Costs of Converting to No-till

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In recent years, many farmers across Kansas have changed their cropping patterns in addition to using different tillage practices. Perhaps the most popular change in tillage practices has been the adoption of reduced tillage. Reduced tillage often is referred to as minimum-till, in which some tillage prior to planting takes place, or no-till in which weed control is accomplished entirely through the application of herbicides. Whether minimum-till or no-till, these practices have many advantages over conventional tillage, especially in drier climates. Some of these advantages include higher yields, reduced water and wind erosion, and the opportunity to increase acres farmed. In the short and long run, reduced tillage may offer the opportunity for increased returns through higher revenues, lower costs, or a combination of both. Of course, the opportunity to take advantage of the benefits of minimum or no-till will depend on geographic conditions and the managerial abilities of the individual producer.

While offering several advantages, reduced tillage also has some drawbacks. One of the potential drawbacks that farmers must consider before they shift to no-till is the cost of converting machinery. For many farmers, no-till offers the possibility for lower machinery investment in the long run. However, for those situations in which a 100% no-till program is not the most profitable, and the transition period between conventional and no-till when farmers keep their conventional equipment while purchasing no-till machinery, investment may actually be higher.

Numerous studies have compared the profitability of no-till versus minimum-till and conventional-till for different crops and cropping systems in Kansas. This study will take a different approach. Instead of concentrating solely on the profitability of different tillage systems, several issues regarding the conversion of a conventional machinery compliment to a reduced tillage system will be addressed. Some of these issues include: estimating machinery costs during the transition to no-till, spreading machinery costs over additional acres in more intensive crop rotations, calculating the cost of keeping equipment that is used sparingly in a reduced tillage system, and estimating the number of acres that are required for ownership of no-till machinery to be comparable to renting or custom hire.

Farm Machinery Cost Components

Because of the many underlying assumptions and sometimes tedious formulas, estimating machinery costs for decision making purposes can be difficult. Although machinery costs may be difficult to estimate, they are important in comparing the profitability of different crops and cropping systems, and especially important when comparing enterprises or systems that are more machinery intensive than others. Furthermore, an estimate of machinery cost is important for evaluating machinery service alternatives, such as lease versus purchase and optimal replacement strategies. Following is a discussion of the major machinery cost components and the methods used to estimate costs in this paper.

Fixed Costs

Fixed, or ownership costs, are those costs that are incurred regardless of how much a machine is used. Depreciation, interest, housing, insurance, and taxes are typically considered fixed costs. Depreciation is often estimated using a flat annual rate, making it a fixed cost. However, most crop farm machinery depreciates faster with higher rates of use, making some portion of depreciation a variable cost (Dumler). This occurs because annual depreciation will vary year to year based on how much a machine is used. Therefore, depreciation methods that consider use as a factor in determining remaining value and annual depreciation are often essential. While depreciation will vary with use with every type of farm machinery, it is only possible to measure use with those machines that have hour or acre meters. Consequently, a flat annual depreciation rate may be the only alternative to estimate depreciation for those machines without hour or acre meters. In this paper, a depreciation method that considers use as a variable in determining annual depreciation will be used for tractors and combines. The formulas for this depreciation method, referred to as Cross and Perry (CP), are presented in Table 1. Depreciation for all equipment besides tractors and combines was estimated using the American Society of Agricultural Engineers (ASAE) formulas in Table 2. These formulas consider remaining value as strictly a function of age.[1]

Interest, in the context of annual machinery costs, is essentially an opportunity cost. Another way to think about it is the return that could be earned if the money invested in farm machinery was instead used in the most profitable alternative investment. Equation 1 shows a simple method of computing interest expense. Multiplying the average investment over the life of the machinery by a current interest rate *i* will give the interest cost:

$$\textit{Interest Cost} = ((\textit{Original Value} + \textit{Salvage Value})/2) * i. \quad (1)$$

Housing, insurance, and taxes are generally the smallest fixed cost component and can be approximated by multiplying the original value of machinery by 1 to 1.5%. One percent was used for calculation purposes in this paper, as no property taxes exist for farm machinery in Kansas.

