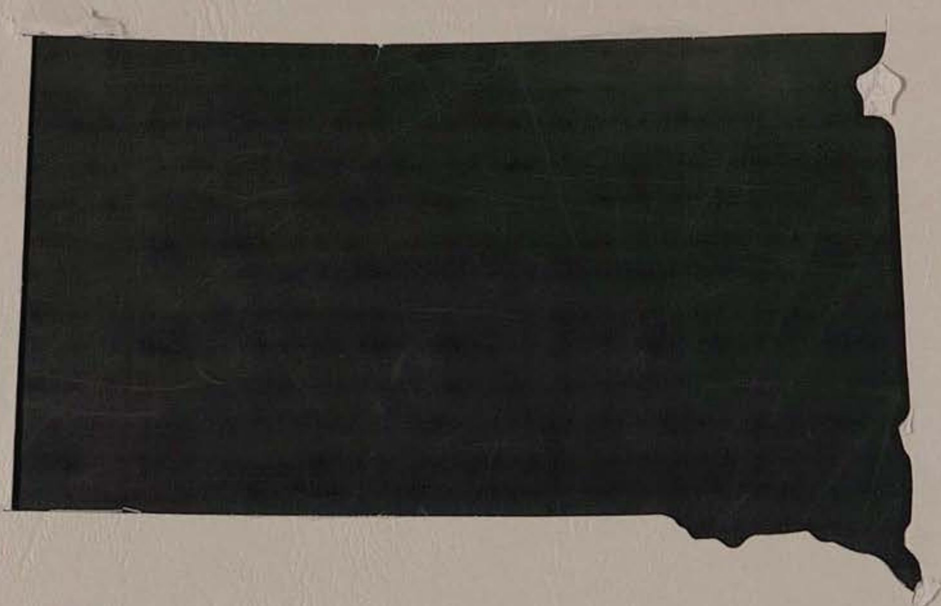

ECONOMICS DEPARTMENT

South Dakota State University
Brookings, South Dakota

Analysis of Effects of Machinery Costs on Relative Profitability of Different Farming Systems[1]

by

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Economics Pamphlet 93-2

August 1993

[1]This research was supported by the SDSU Agricultural Experiment Station and by U.S. Department of Agriculture LISA Grant LI-88-12.

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Preface

The NE Experiment Station case analyses section in this report draws heavily from a machinery analysis compiled by David Becker and Kellie Koehne. Research leading to this report was supported by the SDSU Agricultural Experiment Station and by U.S. Department of Agriculture LISA Grant LI-88-12.

Thanks are expressed to Professors Thomas Dobbs and James Smolik for reviewing this manuscript. The author is responsible for any omissions or remaining errors contained in the report.

LDH
August 1993

"Sixty-five copies of this document were printed by the Economics Department at a Cost of $1.62 per document."

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Analysis of Effects of Machinery Costs on Relative Profitability of Different Farming Systems

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Introduction

The purpose of this analysis is to examine machinery costs and utilization for different farming systems and how each system is affected by such factors as crop diversification, soil tilth, timing of operations, and economies of size.

The analysis is based on data collected at two different geographical areas in South Dakota. The first site is the South Dakota State University (SDSU) Northeast Research Station, north of Watertown, S.D.. This farm is located in the transition area between the region where the primary rotation consists of corn and soybeans and the region where small grains predominate in rotations. Two different studies were conducted to represent different cropping patterns. Farming Systems Study I (FSSI) emphasized row crops and included Alternative, Conventional, and Ridge Till rotations. No commercial fertilizers or pesticides were used in the Alternative system. The Conventional and Ridge Till systems used fertilizers and herbicides at application rates that were recommended by the SDSU Plant Science Department. Farming Systems Study II (FSSII) emphasized small grains and included Alternative, Conventional, and Minimum Till systems.

Once again, no commercial fertilizers or pesticides were used for the Alternative system, and the Conventional and Minimum Till systems used fertilizers and pesticides at rates recommended by the SDSU Plant Science Department.[1]

The other site of data collection is a matched pair of east-central South Dakota Alternative and Conventional farms. The Conventional farm follows a corn-soybean rotation and the Alternative farm until recently has followed a 4-year rotation consisting of small grain overseeded with alfalfa-alfalfa-soybeans-corn. The Alternative farm uses no purchased chemical fertilizer or herbicide inputs, but rather relies on its crop rotation to meet fertility needs and pest control. These two farms have different machinery inventories to fit their different farming systems.

For this analysis, we examined a "normalized" situation for the Northeast Station systems and a "typical" year for the Madison farms. For the Northeast Station, we derived "typical" machine operations from 1986-1992 "cultural practices" tables. From these tables, average machine operations were calculated for the 7-year period. We then decided what to include in the "normalized" budgets. Some of the machine operations averaged out to less than .5 operations a year, but were included in the normalized budget if they were operations that were adopted in the later years of the study and were considered to be the most

[1]A forthcoming bulletin by Smolik, et al (1993) will contain more details on these cropping systems.

effective machine operations.

Annex Tables A-1 and A-2 list the "typical" machine operations in FSSI and FSSII, respectively. These "typical" machine operations were then used to generate machinery budgets, which became a component of our "normalized" Northeast Station budgets. These budgets were based on average yields, average herbicide use, average crop prices, average deficiency payments, average fertilizer use, etc. The normalized budgets used current (1992) prices for all of the inputs. Crop acres were allocated using percentages calculated for the Northeast Research Station studies and multiplying these percentages by 800 acres (the number of crop acres in the normalized budgets).

A different approach was used for the Madison farms. Economic performance was averaged for the 1985-1992 8-year period. Each year's economic performance was then compared to the average economic performance. Once a year was found that compared favorably in terms of economic performance, it was then examined to make sure that the weather patterns of that year were also relatively "typical", having no extremes of temperature or moisture. The 1991 crop year compared most favorably in both the economic and climatic aspects, so 1991 was designated as the "typical" year for the Madison farms.

