be time available for doing custom work with a tractor if the farm were reorganized as proposed. Such work would increase the cash expenses of the tractor, but these should be more than offset by the receipts for the work. No additional charges should be added against the tractor for interest, taxes or ordinary depreciation when custom work is done, but they must be taken into account as a cost when determining the custom rate to charge.

An eight-horse-power stationary engine was used 50 hours for grinding feed on Farm 86, at a cash cost of about 20 cents an hour. This was cheaper than the work could have been done with a tractor. However,

grinding can frequently be done more cheaply with a tractor at home than by custom grinders, since the fixed charges for a year on a tractor remain the same regardless of the number of days the tractor is used.

Effect of adjustments on machinery used.—The investment in farm equipment, not including auto or truck, on Farm 86 averaged $2,255 in 1930; the investment in horses was $617. This amount was considerably above the average investment of all of the farms studied because of the good condition of the equipment and the large number of implements that were owned in duplicate, such as two each of plows, disks, harrows, etc. If a tractor had been purchased in 1930, the implements which would have been rendered of little use on the farm might have been sold then at public sale for about $1,300. Other equipment to render the tractor efficient would have cost about $1,900 if purchased new. This would have meant a sacrifice cost of about $600 for implements only. Many farms with old, or small amounts of machinery might have had to pay a greater difference between the amount received for the old equipment and the price paid for the new, but the sacrifice cost would be less because the old was of little value and needed to be replaced soon.

The relatively high prices of new machinery now (1932) and the low selling price of used machinery accompanied by low prices of farm products, make changes in power and equipment expensive. A similar statement would be true of the relatively high prices of tractors and the 1932 prices of horses.

Miscellaneous considerations.—Interest charges were not included in the previous discussions of Part II because interest is not a cash cost of power unless there are debts against the horses or tractor. If 8 per cent interest on the value of horses and tractor had been included as a charge in tables 25 and 26 the net returns in each case would have been decreased about $25 for the original farm and about $65 for the adjusted farm organizations. This would decrease any economic advantage of the tractor when prices were good and increase any disadvantage when prices are low.

If the price of fuel had been 2 cents lower per gallon and oil 10 cents lower per gallon the net returns would have been increased $42 for the enlarged farm, and $35 for the farm with type-of-power only changed.

If it were necessary to purchase feed for the horses, any economic advantage of horses would be considerably decreased. The average value of all feed and pasture per horse on horse farms was estimated to be about $35 at 1930 prices.

The purchase price of a tractor and implements should be considered as investments, never as expenses of running the current year's business. A fraction of the purchase price, based on the expected life of the implement, should be considered as depreciation and charged as an annual business expense. The purchase price of land and livestock and the cost of remodeling a building to accompany a change from horses to tractor, should also be considered as investments rather than as current expenses.

A successful tractor farmer usually needs a greater command of capital than a horse-power farmer because: The cash costs of operating a tractor are usually higher than the cash costs of horses; the investment in power and equipment on tractor farms is generally greater; and various studies indicate that tractor farms should be larger than horse farms of

the same type of business. The larger capital involved and larger business usually require greater managerial ability.

Adjustment illustration not the most profitable change.—The changes chosen for Farm 86 and discussed in the previous pages were selected to illustrate the changes in receipts, expenses and net returns which might be expected under various conditions if tractor power were substituted for horse power. The organization changes proposed were: To produce 200 acres more of wheat, to use man labor to better advantage, and to add 12 head more of cattle to use the feed released by having eight fewer horses. These changes provided a similar illustration of a method of estimating the result of making adjustments, than would the changing of acreage of several crops and adding different kinds of livestock. The changes discussed were not, however, the best possibilities for increasing the net income. The enumerated costs of producing the wheat on the adjusted farm were greater than the amount received for it in every case, except on the enlarged farm with 1930 prices. This indicates that the production of more feed grains and more livestock might have been a more profitable venture, since most of the net reutrns from the addition of the tractor and land came from the increased returns from livestock.