Variable Costs

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[1] While often referred to as depreciation formulas, CP and ASAE formulas actually yield a remaining value percentage (RVP), and not depreciation. Multiplying the RVP by a current list price for a specific machine will generate a current remaining value. Depreciation can then be computed by subtracting the remaining value in the current year by the previous year's remaining value.

Variable, or operating costs, are those costs that vary year to year based on machine use. The typical variable cost components are repairs and maintenance, fuel and oil, and labor.

Table 1. Cross and Perry Reduced Form Remaining Value Formulas*

Equipment Type	Function
Combines	$RV = (0.94534 - 0.04551\, Age^{0.87} - 0.00182\, HPY^{0.72})^{2}$
Swathers	$RV = (0.94154 - 0.04564\, Age^{0.5})^{5.26}$
Balers	$RV = (0.95433 - 0.05939\, Age^{0.57})^{2.78}$
30-79 HP Tractors	$RV = (0.88507 - 0.05827\, Age^{0.46} - 0.00018\, HPY^{0.9})^{2.17}$
80-149 HP Tractors	$RV = (0.97690 - 0.02301\, Age^{0.76} - 0.0012\, HPY^{0.6})^{3.85}$
150+ HP Tractors	$RV = (1.18985 - 0.22231\, Age^{0.35} - 0.00766\, HPY^{0.39})^{2.22}$
Planters	$RV = (0.80414 - 0.01939\, Age^{0.89})^{1.96}$
Plows	$RV = (0.61135 + 0.47309\, Age^{-0.95})^{1.61}$
Disks	$RV = (0.45198 + 0.60697\, Age^{-0.85})^{2.04}$
Manure Spreaders	$RV = (1.29956 - 0.45113\, Age^{0.25})^{2.22}$
Skid Steer Loaders	$RV = (0.88302 - 0.2549\, Age^{0.05} - 0.00002\, HPY^{1.31})^{1.96}$

Source: Cross, T.L. and G.M. Perry. “Depreciation Patterns for Agricultural Machinery.” *American Journal of Agricultural Economics*. 77(Feb., 1995): p. 194-204.
* RV = remaining value and HPY = hours per year.

Table 2. ASAE Remaining Value Formulas*

Equipment Type	Formula
Tractors	$0.68(0.920)^{n}$
Combines, cotton pickers, SP windrowers	$0.64(0.885)^{n}$
Balers, forage harvesters, blowers, SP sprayers	$0.56(0.885)^{n}$
All other field machines	$0.60(0.885)^{n}$

Source: American Society of Agricultural Engineers. *ASAE Standards*. 43rd ed. St. Joseph, MI., 1996.

* *n* = age of machine. Formulas yield remaining values as a percentage of the list price at the end of year *n*.

While repair costs can vary greatly between farmers based on their machinery management abilities and strategies, the ASAE provides formulas for estimating accumulated repairs for a variety of farm machinery. In these formulas, repairs are basically a function of hours of use and current list price. The generic ASAE formula is

$$ARM_n = RF1 * CLP_n * (AH_n/1000)^{RF2}, \qquad (2)$$

where ARM_n is accumulated repairs and maintenance in year *n*, *RF1* is repair factor 1, CLP_n is current list price in year *n*, AH_n is accumulated machine hours in year *n*, and *RF2* is repair factor 2. The repair factors for each type of machinery are presented in Table A.1. A more detailed discussion of these formulas is available in Kastens.

Fuel and lubrication can be estimated using Equation 3. The fuel requirement number necessary in Equation 3 is found in Table A.2. *APH* is the acres per hour that can be worked with a specific machine. Lubrication costs average about 10% of fuel costs (Bowers), therefore Equation 3 must be multiplied by 1.10 to calculate both fuel and lubrication.

$$Fuel\ Cost = Fuel\ Requirement * APH * Fuel\ Price\ (\$/gal). \qquad (3)$$

The formula for calculating labor costs is shown in Equation 4. To account for time spent checking on field conditions and driving to and from fields, the "field time" is multiplied by 1.20, because it is assumed actual labor is 20% more than machine hours (Kastens).