N.E. Experiment Station Case Analyses

Overview of Machinery Use and Costs

The normalized budgets for the Northeast Station were used to examine the possibility of some differences in the fixed, variable, and total costs for the three types of farming systems and related tillage practices. These differences may be attributed in part to different machinery requirements due to the machine operations scheduled for each type of system and tillage practice. Agronomic factors such as soil tilth may also be affected by the type of system that is used. The Alternative system is assumed to have a positive effect on soil tilth, which may reduce the amount of horsepower required for the tillage operations. These reduced horsepower requirements could result in lower fuel costs.

To study the effects of these possibilities, we have to determine how the fixed, variable, and total costs are affected by changes in fuel cost and depreciation costs. Table 1 gives a baseline value for direct cost, gross income, and various net return values at the Northeast Research Station.[2] One of the values that we are interested in is the direct (variable) cost. For this analysis, direct costs are influenced in part by changes in the fuel costs. Total costs will change with changes in both depreciation and fuel costs, among other things. Table 2 shows

[2]More detailed results over the 1986-1992 period at the Northeast Research Station can be found in Dobbs (1993) and in Smolik, et al (1993).

Table 1. Results of Farming Systems Analyses Based upon the Normalized Budgets for the Northeast Research Station.

System[a]	Direct Costs Other Than Labor	Gross Income	Dollars/Acre — Net Income Over — All Costs Except Land, Labor, and Management	All Costs Except Land and Management	All Costs Except Management	Whole Farm, Net Income Over All Costs Except Management[b] ($)
Farming Systems Study I						
1. Alternative (oats-alfalfa-soybeans-corn)	45	159	82	69	43	34,138
2. Conventional (corn-soybeans-s. wheat)	63	157	62	52	26	20,926
3. Ridge Till (corn-soybeans-s. wheat)	69	144	44	35	9	6,948
Farming Systems Study II						
1. Alternative (oats-clover-soybeans-s.wheat)	31	105	51	42	16	12,487
2. Conventional (soybeans-s. wheat-barley)	50	131	50	40	14	11,107
3. Minimum Till (soybeans-s. wheat-barley)	60	120	32	23	-3	-2,748

[a]Crops are shown in the order in which they occur in each rotation.

[b]For farm with 800 tillable acres.

Table 2. Costs for Farming Systems Study at NE Research Station Near Watertown, SD.[a]

	Total Cost	Total Dep.	Total Fuel
FSSI:			
Alt	$93,445	$13,451	$3,710
Conv	$104,387	$12,866	$3,315
RT	$108,219	$12,744	$3,215
FSSII:			
Alt	$71,168	$9,740	$2,612
Conv	$93,867	$12,897	$3,504
MT	$98,877	$11,750	$2,909

[a]For farm with 800 tillable acres.

total, depreciation, and fuel costs for FSSI and FSSII.

Total normalized costs for FSSI based on an 800-acre farm were as follows: Alternative - $93,445; Conventional - $104,387; and Ridge Till - $108,219. The total costs for the Conventional and Ridge Till systems were substantially greater than the total cost for the Alternative system. Most of this higher cost can be attributed to the use of commercial fertilizers and pesticides. These commercial inputs contributed as much as $37/acre to the spring wheat crop in the Ridge Till system, for example. Total cost has two components: fixed costs and variable costs. For this machinery analysis, depreciation (one of the fixed) and fuel (one of the variable) costs will be compared between the different systems, as will their role in the total cost of each system.

Depreciation costs for each system in FSSI were: Alternative - $13,451; Conventional - $12,866; and Ridge Till - $12,744. For this study, we assume that machinery needed for the farming systems will be fully utilized due (if necessary) to shared use with relatives or neighbors.

Another way to compare depreciation cost between the three systems of FSSI is to look at depreciation cost as a percentage of total cost for each system. These percentages rank in the same order as the depreciation costs, with Alternative, Conventional, and Ridge Till having percentages of 14.4%, 12.3%, and 11.8%, respectively.

The fuel cost followed the same pattern as the depreciation costs. The Alternative system in FSSI had the highest fuel cost, at $3,710. The Conventional system had a fuel cost of $3,315 and the Ridge Till was only slightly lower, at $3,215. The high fuel cost for the Alternative system may be due to the Alternative system's heavier reliance on mechanical weed control operations. Comparing fuel cost on the basis of percentage of total cost, the rank is the same, with the fuel cost in the Alternative system making up 4.0% of the total cost, the Conventional system's fuel cost making up 3.2%, and the Ridge Till system's fuel cost making up 3.0%. Since the Alternative system has the highest depreciation cost and the highest fuel cost, but has the lowest total cost, it is evident that the Conventional and Ridge Till systems are incurring more expense in other areas.

The Alternative system had the highest net return, at $34,138. The Conventional system had a net return of $20,926, and the Ridge Till system had a net return of $6,948.

FSSII systems were comprised of different crop mixes than FSSI, and these differences had some impact on the costs and net returns. One difference is the emphasis on small grain crops in FSSII and the absence of corn in any rotation. Another difference is that a Minimum Till system is used in FSSII as opposed to the Ridge Till system used in FSSI. As with FSSI, all figures cited from FSSII are based on a hypothetical 800-acre farm.

Overall, the total costs for FSSII were less than FSSI. The Alternative system had the lowest total cost of $71,168. The Conventional system had a total cost of $93,867 and the Minimum Till had a total cost of $98,877. Once again, the Conventional system and the Minimum Till system have substantially higher total costs due in part to their reliance on commercial chemical inputs for pest control and fertility.

In FSSII, the rank changed for depreciation costs. The Alternative system had the **lowest** depreciation cost, $9,740. Depreciation costs for the Conventional and Minimum Till systems were $12,897 and $11,750, respectively. Depreciation costs for the Alternative system were significantly lower due to the fact that, each year, 25% of the acres in the Alternative system are planted to clover. The clover crop is not harvested, but rather tilled back into the soil as green manure. When depreciation cost as a percentage of total cost was compared between the systems, it was found that depreciation costs for the Alternative system and the Conventional system made up the same percentage (13.7%) of their respective total costs. The depreciation cost in the Minimum Till systems made up 11.9% of total costs.