It is not within the scope of this publication to treat complete farm budgets at length, but the foregoing discussion indicates that much care should be exercised before major changes in farm power are made, especially in times of low prices for farm products. Budgets similar to that illustrated by Farm 86 should be drawn up showing details of each plan proposed; the various changes in land, labor, livestock, crops, and capital involved which would accompany each plan; and the resulting changes in receipts, expenses and net returns that could be expected from the adjustments.

Choice of Power When Different Units Are Available

Our second major problem will be that of choosing which power to use when various units of power are available and are not all needed at one time; the purpose of such a choice being to reduce cash costs as much as possible. This problem deals with choosing for each season or for each farm operation, which of the available power units should be used. It is in contrast to the first problem which dealt with an adjustment from one kind of power to another, an adjustment which involves a period of several years, the investment of capital, and changes in the farm organization.

We shall use for discussion Farm Number 88 in Potter county. During 1930 the power on this farm consisted of six good draft horses, and a 10-20 and a 15-30 tractor. All of the power was used during peak-load seasons and the 15-30 was used a great deal for belt and custom work. There was a good supply of desirable implements on the farm. The family of the operator of the farm included two grown boys who were at home full time and one younger boy who frequently operated one of the tractors. The crops grown in 1930 included 32 acres of flax, 78 of wheat, 224 of other small grain, 240 of corn, 52 of alfalfa, and 22 of rye pasture; a total of 648 acres of cultivated land. There were also more than 1,000 acres of native hay and pasture.

To illustrate a method of choosing the lowest-cost power it is necessary to discuss only the spring work. The time available in 1930 for one man for field work with horses or tractor was the same as for Farm 86. (Table 22.) The table shows there were 410 hours suitable for doing spring work with horses, and 450 hours suitable for tractor work. The greater number of tractor hours was due to the capacity of a tractor to work longer days than horses. The time which would have been required for the six horses, and for each of the tractors alone to do the field work in the spring is shown in table 27. The work would have required 951 hours of time for men with teams, 530 hours with the 10-20 tractor, and 435 hours with the 15-30 tractor. The 435 hours includes 53 hours use of the 10-20 tractor for planting corn since the large tractor is not adapted to such work.

Our problem is that of keeping current cash costs low, and table 17 indicates that the cash cost of horse power is less than the tractor power, therefore, let us first consider using the horses to their full capacity. Since 951 hours of time would have been required for men with teams to do the spring work and there was only one 6-horse team—capable of 410 hours of work—available, it would have been necessary to use one of the tractors also if the required work were to be finished in good season. The problems then become, which tractor should be used to supplement the horse power, and which operations should it perform.

Table 12 indicates that when wages are not involved, and they are not in this particular case, the cash cost of operating a 10-20 tractor is less than that of a 15-30 tractor. For this reason we shall choose the 10-20. Two combinations of the use of the tractor are given below to illustrate a method of choosing the least cost combination. The tractor must do work which would require approximately 540 hours (951 minus 410) with man and team, although it will not take 540 hours for the tractor to do it. First let us use the 10-20 tractor for all of the plowing,

TABLE 27.—Calculated time necessary for spring field-work with different units of power, Farm 88, Potter county, 1930

Line	Crop	Acres	Operation	Horses, 6 or less	10–20 tractor	15–30 tractor
				Hours	*Hours*	*Hours*
1	Corn	240	Plowing	398	209	146
2			Harrowing 3 times	108	72	65
3			Planting	142	53	* 53
4	Wheat	110	Disking	36	22	16
5	and		Harrowing 1 time	16	11	10
6	flax		Drilling	36	24	24
7	Barley	224	Disking	74	45	32
8	and		Harrowing 2 times	67	45	40
9	oats		Drilling	74	49	49
10	Total time required			951	530	435
11	Time available for 1 power unit			410	450	450

* Fifty-three hours of working time for the 10–20 tractor is inserted here since the 15–30 tractor is not adapted to corn planting.