$$Labor = Wage\ Rate\ (\$/hr) * Machine\ Hours * 1.20. \qquad (4)$$

No-till with Increased Cropping Intensity

Undoubtedly, one of the advantages that no-till offers is the opportunity to increase cropping intensity. In fact, moving to no-till in western Kansas may be unprofitable if cropping intensity is not increased (Dhuyvetter and Norwood). With no-till, not only can western Kansas farmers increase cropping intensity beyond wheat-fallow or wheat-sorghum-fallow, but no-till may make it possible for central and eastern Kansas farmers to establish double crop rotations more efficiently. The ability to increase cropping intensity with no-till can be important when machinery costs are considered. When making the switch from conventional tillage to no-till, many farmers will keep their tillage equipment during the initial trial phase of no-till as a safeguard in case the no-till experiment does not work. Even if no-till proves successful for farmers, they may still keep some tillage equipment to work problem areas in fields or to control weeds that become resistant to herbicides. Also, some farmers may not move to a 100% no-till rotation. For example, farmers that grow crops on a wide range of soil types and land qualities may use no-till on some land but use conventional tillage on other land. Likewise, no-till may be more profitable for some crops (row crops in western Kansas) but less profitable for others (wheat in western Kansas). As a result, farmers will use a combination of conventional and no-till equipment.

Farmers that move to a pure no-till machinery line may be able to reduce machinery costs without increasing cropping intensity, but may, by increasing cropping intensity, further lower their costs on a per acre basis. For those farmers who maintain conventional and no-till machinery and those farmers who do not obtain significant yield increases from no-till, the ability to make no-till profitable may depend on their ability to spread these machinery costs over more acres. The following example shows the effect increasing cropping intensity has on machinery costs.

Three example central/western Kansas machinery compliments that correspond to three different crop rotations – wheat-fallow (WF), wheat-sorghum-fallow (WSF), and wheat-sorghum-soybean (WSB) are shown in Table 3. These machinery compliments will be used to demonstrate the effect that the implementation of no-till and increased cropping intensity have on machinery costs. The WF rotation in this example uses conventional tillage exclusively, the WSF rotation uses conventional tillage prior to sorghum, and the WSB rotation is purely no-till. Undoubtedly, there are numerous crop rotations that farmers have adopted in central and western Kansas, but these rotations provide reasonable examples of varying levels of cropping intensity and conversion to no-till.

Table 3. Machinery Compliment and Associated Purchase Prices Used to Calculate Costs for Crop Rotations

Machine	Size	WF	WSF	WSB
MFWD Tractor	105 hp	$39,260	$39,260	$39,260
MFWD Tractor	200 hp	$57,543	$57,543	$57,543
Combine	260 hp (30 ft)	$86,716	$86,716	$86,716
Disk	25 ft	$7,811	$7,811	–
Sweep Plow	25 ft	$7,238	$7,238	–
Field Cultivator	30 ft	$5,450	$5,450	–
Grain Drill	30 ft	$18,578	$18,578	–
No-till Drill	20 ft	–	–	$40,800
No-till Planter	8r30	–	$30,900	$30,900
Sprayer	50 ft	–	$5,600	$5,600

The machinery compliment selected for each crop rotation was based on a farm with 1,600 tillable acres, the average size crop farm in the northwest and southwest Kansas Farm Management Associations. All machinery price information was obtained from *Doane's Agricultural Reports.* This report is taken from price and cost information compiled by William Lazarus of the University of Minnesota. Because the last report was provided last year, 1999 will be used as the current year. For this example, each machine in the WF compliment is five years old and will be owned for ten additional years. Although it is unlikely that every implement in a farmer's machinery compliment is the same age, a used machinery compliment, albeit the same age, is more realistic than an entirely new machine line. Thus, each machine was considered purchased new in 1994. Assuming that the WSF rotation was previously in a conventional WF rotation, a new planter and sprayer were assumed purchased for the addition of no-till sorghum. All tillage equipment from the WF rotation was kept as it will still be used in the wheat crop. Conversely, it was assumed that a purging of tillage equipment was made when the farm went to a WSB rotation. As a result, a new no-till drill, planter, and sprayer were purchased.