The practice of tilling the clover crop back into the soil as green manure in the Alternative system may also be a contributing factor in its low fuel cost, $2,612. Fuel costs for the Conventional system were $3,504 and they were $2,909 for the Minimum Till system. Fuel costs for the Alternative system and the Conventional system made up the same percentage (3.7%) of total costs for their respective systems. Fuel cost for the Minimum Till system was 2.9% of total costs.

The Alternative and Conventional systems had positive net returns of $12,487 and $11,107, respectively. The Minimum Till system failed to cover all costs, having a negative net return of -$2,748. These low return figures may be attributed to the absence of corn and alfalfa hay from any of the rotations in FSSII.

Farm Diversity

Machinery utilization is the next factor we examined in the study. Some of the equipment was either "overused" or "underused" in relation to the number of hours that were assumed for them in the machinery analysis for 1986-1992 compiled by David Becker and Kellie Koehne.[3] The criteria that was used to determine if a piece of equipment was "overused" or "underused" was if the actual hours of use was more than 25% above or below the assumed use for a single piece of equipment. Table 3 shows which pieces of equipment were overused or underused for each system. The table also shows by what percentage each piece of equipment was overused or underused. Table 3 was derived by totaling the hours of use for each piece of machinery for all crops in each system. Total hours for each piece of machinery were then compared to the assumed hours of use taken from the machinery analysis. If total hours were greater than 25% over or

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[3]This machinery analysis was compiled in 1992 by David Becker and Kellie Koehne, former SDSU Economics Department Research Asssistants.

Table 3. Underused and Overused Machinery for the Normalized Study at the Northeast Research Station.

Underused Machinery - FSSI

	Actual Hours			Assumed Hours			% of Assumed Hours Left Unused		
Machinery	Alt	Conv	RT	Alt	Conv	RT	Alt	Conv	RT
Drill	57.02	72.49	72.49	100	100	100	42.98	27.51	27.51
Baler	69.30			100			30.70		
Combine	115.74			180			35.70		
Chisel Plow	71.10	13.92	53.99	100	100	100	28.90	86.08	46.01
2		24.68	24.68		50	50		50.64	50.64
Fld. Cultivator			54.78			100			45.22
Swather		28.22	28.22		75	75		62.37	62.37
Stalk Shredder			40.57			80			49.29
Moldboard Plow		81.75			250			67.30	
Drag Harrow		66.44			100			33.56	
Disk	22.90	29.11		100	100		77.10	70.89	

Underused Machinery - FSSII

	Actual Hours			Assumed Hours			% of Assumed Hour Left Unused		
Machinery	Alt	Conv	MT	Alt	Conv	MT	Alt	Conv	MT
Moldboard Plow		163.50			250			34.60	
Planter	32.35	38.66	38.66	60	60	60	46.08	35.57	35.57
Rotary Hoe	65.13			100			34.87		
Swather	47.22			75			37.00		
Combine	123.13			180			31.60		
Rotary Mower	68.02			100			31.98		
Chisel Plow	67.07	13.92		100	100		32.93	86.08	
Drag Harrow	74.13	66.44	22.15	100	100	100	25.87	33.56	77.85
Fert. Spreader		24.68	24.68		50	50		50.64	50.64
Fld. Cultivator			54.11			100			45.89
Disk		29.11			100			70.89	

Overused Machinery - FSSI

	Actual Hours			Assumed Hours			% Over Assumed Hours		
2	Alt	Conv	RT	Alt	Conv	RT	Alt	Conv	RT
Cultivator	143.21	182.06		100	100		43.21	82.06	
Planter		77.32	77.32		60	60		28.87	28.87
Grain Wagon		145.70	138.62		100	100		45.70	38.62

Overused Machinery - FSSII

	Actual Hours			Assumed Hours			% Over Assumed Hours		
Machinery	Alt	Conv	RT	Alt	Conv	RT	Alt	Conv	MT
Fld. Cultivator	134.43			100			34.43		
Drill		144.98	144.98		100	100		44.98	44.98

Note: "Actual hours" are based on machine hours.

under the assumed hours, then the piece of machinery was considered overused or underused. The total hours of use are based on the "normalized" budgets.

Timeliness of operations is a factor that must be considered when discussing machinery utilization. However, timeliness is not a consideration in Table 3. If too many operations must be completed during a certain time frame, then more tractors and labor will have to be employed to meet these requirements. The Alternative systems, with their diverse crop rotations, have the benefit of spreading their operations out over a longer time frame than the Conventional systems. Since the Alternative systems have more crops, each crop has less acreage, making it potentially easier to avoid time constraints. The reduced tillage (Ridge Till and Minimum Till) systems also have some advantage over the Conventional systems, due to the reduced number of tillage operations used in these systems.

When the machinery operations for each system listed in the machinery analysis were scrutinized, it was decided that all of the systems could probably get by with three tractors, and in some systems it would be feasible to assume that only two tractors are needed to perform the required machinery operations. The systems that could get by with two tractors include the Ridge Till system in FSSI and the Alternative system in FSSII. These systems are able to get by with two tractors because the Ridge Till system has fewer machine operations compared to the other systems, and the Alternative system in FSSII has 25% of its acres in clover that is tilled back into the ground, greatly reducing the amount of tractor hours for these systems. Farmers using the Minimum Till system of FSSII could cover all of the necessary operations with two tractors, but the tractor use would be so inefficient in the terms of fuel consumption (because of tractor size) that it was decided that three tractors would be more reasonable. It was necessary to make sure that all of the possible bottlenecks that could occur during the cropping season could be accommodated by the reduced number of tractors.

As the number of tractors decreases, the fixed costs also tend to decrease. This decrease in fixed costs is slightly offset by increased machinery repairs. As fewer tractors are used, more hours are put on each tractor, resulting in higher machinery repair costs and a shorter life expectancy. Table 4 shows a sensitivity analysis in which depreciation was decreased by 5% and 10% for each system and how these changes affect net returns. Table 4 shows that lowering depreciation costs in FSSI for any of the systems by 5% or 10% would undoubtedly improve their profitability, but the changes would not be sufficient to rearrange the profitability rankings. However, in FSSII, decreasing depreciation by 10% in the Conventional system while leaving depreciation at the same level in the Alternative system nearly equalizes the profitability for these systems.