for harrowing the corn ground three times, and for disking the wheat ground. This would require 398, 108 and 36 hours respectively with the team, or a total of 542 hours. (Table 27, lines 1, 2, 4.) The cash cost of fuel and lubricants would be $119. (Example A.) A second trial might be to use the tractor for all of the plowing and corn planting. The cash cost in this case would be $99. (Example B.) Thus the costs of different combinations of use of horses and tractor may be tried until the lowest cash cost plan for the spring work is found. Similar calculations may

Example	Team time saved by using tractor	Tractor work and cash cost	
	Hours		
A	398	Plowing 240 acres @ .34 (Table 12)	$ 82
	108	Harrowing 240 acres 3 times @ .04	28
	36	Disking 110 acres @ .08	9
	542		$119
B	398	Plowing 240 acres @ .34	$ 82
	142	Planting 240 acres @ .07	17
	540		$ 99

also be made to determine the lowest cost combinations for other seasons of the year. The cost of horses was not considered in this discussion because in our problem they are worked to full capacity and their cost remains constant throughout the problem.

The lowest cost plan may not be the most profitable plan, however, since it may incur conflicts which would prevent timeliness of performing work, and losses might result. On Farm 88, for example, losses would occur if the horses were used for cultivating corn when they could be employed more profitably for making alfalfa hay.

If the lowest cost of producing crops on Farm 88 is sought, this illustration indicates that the 15-30 tractor should not be used for any of the spring field work with the 1930 farm organization, and the 10-20 should be used as a supplement to horse power for spring work, rather than as major power. If it were necessary to hire help because of using a slower kind of power, the added wages would need to be considered as a cash cost of getting the work done. The illustrations used may not be the best adjustments for the farm since livestock enterprises and net returns to the farm were not considered; however, they demonstrate the desirability of carefully choosing which power to use when a choice is available, and they show a method of making the choice.

CONCLUSIONS

The data discussed in this circular indicate that many farms in the Wheat Area of South Dakota are not operating their separate power units at their maximum efficiency. The low efficiency units are represented by the tractors which consume more fuel and oil per 10 hours than the averages given in table 3; by the horses which are fed more than the average of other horses doing a similar amount of work; and by tractors and horses that perform less work per 10 hours than the most common performances given in tables 10 and 16. Even the averages are not to be considered the optimum of efficiency since many teams and tractors do better than the averages; and since the averages include power units which were operated with less than their respective optimum loads.

The efficiency of tractors may be improved and the cash costs of operation reduced by making needed repairs and adjustments, by using proper hitches, by operating with an optimum load, and by good bargaining for fuel and oil. Efficiency of horses may be increased and the costs reduced by having harness and implements in best adjustment, by using proper hitches and loads, by economical feeding and by using mostly young horses. Farm power costs may be further reduced by less threshing of feed crops, and by harvesting more of the feed crops with livestock.

Data discussed in this circular and unpublished data secured in 1930, also indicate that many farms in the South Dakota Wheat Area do not have the best possible power combinations. Adjustments to secure such combinations frequently involve considerable changes in amounts of land, labor and capital, and a period of several years. Increasing the crop acreage of farms would reduce the total costs per acre of the power units thereon, and on many farms the increase would make the power units more effective. If the added acreage could be secured with small cash outlay, the net returns to the farm might be enhanced also. A partial shift from the use of a large tractor to more use of a smaller one; or a shift from tractor as major power to horses as major power, would be desirable on some farms during periods of low prices for farm products. Net returns to the farm business over a period of years should determine any adjustments which would be effective for a long time. Under normal economic conditions net returns are of greater importance than the temporary lowering of cost per unit of power, per unit of land, per laborer, or per unit of product.

Adjustment and Utilization of Farm Power Under Conditions Similar to 1932

Insofar as power is concerned, what can a farmer do to help his financial conditions during a depression?

The success of any business depends on the total net income over a period of years. Net income is determined by the gross income and the total costs of production. Gross income is determined by the volume of production and the prices of the products. Costs of production are affected by volume of production. During periods of depression the need for low cost of production is especially imperative. These principles should aid in choosing what farm power to use. For purposes of discussing the question, South Dakota farmers might be classified first, into those with little or no debts and those with high indebtedness; then subdivided into horse farmers, tractor farmers with few horses and little horse equipment, and tractor farmers with more horses and horse equipment. The following general statements are based on quantity data secured in the 1930 study and calculations made with 1932 prices.