The machinery costs computed for each rotation were based on typical tillage and herbicide operations for that rotation. These operations are outlined in Tables 4, 5, and 6. The first step in calculating machinery costs for these rotations, is to estimate how many hours it takes to complete each operation. The ASAE field efficiency formula shown in Equation 5 is

$$APH = (S * W * E)/8.25, \qquad (5)$$

where APH = acres per hour, S = field speed, W = machine width, and E = field efficiency. To calculate hours per operation, divide the number of acres covered by APH. Once total hours for each operation are figured, fuel and labor values associated with each operation can then be computed using Equations 3 and 4. Then, after total hours per operation are computed, repair and maintenance costs for each machine can be calculated using Equation 2. Like the repair and maintenance formulas that estimate repairs based on annual hours of use, the depreciation formulas for tractors and combines also require annual hours of use. Consequently, it is necessary to assign each tillage, planting, and spraying operation to a specific tractor so annual hours for the tractors can be estimated.

Table 4. Field Operations, Acres Worked, Acres per Hour, and Total Hours for WF Rotation

Machine	No. of Operations	Acres Worked	Acres/Hour	Hours
105 HP Tractor	1	800	–	62.9
200 HP Tractor	6	4800	–	331.7
Disk	1	800	12.12	66.0
Sweep Plow	4	3200	14.17	225.9
Field Cultivator	1	800	20.09	39.8
Drill	1	800	12.73	62.9
Combine	1	800	7.64	104.8

Table 5. Field Operations, Acres Worked, Acres per Hour, and Total Hours for WSF Rotation

Machine	No. of Operations	Acres Worked	Acres/Hour	Hours
105 HP Tractor	6	3198	–	186.7
200 HP Tractor	5	2665	–	183.4
Disk	1	533	12.12	44.0
Sweep Plow	3	1599	14.17	112.9
Field Cultivator	1	533	20.09	26.5
Drill	1	533	12.73	41.9
No-till Planter	1	533	8.67	61.5
Sprayer	4	2132	25.60	83.3
Combine	2	1066	7.64	139.6

Table 6. Field Operations, Acres Worked, Acres per Hour, and Total Hours for WSB Rotation

Machine	No. of Operations	Acres Worked	Acres/Hour	Hours
105 HP Tractor	7	3731	–	227.1
200 HP Tractor	1	534	–	62.9
No-till Drill	1	534	8.48	62.9
No-till Planter	1	1066	8.67	123.0
Sprayer	5	2665	25.60	104.1
Combine	3	1600	7.64	209.5

Table 7 shows the machinery operating and ownership costs estimated for each rotation. Interest is the largest expense in each crop rotation, ranging from 34.1% of total costs in WF to 37.1% in WSF. Because the machinery compliments are mostly used, interest is the largest cost in this example. Usually, with new machinery, depreciation is large early in a machine's useful life, making it the largest ownership cost. However, with the five-year-old machinery in this example, the largest portion of depreciation has already occurred, thereby making interest the largest expense. If the machinery compliments were all new, depreciation would likely be more than interest. Nevertheless, depreciation is the second largest cost in each rotation, accounting for 24.2%, 27.1%, and 25.8% of total costs in the WF, WSF, and WSB rotations, respectively.

Following depreciation, repairs and maintenance constituted the third largest expense for the WF and WSB rotations. In the WSF rotation, it is the forth largest expense, following labor. Although the repairs total between $5,354 and $8,932 in the three rotations, this expense may actually be understated. In the author's opinion, the ASAE repair formulas used in this study probably underestimate repairs for equipment that is not used intensively and overestimate

repairs for machinery that is used very intensively. As a result, the repair expenses estimated in this paper should be used with some caution.

Table 7. Annual Machinery Operating and Ownership Costs for WF, WSF, and WSB Rotations

Cost Category	WF	WSF	WSB
Repairs	$6,674	$5,354	$8,932
Fuel and Oil	$4,224	$3,488	$2,669
Labor	$5,393	$5,504	$5,396
Depreciation	$10,774	$12,800	$12,933
Interest	$15,186	$17,559	$17,654
Housing and Insurance	$2,226	$2,591	$2,608
Total	$44,477	$47,297	$50,192

After repairs, labor was the next highest expense. The wage rate used in the labor calculations was $9.00 per hour. Although the labor total was multiplied by a factor of 1.20 to account for checking fields and travel time, the additional labor needed at harvest, for truck and/or grain cart drivers is not included in the labor value. Given the large differences in acreages, the labor expense of these three rotations differed by only $111, with WSF having the highest labor cost. Although WSB annually plants 534 more acres than WSF, labor costs are actually lower than WSF. However, as the additional harvest labor is accounted for, the difference in labor between WSB and WSF would likely shrink.