Table 4. Machinery Sensitivity Analyses for 5% and 10% Decrease in Depreciation Costs: NE Station.

System	Normal Dep. Cost	5% Depreciation Decrease	
		New Dep. Cost	Increase in Net Returns
FSSI:			
Alternative	13,451	12,779	673
Conventional	12,866	12,223	643
Ridge Till	12,744	12,107	637
FSSII:			
Alternative	9,740	9,253	487
Conventional	12,897	12,253	645
Minimum Till	11,750	11,163	588

System	Normal Dep. Cost	10% Depreciation Decrease	
		New Dep. Cost	Increase in Net Returns
FSSI:			
Alternative	13,451	12,106	1,345
Conventional	12,866	11,580	1,287
Ridge Till	12,744	11,470	1,274
FSSII:			
Alternative	9,740	8,766	974
Conventional	12,897	11,608	1,290
Minimum Till	11,750	10,575	1,175

There is another cost that is affected by the reduction of the number of tractors. As the number of tractors is decreased, some machine operations will be taken over by the tractor that can best fulfill the horsepower requirements. This probably would lead to a reduction in fuel efficiency. For example, if a 125 hp tractor is used for a machine operation that only requires a 100 hp tractor, then there is going to be some extra fuel consumption because the 125 hp uses 6.05 gallons of fuel per hour and the 100 hp tractor uses 4.84 gallons of fuel per hour. We can assume that even though the 100 hp machine operation will not cause the 125 hp tractor to use 6.05 gallons per hour, neither will the 125 hp tractor be able to do the job with as little fuel as a 100 hp tractor could. It would be difficult to estimate the actual rate of fuel consumption. Fuel consumption rates were taken from Allen (1986).

Based on the tractor hours for the "normalized" budgets and gallons per hour figures taken from Allen (1986), Table 5 shows a worst-case scenario of reducing the number of tractors for each system by using the fuel consumption rate of a higher horsepower tractor performing a task that requires a tractor with less horsepower. Fuel data in Table 2 and Table 5 differ because Table 2 is based on data from the 1986-1992 N.E. Research Station budgets and Table 5 is based on tractor usage figures in the machinery analysis by Becker and Koehne that was referred to earlier. The systems have varying numbers of combinations of tractors that can be used, but the tractors shown in Table 5 represent what is believed to be the fewest number of tractors necessary to complete all of the required machine operations. This analysis shows that the Alternative systems for FSSI and FSSII have the highest increase in fuel use when fewer tractors are used. In FSSI, this occurred even though the number of tractors for the Alternative system was decreased by only two tractors and the number of tractors in the Ridge Till system was decreased by three tractors. This may be due to the fact that the Alternative system machinery operations require more tractors with different horsepower ratings; therefore, a higher level of inefficiency may occur when machinery operations are performed with fewer tractors in that system.

Table 5. Potential Fuel Use Implications Of Reducing Tractor Numbers: NE Station

FSSI

System	Fuel Costs ($)	Increase in Fuel Costs ($)
Alternative:		
125 hp, 100 hp 80 hp,60 hp, 45 hp	2,844	
125 hp, 80 hp and 45 hp	3,250	406
Conventional:		
125 hp,80 hp,70 hp 60 hp, and 45 hp	2,078	
125 hp, 80 hp and 45 hp	2,294	216
Ridge Till:		
125 hp,80 hp,70 hp 60 hp, and 45 hp	2,161	
125hp and 60 hp	2,491	330

FSSII

System	Fuel Costs ($)	Increase in Fuel Costs ($)
Alternative:		
125 hp, 100 hp 80 hp,60 hp, 45 hp	1,819	
125 hp and 60 hp	2,302	483
Conventional:		
125 hp,80 hp,70 hp 60 hp, and 45 hp	2,480	
125 hp, 70 hp and 45 hp	2,593	113
Minimum Till:		
125 hp,100 hp,80 hp 70 hp,60 hp, and 45 hp	1,924	
125 hp,60 hp, and 45 hp	2,097	172

Economies of Size

Economies of size must also be taken into account when comparing the different systems. Conventional farms tend to be larger than alternative farms in terms of total acreage. Also, conventional farms tend to have fewer crop enterprises; consequently, a larger percent of the acreage is devoted to each crop. Economies of size exist when fixed costs are spread over a greater number of acres, thereby lowering per acre fixed costs.

In FSSI, the Alternative system is clearly more profitable than the Conventional system when depreciation cost are assumed to be spread over the same number of acres, regardless of system. We can do a sensitivity analysis to see how much the depreciation cost for the Alternative system would have to increase to drop the profitability of that system to the level of profitability of the Conventional system. In order for the two systems to be equally profitable, the depreciation cost for the Alternative system would need to increase by 98%.

Soil Tilth

Since there is no research currently being done with soil tilth at the Northeast farm, we made an assumption about the relationship between soil tilth and fuel requirements based on research on soil tilth performed on the Madison farms.[4] Since the Alternative systems may have a lower level of soil strength,

[4]Soil strength information was obtained from Alternative Farming Systems Project Cooperator Studies conducted by Schumacher, et al (1992). Soil strength was measured in MPa using a cone penetrometer.

we conducted a sensitivity analysis to determine the effects this increased soil tilth might have on the net returns of the Alternative systems. In the sensitivity analysis shown in Table 6, fuel costs for the Alternative systems were decreased by 5% and 10%. This reduction in fuel costs also was transformed into decreases in direct costs and consequent increases in net returns. These decreases in the fuel costs for the Alternative systems in FSSI and FSSII have very little impact on the relative profitabilities of the different systems, since the Alternative systems' profitability are increased only by small amounts, and they already have the highest profitability in both sets of comparisons.

Table 6. Fuel Sensitivity Analysis Based on Increased Soil Tilth for the Alternative Systems at NE Research Station.