Adjustments where debts are low.—The best procedure in most cases would be to borrow as little money as possible for operating expenses.

1. *Horse farmers.*—Continuing with horses would be more economical at present than a shift to tractor power, even if it were necessary to hire some help, or buy horse feed, or replace some implements. Cash outlay would be less in replacing implements if good used ones were purchased.

2. *Tractor farmers with few horses and little horse equipment.*—If the farm business is small, tractor farming is likely to be a loosing proposition; the production cost per crop acre is sure to be relatively high. An increase in crop acreage on the share basis should reduce the cash cost per acre and provide a larger volume of products for sale. If the probable cash cost of any added acreage does not exceed the anticipated returns from the additional area, any expansion in the crop acreage with normal yields should increase the farm income. If the farm business is large, it might pay to secure some used horse equipment and add a few horses, thus eliminating some of the cash costs of operating the tractor.

3. *Tractor farmers with more horses and horse equipment.*—The current cash cost of horse power is less than the current cash cost of tractors. Depreciation and taxes on tractors will continue but cost of gas, oil and repairs may be reduced by a minimum use of the tractor in the production of crops, thus lowering the cost per farm and per acre.

Adjustments where debts are high.—High indebtedness means high interest to pay, therefore relatively high fixed charges against the farm business. To meet the interest and other costs one should attempt to add to the cash receipts without adding as much or more to the cash costs. This attempt must sometimes be made even though the risk may be increased.

1. *Horse farmers.*—Continuing with horses is the only economical choice. Share renting so as to operate as much crop land as can be effectively farmed with the available horses and equipment should increase

the receipts without a corresponding increase in cost even if some labor need be hired. Where custom plowing can be hired at reasonable rates, the crop acreage might be increased to advantage by that method.

2. *Tractor farmers with few horses and little horse equipment.*—If the farm business is small probably the only way of meeting the relatively high costs of the indebtedness and the tractor would be to increase the number of crop acres, through share renting, so as to increase the volume of products for sale and at the same time reduce the cash costs per acre. If cheap horse feed is available, an advantage might be gained by trading the tractor and its equipment for horses and horse equipment.

3. *Tractor farmers with more horses and horse equipment.*—The less the tractor is used the lower will be the cash cost per farm and per acre. However, limited use of the tractor at times when the demand for draw bar work is great, may enable a farmer to farm many more acres at an additional cost lower than the anticipated additional returns. This should increase the net cash returns to the farm business.

Adjustments applicable to most farms.—Farming more acres at lower cost per acre in South Dakota is likely to be more profitable during periods of low prices than farming small areas intensively. This is because of the low returns per acre for products, and the risks of drought. When prices get so low, however, that returns per acre are likely to be less than the out-of-pocket cost per acre, it would be desirable to decrease the size of the business. Cash costs of power may be reduced by growing more crops with low labor requirements, having the livestock harvest as much of the grain as possible, feeding low priced grain to livestock without threshing it, and using horses instead of tractors whenever it is practical. Increasing the crop area by share renting eliminates cash rental cost and reduces risk.

As long as the present disparity exists between the costs of machinery and the income from farm products sold, the purchase of new equipment to save labor is doubtful economy however, over a long period of years, labor saving machinery is likely to prove profitable.

Every farm is a problem in itself and the most profitable power combination on one farm might be unprofitable on another farm of similar type or under similar conditions. When considering any major adjustment on a farm, the making of a budget should be helpful. The budget could be drawn up on a plan similar to the illustrations of Farms 86 and 88; first listing changes that would be affected in labor, use of power, land use, feed, products for sale, and capital investment. The listed changes should then be carried through to discover if any are out of balance; to find the additional receipts and expenses that may be expected of each item at prospective prices and rates of production; and, most important of all, to calculate the probable net returns that would result if the adjustments were put into effect. Before making adjustments involving the investment of much capital, the probable net returns over a period of years should be considered.