The two smallest machinery cost components, in terms of total costs, were fuel and oil and housing and insurance. As table 4 indicates, there is a reduction in fuel costs from $4,224 for WF to $2,669 for WSB. With diesel cost assumed to be $1.00 per gallon, the reduction in tillage significantly reduces fuel costs. Because WSB has the highest machinery investment, and housing and insurance is figured as a percentage of original depreciable value, WSB has the highest housing and insurance cost at $2,608. In each case, housing and insurance costs are about 5% of total costs.

For an analysis of machinery costs to be complete, costs *per acre* must also be considered. Figure 1 breaks out the machinery costs for each rotation on a per planted acre basis. As illustrated in this figure, the WSB rotation had the lowest cost per acre for all cost items except repairs. In the case of repairs, WSF was $0.55 lower per acre than WSB. All other WSB costs were much lower than for WSF or WF. This is because the WSB rotation has 100% of the tillable acres on the farm planted to a crop while the WSF and WF have only 67% and 50%, respectively. This demonstrates one of the fundamental benefits of no-till: the opportunity to increase cropping intensity and spread fixed machinery costs over more acres.

One of the concerns that farmers often have about no-till is the short run cost of purchasing no-till equipment. From the previous example, we can take a simple look at the short run cost of conversion. The switch from WF to WSF requires the purchase of a $30,900 no-till planter and a $5,600 sprayer. Since wheat is still grown using conventional tillage, all tillage equipment was retained. If a farmer already owns a conventional planter, it can often be converted to no-till for a few hundred dollars per row. The cost of the planter and sprayer spread over 10 years is $1,878 in depreciation and $2,440 in interest per year. However, the farmer must still come up with $36,500 the first year to purchase the planter and sprayer. Conversion to the WSB rotation requires a more significant investment in new machinery. In addition to the planter and sprayer purchased in the WSF rotation, a $40,800 no-till drill was also purchased. In this case though, the sweep plow, disk, and field cultivator were sold for a value of $20,499, resulting in a net purchase of $56,801. Again, this is just one example. Farmers may be able to use the no-till drill in the WSB rotation to plant all crops and forgo the planter, or convert a conventional planter to no-till.

When farmers convert to no-till and increase cropping intensity, they tend to do so gradually, rather than all at once. Using the same WF machinery compliment, Figure 2 shows the annual machinery costs per planted acre during the transition from WF to WSF. In this figure, machinery costs where sorghum planting and spraying were custom hired at all levels of WSF adoption are compared to purchasing a new planter and sprayer at 10% WSF adoption. When the planter and sprayer are purchased at 10% WSF adoption, costs per planted acre are around $5 more than custom hire. The difference in costs shrinks as more acres are devoted to WSF. At approximately 70% WSF, the costs of owning the planter and sprayer become equal to custom hire. From 70%-100% WSF conversion, the cost of owning is less than custom hire. Although the cost of custom hire for planting and spraying is lower up to 30% WF, yield losses that occur when these operations are not completed at the optimal time can potentially offset any cost savings.

While machinery costs are important factors in making the decision to convert to no-till and increase cropping intensity, the overriding decision maker is profitability. Figure 3 shows the returns per tillable acre during different levels of transition between WF and WSF. The yields for wheat and sorghum are based on average yields for conventional wheat and no-till sorghum from 1991-99 at the K-State Southwest Research-Extension Center in Tribune. The average wheat and sorghum yields over this period were 40 and 79 bushels per acre, respectively. Production costs, in 1999 dollars, are based on typical agronomic practices for these crops. Using average breakeven prices of $3.30 for wheat and $2.20 for sorghum, returns over variable costs increase from $50 per acre at 100% WF to $63 per acre at 100% WSF. Because machinery costs are nearly constant across all transition levels, the difference in returns over total costs between 100% WF and 100% WSF are nearly identical to returns over variable costs. Thus, WSF is about $12 per acre more profitable than WF. Another interesting point to notice is that the returns over total costs reflect current cash rents in southwest Kansas. As land is gradually converted from WF to WSF, cash rents are bid up reflecting the increased profitability of WSF.