		5% Decrease in Fuel Cost	
System	Normal Fuel Cost	New Fuel Cost	Increase in Net Returns
FSSI:Alternative	3,710	3,524	197
FSSII:Alternative	2,612	2,481	138

		10% Decrease in Fuel Cost	
System	Normal Fuel Cost	New Fuel Cost	Increase in Net Returns
FSSI:Alternative	3,710	3,339	393
FSSII:Alternative	2,612	2,351	277

Madison Farm Case Analyses

Overview of Machinery Use and Costs

The two farms involved with the study at Madison permitted us to examine another set of contrasting farming systems. The first component that we will look at is the machinery inventories for the two different farms. Tables 7 and 8 show the machinery inventories for each farm. Some of the machinery inventory is livestock-related. The economic data did not include livestock in the profitability of the systems. These machinery inventories are based upon information provided by the farmers in 1989; some changes in their machinery inventories could have occurred by 1991, the "typical" year used for our analysis.

The Alternative farmer owns a total of 41 pieces of equipment, as compared to the 25 pieces listed by the Conventional farmer. Some of each farmer's machinery is shared with others (relatives); also, there may be some machinery items owned by relatives that they have access to, but are not included in these inventories. The differences between these two machinery inventories extends past the number of machines for each farm. Only 9 of the 41 pieces of machinery on the Alternative farm were purchased new, while 12 of the 25 pieces of equipment on the Conventional farm were purchased new. Another interesting fact is that, on the Alternative farm, 29 of the 32 pieces of equipment that were purchased used were 10 or more

Table 7. Machine Inventory for Alternative Farm at Madison

ITEM	MAKE	MODEL	SIZE	YEAR BOUGH	NEW OR USE	AGE	SPECIAL FEATURES
TRACTORS	JD	3020	70-80 H.P.	1984	USED	20 yrs.	DIESEL
	JD	4020	95-100 H.P.	1981	USED	14 yrs.	DIESEL
	JD	4230	100-110 H.P.	1988	USED	14 yrs.	DIESEL
	IH	H	50 H.P.	1981	USED	32 yrs.	GAS
*	JD	4440	135+ H.P.	1978	NEW	——	DIESEL
TRUCKS							
FARM	IH	1600		1989	USED	13 yrs.	NO BOX OR HOIST
PICKUP	CHEVY	C-40		1987	USED	19 yrs.	GRAVITY BOX MOUNTED
	CHEVY	4WD		1984	USED	5 yrs.	HAULS LIVESTOCK
	GMC	2WD		1987	USED	10 yrs.	ODD JOBS
WAGON	M&W	GRAIN	250 bu.	1981	USED	10 yrs.	
CHISEL	MORRIS		13'	1983	USED	12 yrs.	LIMITED USE
with sweep*	JD	1600	16'	1978	NEW	——	FALL PLOWING
TANDEM DISK	KRAUSE	ROCK-FLEX	20'	1987	NEW	——	HARROW MOUNTED
ROTARY HOE	JD		20'	1989	USED	13 yrs.	
FIELD CULTIVATOR	IH		15'	1987	USED	10 yrs.	DRAGS PULLED BEHIND
with harrow	IH		18'	1983	USED	10 yrs.	DRAGS PULLED BEHIND
ORDINARY PRESS DRILL	JD	GRAIN DRILL	15'	1981	USED	20 yrs.	GRASS SEED ATTACHMENT
ROW PLANTER	JD	7000	4-ROW	1987	USED	10 yrs.	
ROW CULTIVATOR	IH	153	4-ROW	1982	USED	12 yrs.	GETS USED A LOT
MANURE SPREADER	NEW IDEA			1981	USED	12 yrs.	
BALERS	MASSEY		SQ. BALER	1986	USED	20 yrs.	
	NEW HOLLAND	846	ROUND BALER	1986	USED	5 yrs.	MAKES 600-700 LB. BALES
COMBINE	JD	6600		1988	USED	13 yrs.	DIESEL STRAW CHOPPER
SWATHER	VERSATILE		15'	1981	USED	11 yrs.	
MOWERS	IH	SICKLE	9'	1986	USED	15 yrs.	
	JD	ROTARY	6'	1988	NEW	——	
RAKE	NEW HOLLAND		8'	1981	USED	20 yrs.	
OTHERS							
Bean Head				1988	USED	15 yrs.	
Corn Head				1986	USED	10 yrs.	
Grinder-feed	NEW HOLLAND			1984	USED	15 yrs.	
Grain auger-truck	FETERL		27'	1987	NEW	——	
Swather transport				1986	USED	15 yrs.	
Loader	JD	148		1985	USED	15 yrs.	
Running gear			2 1/2 TON	1988	USED	20 yrs.	
3 pt. blade	JD		7'	1982	NEW	——	
Stock trailer	DELTA		6' x 16'	1981	NEW	——	
Bale elevator	JD		20'	1985	USED	10 yrs.	
Pickup Head	JD		5 belt	1982	USED	15 yrs.	
Drag	FETERL	7 SECTION	32'	1982	NEW	——	
Tractor	JD	4010	90 H.P.	1961	NEW	——	DIESEL

* - designates pieces of machinery owned by a relative.

Table 8. Machine inventory for Conventional Farm at Madison.

ITEM	MAKE	MODEL	SIZE	YEAR BOUGH	NEW OR USE	AGE	SPECIAL FEATURES
TRACTORS	CASE-IH	3394	170 H.P.	1986	USED	6 months	
	JD	4440	130 H.P.	1981	NEW	———	
	JD	4430	120 H.P.	1975	USED	2 yrs.	
TRUCKS	IHC	1710	2 TON	1987	USED	12 yrs.	
	IHC	1600	2 TON	1978	USED	6 yrs.	
	CHEVY	C50	2 TON	1979	USED	10 yrs.	
	CHEVY	K10	1/2 TON	1985	NEW		
	CHEVY	K20	3/4 TON	1980	USED	1 yr.	
	CHEVY	K20	3/4 TON	1988	NEW		
WAGONS							
Gravity wagon	SOO BUILT		200 BU.	1986	USED		
Silage dump wagon*	S&H		6 TONS	1978	NEW		
CHISEL	MORISS		16'	1982	USED	1 yr.	
DISK CHISEL	JD	712	13'	1987	NEW		
TANDEM DISK *	KRAUSE	1900	21'	1983	NEW		
SOIL FINISHER	KRAUSE	3124A	24'	1984	NEW		
ORD. PRESS DRILL	GREAT PLAINS		20'	1989	NEW		8 INCH SPACING: FERT.
ROW PLANTER *	IHC	800	12x30"	1987	USED	2 yrs.	STARTER FERT.
ROW CULTIVATOR *	IHC	183	12x30"	1987	NEW		28% NITROGEN APPL. KIT
SPRAYER							
SELF PROPELLED	FORD	F250	60' BOOM	MADE IN '88			RAVEN 440 MONITOR
			400 GAL.				
MANURE SPREADER	BALZER		180 BU.	1981	USED	2 yrs.	
COMBINE **	IHC	1460		1982	USED	1 yr.	
	JD	643	6 ROW	1984	USED	2 yrs.	
BEAN HEAD	IHC	1020	20'	1988	NEW		
SILAGE CUTTER *	JD	3960	3 ROW	1981	NEW		
SWATHER *	VERSATILE	400	18'	1976	NEW		

* - designates pieces of machinery owned by a relative.