Although no-till combined with increased cropping intensity can spread machinery costs over more acres, it is still important that the new no-till crops yield high enough to at least break even with previous rotations. Moreover, whether a farmer uses no-till only on part of his cropland or converts to 100% no-till, the initial cash requirements of conversion can be very high. Consequently, when making the decision to convert to no-till, farmers must analyze several issues including machinery costs, non-machinery production costs, and yield expectations.

Keep or Sell That Tillage Equipment

Another issue that farmers often face when converting to no-till is whether they should keep their tillage equipment when they buy no-till equipment. As previously noted, there are many cases in which farmers may choose to keep some or all of their tillage equipment.
To determine whether to keep or sell a tillage implement, a farmer must first estimate the annual cost of keeping that implement. Figure 4 shows the annual cost of a 25 foot tandem disk. A new disk, not used at all and depreciated over 10 years, would cost $2,900 per year in depreciation, interest and repairs. As the disk is used on progressively more acres, the annual cost increases. This is due entirely to an increase in repairs that occurs with increased use. While higher depreciation is likely to occur with increased use, no depreciation formula can capture that as there are no acre or hour meters on disks. Nevertheless, the higher depreciation likely will be captured to some extent in the higher repair costs. A five year old disk, depreciated for an additional ten years has an annual cost of $991 if it is not used. Like the new disk, the cost of a used disk increased as it is covers more acres. Also like the new disk, the increase in cost is entirely due to repairs.

The per acre costs of the same disks are shown in Figure 5. As the figure indicates, if the new disk is used on 200 acres per year, the total cost would be $16.00 per acre (this includes fuel and labor costs of $1.39 per acre). The cost per acre decreases to $4.20 when it is used on 1200 acres per year. The cost of the used disk, used on 200 acres per year, is $6.49 per acre, compared to $2.74 per acre when used on 1200 acres per year. The conclusions that can be drawn from this example are that keeping an older tillage implement that is largely depreciated out is certainly less costly than keeping a new disk that would be used on only a few acres. Also, the cost of the disk kept after converting to no-till is largely non-cash depreciation and interest. Thus, the decision to keep or sell the disk may depend on alternative investment opportunities.

When to Buy No-till Equipment

Yet, another decision farmers have to make when they begin experimenting with no-till is when and if they should buy a no-till planter, drill, or sprayer. This section compares the cost of owning a no-till drill and self propelled sprayer to average rental rates and custom hire. Focusing on the no-till drill, Figure 6 compares the cost of owning a new drill to owning a used drill and to renting a drill. The new 20 foot drill, purchased for $40,800, would cost $23.01/acre annually if used on only 200 acres per year. That cost drops to $7.43/acre on 800 acres, making it comparable to the $7.38/acre it would cost to rent a drill (*Kansas Custom Rates*). A 5 year old no-till drill would cost $12.56/acre if used on 200 acres per year, but decreases to $7.27/acre at 400 acres per year. After 800 acres repairs begin to mount and the cost of owning a drill begins to increase. As Figure 6 shows, a new no-till drill would need to be used on about 800 acres per year to have a cost comparable to renting a drill. A used drill, however, would only need to be used on about 400 acres per year to be comparable to renting a drill. However, this example does not take into account that a rental drill may not be available when it is needed, possibly resulting in some timeliness losses. Also not considered in this example are the income tax consequences of buying a drill, the timing of cash flows, and the time value of money. For a complete analysis to determine whether to purchase or rent a drill, a Net Present Value investment analysis should be completed in addition to calculating annual costs.

With the popularity of reduced tillage and biotech crops among farmers, several companies have introduced large self-propelled sprayers into the sprayer market. Given the advantages of owning a sprayer, including timely applications and potentially lower application costs, at what point can farmers begin thinking about owning a self-propelled sprayer? In an example similar to the no-till drill example, Figure 7 compares the cost of owning a sprayer versus custom hire. However, since owning a sprayer is being compared to custom application, all costs, including fuel and labor are included in this example. The purchase price of a new sprayer with a 60 foot boom was $68,200, compared to $22,800 for a five year old sprayer. Using the ASAE depreciation formulas in Table 2, notice that the self-propelled sprayers have a high rate of depreciation compared to other equipment. Because of the high rate of depreciation of a new sprayer, it would have to cover nearly 5,250 acres to make the owning and operating costs comparable to custom application. On the other hand, a used sprayer would require only 1500 acres to make ownership competitive to custom application. Although custom application may be less expensive in some situations, some farmers may be willing to accept higher ownership costs in order to improve weed control through timely applications.

Conclusion

Making decisions about machinery requires much thought and calculation. Not only do farmers have many options regarding manufacturers, sizes, features, and financing for an individual machine, they must also consider how that machine will fit into their overall operation. More than ever, farmers have the freedom to plant the crops the market dictates. With this freedom comes the increased responsibility of determining which cropping system is most profitable for them. In these cropping systems, farmers must choose which crops to grow, in which rotations, and with which tillage intensities. Within these decisions, farmers must then determine which machines will be needed in their cropping system and how the acquisition and use of these machines will affect the overall profitability of the system. This paper provides an explanation of the machinery cost formulas that can be used for making some of these decisions. In addition, several examples illustrate how machinery costs are affected by conversion to no-till and increased cropping intensity. While individual situations may differ, these examples provide a framework farmers can use to make no-till decisions on their own operations.

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Table A.1 Field Efficiency, Field Speed, and Repair and Maintenance Factors for Field Operation

	Field Efficiency		Field Speed		EUL		Repair Factors	
	Range %	Typical %	Range mph	Typical mph	Est. Life hours	Tot. Life Cost%[a]	RF1	RF2
TRACTORS								
2WD & stationary					12,000	100	0.007	2.0
4WD & crawler					16,000	80	0.003	2.0
TILLAGE & PLANT								
Moldboard plow	70-90	85	3.0-6.0	4.5	2,000	100	0.29	1.8
Heavy-duty disk	70-90	85	3.0-6.0	4.5	2,000	60	0.18	1.7
Tandem disk harrow	70-90	80	4.0-7.0	6.0	2,000	60	0.18	1.7
(Coulter) chisel plow	70-90	85	4.0-6.5	5.0	2,000	75	0.28	1.4
Field Cultivatior	70-90	85	5.0-8.0	7.0	2,000	70	0.27	1.4
Spring tooth harrow	70-90	85	5.0-8.0	7.0	2,000	70	0.27	1.4
Roller-packer	70-90	85	4.5-7.5	6.0	2,000	40	0.16	1.3
Mulcher-packer	70-90	80	4.0-7.0	5.0	2,000	40	0.16	1.3
Rotary hoe	70-85	80	8.0-14.0	12.0	2,000	60	0.23	1.4
Row crop cultivator	70-90	80	3.0-7.0	5.0	2,000	80	0.17	2.2
Rotary tiller	70-90	85	1.0-4.5	3.0	1,500	80	0.36	2.0
Row crop planter	50-75	65	4.0-7.0	5.5	1,500	75	0.32	2.1
Grain drill	55-80	70	4.0-7.0	5.0	1,500	75	0.32	2.1
HARVESTING								
Corn picker sheller	60-75	65	2.0-4.0	2.5	2,000	70	0.14	2.3
PT Combine	60-75	65	2.0-5.0	3.0	2,000	60	0.12	2.3
SP Combine	65-80	70	2.0-5.0	3.0	3,000	40	0.04	2.1
Mower	75-85	80	3.0-6.0	5.0	2,000	150	0.46	1.7
Mower (rotary)	75-90	80	5.0-12.0	7.0	2,000	175	0.44	2.0
Mower-conditioner	75-85	80	3.0-6.0	5.0	2,500	80	0.18	1.6
Mow-cond (rotary)	75-90	80	5.0-12.0	7.0	2,500	100	0.16	2.0
SP Windrower	70-85	80	3.0-8.0	5.0	3,000	55	0.06	2.0
Side delivery rake	70-90	80	4.0-8.0	6.0	2,500	60	0.17	1.4
Square baler	60-85	75	2.5-6.0	4.0	2,000	80	0.23	1.8
Large square baler	70-90	80	4.0-8.0	5.0	3,000	75	0.10	1.8
Large round baler	55-75	65	3.0-8.0	5.0	1,500	90	0.43	1.8
Forage harvester	60-85	70	1.5-5.0	3.0	2,500	65	0.15	1.6
SP Forage harvester	60-85	70	1.5-6.0	3.5	4,000	50	0.03	2.0
Sugar beet harvester	50-70	60	4.0-6.0	5.0	1,500	100	0.59	1.3
Potato harvester	55-70	60	1.5-4.0	2.5	2,500	70	0.19	1.4
SP Cotton picker	60-75	70	2.0-4.0	3.0	3,000	80	0.11	1.8