** - designates pieces of machinery co-owned with a relative on a 50/50 basis.

years old at the time of the purchase. On the Conventional farm, only 2 of the 13 pieces of used equipment were 10 years or older at the time of purchase. This information leads us to believe that the Conventional farm is operating with a newer machinery base. These differences open the possibility that in our budgets based on economic engineering estimates, the Alternative farm machinery depreciation costs may sometimes have been overstated, but the machinery repair cost may have been underestimated. Conversely, the Conventional farm budgets may sometimes have overstated repair costs, but understated machinery depreciation costs.

Figures for the Madison farms will be presented differently than those for the Northeast Station in our comparison of fixed, variable, and total costs. The Northeast Station studies assumed that all of the systems were based on 800 acres, but the "typical" year for the Madison farms has differing numbers of acres (Conventional farm = 1030 acres vs. Alternative farm = 806 acres). Therefore, Table 9 compares the total, depreciation, and fuel costs on a per acre basis. Table 9 data was taken from 1991 budgets.

Table 9. Costs for Farming Systems Study at Madison, SD.

	Total Cost	Total Dep.	Total Fuel	Net Income
Alt	$124	$17	$4	$40
Conv	$164	$15	$3	$68

Note: All figures are shown on a per acre basis. They are for the year 1991.

The total per acre cost of all inputs, including land, for the Conventional farm was $164 per acre, as compared to $124 per acre for the Alternative farm. As with the Farming Systems Study at the Northeast Research Station, the Conventional farm's use of chemical fertilizer and herbicide inputs was the main reason for the higher total cost on the Conventional farm.

When comparing the depreciation costs on a per acre basis, the Alternative farm had the higher costs, $17 per acre, compared to $15 per acre for the Conventional farm. We can also look at depreciation cost as a percentage of total cost. The Alternative farm depreciation cost made up 13% of the total cost, while the Conventional farm depreciation cost made up 9% of the total cost. These percentages show that there are other costs, e.g., for fertilizer and herbicide inputs, that are contributing to the total cost.

When fuel cost was compared on a per acre basis, the Conventional farm had the lower fuel cost, $3 per acre, compared to $4 per acre for the Alternative farm. On the Conventional farm, fuel cost made up 2% of the total cost and on the Alternative farm it made up 3% of the total cost.

Farm Diversity

When machinery utilization was examined for the Madison farms, we used the same criteria that were used to study machinery utilization on the Northeast Research Station. Economic engineering assumptions about machinery on each farm were used, rather than the actual machinery inventory on each hours of use for a piece of machinery were greater than 25% above or below the assumed hours, then that piece of machinery was designated as "overused" or "underused". Table 10 lists the underused and overused pieces of machinery, based on this criteria.

Table 10 shows that the Conventional farm has 11 pieces of machinery that were underused, while the Alternative farm has 6 pieces of underused machinery. Both farms had two pieces of machinery that were overused. Underused machinery may be overstated since it may shared with a relative.

Table 10. Underused and Overused Machinery for the Study at Madison, SD.

Underused Machinery - Madison Farms

	Actual Hours		Assumed Hours		% of Assumed Hours Left Unused	
Machinery	Alt	Conv	Alt	Conv	Alt	Conv
Drill	66.42		100		33.58	
Baler	59.24	36.86	100	100	40.76	63.14
Combine	120.26		180		33.18	
Chisel Plow	41.92		100		58.08	
Fert. Spreader		8.26		50		83.48
Swather	47.11	42.50	70	75	32.7	43
Drag Harrow	16.59		100		83.41	
Disk		24.12		100		75.88
Soil Finisher		32.94		100		67.06
Anhydrous Applicator		29.07		60		51.55
No-Till Drill		9.10		100		90.9
Cultivator		42.85		100		57.15
Forage Harvester		12.88		50		74.24
Forage Wagon		17.86		50		64.28
Sickle Mower		10.19		50		79.62

Overused Machinery - Madison Farms

	Actual Hours		Assumed Hours		% Over Assumed Hours	
Machinery	Alt	Conv	Alt	Conv	Alt	Conv
Drill		134.97		100		35%
Cultivator	212.91		100		213%	
Grain Wagon	149.65	281.36	100	100	50%	281%

Table A-3 and Table A-4 show acres of use and machine hours for the machines in the Alternative and Conventional systems, respectively. The total hours of tractor use is not the same as total machine hours listed on Annex Tables A-3 and A-4, since these figures include machine hours for self propelled implements such as the combine, swather, etc.. When these hours were deducted from the total hours, the Conventional farm had a total of 768 tractor hours and the Alternative farm had a total of 1,075 tractor hours.

Economies of Size

Economies of size do not appear to have much impact on the level of utilization between the farms. The Conventional farm cropped 1,030 acres in 1992 and also the "typical" year (1991). The Alternative farm cropped 806 acres in 1992 and also the "typical" year. Even though the Alternative farm has fewer cropped acres than the Conventional farm, the Alternative farm may have better machinery utilization than the Conventional farm in terms of number of acres used. This may be attributed to the fact that the Alternative farm must rely more heavily upon machinery operations for weed control, so some machines may be used for several operations rather than just one operation. This led to the Alternative farm covering 6,924 acres with all of the machine operations, while the Conventional farm covered 5,733 acres. These numbers show the reason that the Alternative farm may have more complete utilization of machinery.