MISCELLANEOUS								
Fertilizer spreader	60-80	70	5.0-10.0	7.0	1,200	80	0.63	1
Boom-type sprayer	50-80	65	3.0-7.0	6.5	1,500	70	0.41	1
Bean puller/windrower	70-90	80	4.0-7.0	5.0	2,000	60	0.20	1
Beet topper/chopper	70-90	80	4.0-7.0	5.0	1,200	35	0.28	1

Source: ASAE Standard 1993, American Society of Agricultural Engineers, St. Joseph, Michigan, 1993, p. 332.
[a] percent of current list price

Table A.2 Average Energy and Fuel Requirements for Selected Machinery Operations

		Gasoline	Diesel	LP Gas
Avg fuel consump. per max pto hp (gal per hr)>		0.068	0.044	0.08
Field Operation	PTO hp-hrs/acre	Gasoline gal/acre	Diesel gal/acre	LP Gas gal/acre
Shred stalks	10.5	1.00	0.72	1.20
Plow 8-in deep	24.4	2.35	1.68	2.82
Heavy offset disk	13.8	1.33	0.95	1.60
Chisel Plow	16.0	1.54	1.10	1.85
Tandem disk, stalks	6.0	0.63	0.45	0.76
Tandem disk, chiseled	7.2	0.77	0.55	0.92
Tandem disk, plowed	9.4	0.91	0.65	1.09
Field cultivate	8.0	0.84	0.60	1.01
Spring-tooth harrow	5.2	0.56	0.40	0.67
Spike-tooth harrow	3.4	0.42	0.30	0.50
Rod weeder	4.0	0.42	0.30	0.50
Sweep plow	8.7	0.84	0.60	1.01
Cultivate row crops	6.0	0.63	0.45	0.76
Rolling Cultivator	3.9	0.49	0.35	0.59
Rotary hoe	2.8	0.35	0.25	0.42
Anhydrous applicator	9.4	0.91	0.65	1.09
Planting row crops	6.7	0.70	0.50	0.84
No-till planter	3.9	0.49	0.35	0.59
Till plant (with sweep)	4.5	0.56	0.40	0.67
Grain drill	4.7	0.49	0.35	0.59
Combine (small grain)	11.0	1.40	1.00	1.68
Combine, beans	12.0	1.54	1.10	1.85
Combine, corn & milo	17.6	2.24	1.60	2.69
Corn picker	12.6	1.61	1.15	1.93
Mower (cutterbar)	3.5	0.49	0.35	0.59
Mower conditioner	7.2	0.84	0.60	1.01
Swather	6.6	0.77	0.55	0.92
Rake, single	2.5	0.35	0.25	0.42
Rake, tandem	1.5	0.21	0.15	0.25
Baler	5.0	0.63	0.45	0.76
Stack wagon	6.0	0.70	0.50	0.84
Sprayer	1.0	0.14	0.10	0.17
Rotary Mower	9.6	1.12	0.80	1.34
Haul small grains	6.0	0.84	0.60	1.01
Grain drying	84.0	8.40	6.00	10.08
Forage harvester, green	12.4	1.33	0.95	1.60

Forage harvester, haylage	16.3	1.75	1.25	2.10
Forage harvester, corn	46.7	5.04	3.60	6.05
Forage blower, haylage	3.3	0.35	0.25	0.42
Forage blower, corn silage	18.2	1.96	1.40	2.35

Source: Machinery Replacement Strategies, by Wendell Bowers, Deere and Company, 1994, p. 80,81.