Since the Alternative farm may have a higher level of machinery utilization, we can do some sensitivity analysis to examine the effects of decreased depreciation cost on the relative profitability of the two systems. Table 11 shows the effects of lowering depreciation cost for the Alternative system by 5% and 10% and the resulting change in net income. As expected, lowering the depreciation cost increases net income, but not nearly enough to make the Alternative farm as profitable as the Conventional farm.

Soil Tilth

Tom Schumacher (see previous footnote 4) of the SDSU Plant Science Department has been doing studies on these farms and has found that the Alternative farm has a lower soil strength, which is a characteristic of greater soil tilth, than the Conventional farm. Sensitivity analysis can be performed to determine the effects of possibly lower fuel cost due to greater soil tilth on the Alternative farm. Table 12 shows the effects of a 5% and a 10% drop in fuel cost for the Alternative farm. As with the depreciation costs, reducing the fuel cost for the Alternative farm will increase the net income, but the profitability is still much greater on the Conventional farm.

Table 11. Sensitivity Analyses of 5% and 10% Decrease in Depreciation Costs: Madison Farms.

System	Normal Dep. Cost	5% Depreciation Decrease	
		New Dep. Cost	Increase in Net Returns
Alternative			
Per acre	17.07	16.22	0.85
Conventional			
Per acre	15.20	14.44	0.76

System	Normal Dep. Cost	10% Depreciation Decrease	
		New Dep. Cost	Increase in Net Returns
Alternative			
Per acre	17.07	15.36	1.71
Conventional			
Per acre	15.20	13.68	1.52

Table 12. Fuel Sensitivity Analysis Based on Increased Soil Tilth for the Alternative Farm at Madison, SD.

System	Normal Fuel Cost	5% Decrease in Fuel Cost	
		New Fuel Cost	Increase in Net Returns
Alternative			
Per acre	4.34	4.11	0.23

System	Normal Fuel Cost	10% Decrease in Fuel Cost	
		New Fuel Cost	Increase in Net Returns
Alternative			
Per acre	4.34	3.88	0.46

Summary and Conclusions

The two systems at the Northeast Research Station were quite dissimilar. In FSSI, the Alternative system had the highest total, depreciation, and fuel costs. The Alternative system also had the highest level of profitability. In FSSII, the Alternative system had the lowest total, depreciation, and fuel cost. The profitability was nearly equal for the Alternative and Conventional systems.

The type of crops included in the rotation seemed to have the most impact on the differences between the systems. In FSSII, the Alternative system had 25% of the acres planted to a mixture of red clover and sweet clover that was tilled back into the soil as green manure. This may have been the reason that the costs (total, depreciation, fuel) for the Alternative system were significantly lower in FSSII compared to FSSI. The profitability was nearly equal for the Alternative and Conventional systems in FSSII.

The farms in the Madison study were compared on a per acre basis. Total and depreciation costs were greater on the Conventional farm. Net income was also higher for the Conventional farm. Fuel costs for the Alternative farm were higher than for the Conventional farm.

In comparing costs for farming systems in the two different agro-climatic study areas, we see that the Madison farming system costs were similar to the costs incurred by the respective

Alternative and Conventional systems in FSSI at the Northeast Research Station. This supports the conclusion that crop rotation has an effect on the costs incurred by each system, since the crop rotations for the Alternative and the Conventional systems in FSSI and the farming systems in the Madison study are similar.

At both study locations, it is apparent that machinery utilization and soil tilth could have an impact on the net returns for each system, but in this study it does not appear to have much effect on the relative profitability of the different systems. After more studies are done on how fixed and variable costs can be affected by machinery use for different systems, then other, more precise assumptions may be used for sensitivity analyses.

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Annex

Table A-1. Typical Crop Production Practices in FSSI at NE Research Station.

System/Crop	Cultural Practices
Alternate	
Corn:	Spring tooth harrow, field cultivate with harrow, plant, rotary hoe twice, cultivate twice, fall chisel plow (w/sweeps).
Soybeans:	Spring tooth harrow, field cultivate w/harrow, plant, rotary hoe twice, cultivate twice.
Oats/alfalfa:	Disk w/harrow, packer behind drill, apply manure in fall (2.5 Ton/A-dry wt.)
Alfalfa:	3 cuttings, fall chisel plow and field cultivate.
Conventional	
Corn:	Field cultivate w/harrow, plant, apply 64 lb N, 4 lb P_2O_5, band Lasso II at 7 lb, cultivate twice, fall disk.
Soybeans:	Apply Treflan 1.5-2 pt, disk twice and harrow, plant, cultivate twice.
Spring Wheat:	Field cultivate w/harrow, drill, apply 72 lb N, 7 lb P_2O_5, spray Hoelon 2 pt plus Buctril 1 pt, or MCPA 1 pt, fall moldboard plow.
Ridge-till	
Corn:	Ridge plant, apply 70 lb N, 4 lb P_2O_5, , band Lasso II at 7 lb, ridge cultivate twice, post-emerge spray with Banvel 0.5 pt or Buctril 1 pt, shred stalks.
Soybeans:	Gramoxone 1.5 pt, ridge plant, band Lasso II at 7 lb, cultivate twice, post-emerge spray with Blazer 1.5 pt, or Poast 1-1.5 pt or Pursuit 4 oz and Pinnacle 0.25 oz, or Cobra 15 oz.
Spring Wheat:	Field cultivate, hoe drill, apply 83 lb N, 7 lbs P_2O_5, spray with Hoelon 2 pt plus Buctril 1 pt or MCPA 1 pt, fall spray Roundup 1 qt (2 yr), fall chisel plow (w/sweeps).

Average Seeding Rates: corn 18,900 seeds/A, soybean 1.1 bu/A, spring wheat 71 lbs/A, oats 57 lb/A, alfalfa 9.5 lb/A. The herbicides applied over the 7-year period varied from year to year, particularly in the reduced-till systems, and products listed include all of the materials applied from 1986-1992. Rates listed are actual/A. The fertilizer rates also varied from year to year, and rates listed are the average for the 7-year period. Phosphorous and banded herbicides were applied at planting. Nitrogen fertilizer was applied 2 to 3 weeks post-plant. Most SD soils are naturally high in plant-available potassium, and no potassium fertilizer was applied. All row crops were planted in 36-inch rows. The spring tooth harrow was used early preplant in the Alt corn and soybeans to stimulate early weed seed germination prior to the final preplant tillage operation.

Table A-2. Typical Crop Production Practices in FSSII at NE Research Station.

System/Crop	Cultural Practices
Alternate	
Oats/Clover:	Field cultivate w/harrow, packer behind drill.
Clover:	Mow, chisel plow (w/sweeps), field cultivate.
Soybeans:	Spring tooth harrow, field cultivate w/harrow, plant, rotary hoe twice, cultivate twice.
Spring Wheat:	Field cultivate w/harrow, drill, rotary hoe once, fall chisel plow (w/sweeps).
Conventional	
Soybeans:	Apply Treflan 1.5-2 pt, disk twice and harrow, plant, cultivate twice.
Spring Wheat:	Field cultivate w/harrow, drill, apply 62 lb N, 7 lb P_2O_5, spray with Hoelon 1 pt plus Buctril 1 pt, or MCPA 1 pt or Buctril 1 pt, fall moldboard plow.
Barley:	Field cultivate w/harrow, drill, apply 21 lb N, 7 lb P_2O_5, spray with MCPA 1 pt, Buctril 1 pt, or Hoelon 1 pt, fall moldboard plow.
Minimum-Till	
Soybeans:	Plant, pre-emerge spray with Lasso 3 qt or band Lasso II 7 lb, post-emerge spray with Poast 1.5 pt, or Blazer 1.5 pt, or Pursuit 4 oz and Pinnacle 0.25 oz, or Cobra 15 oz, fall spray w/Roundup 1 qt (1 yr).
Spring Wheat:	Spring tooth harrow, apply 82 lb N, 7 lb P_2O_5, hoe drill, spray with Hoelon 2 pt plus Buctril 1 pt or MCPA 1 pt, fall spray w/Roundup 1 qt (2 yr), fall chisel plow (w/sweeps).
Barley:	Field cultivate, hoe drill, apply 52 lb N, 7 lb P_2O_5, spray with Hoelon 2 pt plus MCPA 1 pt, or Bronate 1 pt, or MCPA 1 pt, fall apply Roundup 1 qt (1 yr), fall chisel plow (w/sweeps).

Average seeding rates: Soybeans 1.1 bu/A, spring wheat 71 lb/A, barley 58 lb/A, oats 57 lb/A, sweet clover 5 lb/A, red clover 4 lb/A. Herbicides applied varied from year to year, and products listed include all of those used from 1986-1992. Rates listed are actual/A. Fertilizer rates are the average for the 7-year period.

Table A-3. Madison Farm Alternative System Machinery Utilization Analysis - Yearly Total.

Implement	Acres of Use	Machine Hrs/Ac	Machine Hours	Assumed Hours
Drag Harrow (24')	179	0.09266	16.59	100
Disk (17')	973	0.12181	118.52	100
Planter (6-row)	433	0.16176	70.04	60
Drill (10')	219	0.30331	66.42	100
Rotary Hoe (20')	866	0.10855	94.00	100
Cultivator (6-row)	1118	0.19044	212.91	100
Swather (16.5')	399	0.11806	47.11	75
Raking Wheel (18')	564	0.11317	63.83	80
Baler (Lg. Rd.) - 1st cutting	194	0.14933	28.97	-
Baler (Lg. Rd.) - 2nd cutting	138	0.11000	15.18	|- 100
Baler (Lg. Rd.) - 3rd cutting	138	0.10933	15.09	-
Bale Fork (1st cutting)	194	0.22400	43.46	
Bale Fork (2nd cutting)	138	0.16500	22.77	
Bale Fork (3rd cutting)	138	0.16400	22.63	
Combine (6-row)	586	0.20522	120.26	180
Chisel Plow (15')	250	0.16768	41.92	100
Field Cultivator (17')	592	0.16804	99.48	100
Grain Wagon (260 bu.) Oats	109	0.21153	23.06	-
Grain Wagon (260 bu.) Soybeans	227	0.10808	24.53	|- 100
Grain Wagon (260 bu.) Corn	206	0.46538	95.87	|
Grain Wagon (260 bu.) Wheat	70	0.08846	6.19	-
Sickle Mower (9')	231	0.22634	52.28	50
Total Machine Hours...........................			1,242.64	

Table A-4. Madison Farm Conventional System Machinery Utilization Analysis - Yearly Total.

Implement	Acres of Use	Machine Hrs/Ac	Machine Hours	Assumed Hours
Fertilizer Spreader	160	0.05163	8.26	50
Soil Finisher	460	0.07160	32.94	100
Disk (17')	198	0.12181	24.12	100
Anhydrous Applicator	220	0.13212	29.07	60
Planter (6-row)	445	0.16176	71.98	60
Drill (10')	445	0.30331	134.97	100
No-Till/Hoe press drill	60	0.15165	9.10	100
Cultivator (6-row)	225	0.19044	42.85	100
Swather (16.5')	360	0.11806	42.50	75
Baler (Lg. Round) 1st cutting	100	0.14933	14.93	-
Baler (Lg. Round) 2nd cutting	100	0.11000	11.00	|- 100
Baler (Lg. Round) 3rd cutting	100	0.10933	10.93	-
Bale Fork (1st cutting)	100	0.22400	22.40	
Bale Fork (2nd cutting)	100	0.16500	16.50	
Bale Fork (3rd cutting)	100	0.16400	16.40	
Sprayer	905	0.13552	122.65	100
Combine (6-row)	880	0.20522	180.59	180
Forage Harvester	25	0.51528	12.88	50
Forage Wagon	25	0.71429	17.86	50
Grain Wagon (260 bu.) Corn	420	0.48692	204.51	-
Grain Wagon (260 bu.) Soybeans	400	0.16270	65.08	|- 100
Grain Wagon (260 bu.) Barley	60	0.19615	11.77	-
Sickle Mower (9')	45	0.22634	10.19	50
Total Machine Hours......................			1,113.47	