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Suggested Procedures for Estimating Farm Machinery Costs for Extension Audiences

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Suggested Procedures for Estimating Farm Machinery Costs for Extension Audiences

by William Lazarus and Roger Selley

One of the goals of the North Central Farm Machinery Task Force was to help evaluate alternative methods for estimating farm machinery ownership and operating costs and to make recommendations for the development of extension materials. The purpose of this paper is to describe the procedures agreed upon by task force members, and to explain the rationale for the procedures chosen. "Extension materials" above refers mainly to those such as the Minnesota fact sheet that provide "typical" machinery costs for use in extension budgets and other analyses and examples. Much of the discussion would also be applicable to individualized analyses such as those by a farmer who wants to estimate costs for a particular operation, but the "typical" values discussed here for factors such as years of ownership, annual usage, tax rates, etc. would need to be tailored to the individual situation. This paper also provides detailed documentation of the methods used in recent versions of the widely used *Minnesota Farm Machinery Economic Cost Estimates* publication (referred to below as "the Minnesota fact sheet"), focusing mainly on the 2000 version. Refer also to Lazarus (2001) for user instructions for the MACHDATA.XLS template used to calculate the estimates in that publication. The task force members reviewed the procedures used in Iowa, Minnesota, Missouri, and Nebraska publications. We also reviewed chapters five and six of the AAEA Costs and Returns (CAR) Task Force report, which discusses machinery operating and ownership costs.

Consistent with the CAR Task Force report, we will use the following cost terminology:

- Ownership Costs
  - ⇒ Overhead
    - Personal property taxes
    - Interest
    - Insurance
    - Housing
  - ⇒ Depreciation (capital recovery)
- Operating Costs
  - ⇒ Fuel, oil and lube
  - ⇒ Repairs
  - ⇒ Labor
  - ⇒ Materials (baler twine, etc.)

The above terminology contrasts with identifying ownership costs as fixed costs and operating costs as variable costs. Any one of the above cost categories could be fixed or variable depending upon the decision context.

Assumptions Underlying Cost Estimates

The estimation of machinery ownership and operating costs depends critically upon the availability of reliable cost data and knowledge of when the cost will be incurred. Simplicity may also be a consideration which relates to both the method used and the detail of the information required.

Consistent with the determination of the CAR Task Force, the ideal situation that is discussed here assumes that estimates of the magnitude and timing of all costs are available, i.e. the amount and timing of purchase and sale or trade-in (or if financed, the amount and timing of all principal and interest payments) as well as the amount and timing of all repair costs, insurance, and personal property tax payments. Estimates of fuel, labor, and material costs (and housing) must, of course, also be available but are usually not considered timing dependent, e.g. fuel consumption per hour is typically assumed constant regardless of the age of the power unit [1].

In this ideal situation, the preferred method would involve laying out a periodic cash flow, adjusting all of the cash flows to current dollars, discounting the cash flows to the present and determining an average periodic (usually annual) amortized cost. Cost per hour or per acre can then be determined by dividing the cost per period by the hours or acres per period.

As will be discussed below, if the timing of the cash flows is not known (or as a short cut timing is ignored) the preferred cost estimation method will depend upon the time value of money.

We will first consider the estimation and timing of the cash flows before we return to the method of analysis.

Purchase Prices

The purchase price (including any applicable sales tax) provides the initial depreciable balance or capital recovery amount in any machinery cost estimate. However, purchase prices of machinery commonly reflect varying discounts resulting in actual purchase prices that are case specific. List prices, on the other hand, are set by the manufacturer and typically remain unchanged over a large geographic area. List prices, therefore, provide a convenient starting point for establishing machinery costs and historically have been used in estimating repair costs and projecting resale values. Adjusting manufacturer list prices for typical dealer discounts, manufacturer rebates, and sales taxes likely provides an accurate basis for estimating purchase prices in budget estimates that are for general distribution. Periodically collecting current list prices and adjusting machinery ownership and repair costs accordingly provides cost estimates in current dollars. The rationale that repair costs (particularly parts) likely increase as list prices increase is generally well received. To convince an audience that depreciation costs should be revised annually to reflect ownership costs in current dollars is more challenging. However, failure to adjust depreciation costs with changes in replacement costs could be disastrous in a period of high inflation. Failure to adjust for even a 3% annual inflation would result in a 34% underestimate in the final year of depreciation of a piece of equipment purchased 10 years ago. It is important that depreciation is estimated in current dollars!

The CAR Task Force and others have used capital budgeting techniques to demonstrate the need to deal with the "depreciation under inflation" problem discussed above. Many machinery owners are unfamiliar with capital budgeting, however, and tend to use reasoning such as:

Q: "The purchase cost of a machine has been (or is being) recovered through annual depreciation of the purchase cost. Why do I need to worry about anything more complicated?" This question might come up, for example, for a machine that the owner has used for five years after purchasing it for $10,000. He has been expecting to use it for ten years, and has been claiming depreciation of $1,000 each year. Now, a neighbor wants to use it this next year. What should the owner charge? If he charges interest on the undepreciated (or loan) balance plus taxes, insurance, an allowance for repairs, and $1,000 to cover the annual depreciation, he will recover the amount he has been charging himself the last five years. If he has a loan with, say, a principal payment of $1,000/year, he will be able to make the annual principal payment. What is he missing?

[1] All prices including fuel prices could be expected to change over time and the timing of those changes could be important in estimating the average annual (or hourly) fuel cost for the use period in today's dollars.

A: He is okay if the item is currently worth $5,000 and if it can be replaced in another five years for the same $10,000 as the current machine cost. But, machinery prices have likely increased over time. What if it will cost $15,000 to replace? The owner will have to come up with an extra $5,000 in addition to the $10,000 in depreciation he will have written off as expense over the ten years. Shouldn't the depreciation expense he charges the neighbor increase over time as the replacement's price increases?

A solution for the owner above would be to recalculate his depreciation expense each year using a current new price for the machine, and adjust the charge to account for the new depreciation expense. The current north central regional machinery cost publications use current prices of new equipment to estimate ownership costs, so depreciation is in current dollars. Using the current purchase price and estimating the trade-in or salvage value from the current sale price of a comparable used unit will facilitate the estimation of investment cost and depreciation that is expressed in current dollars. A comparable unit is one that is of the same size and features and that is of the same age in years and use as the item being costed is expected to be at trade-in or salvage. Using the subsequent depreciation estimate and a real rate of interest on the investment will result in a cost estimate that is inflation-adjusted in line with the CAR Task Force recommendations (CARE Handbook, pp. 6-16).

The methodology reported in this paper is consistent with the post-1981 USDA approach presented by Hoffman and Gustafson and described by Harrington as an incomplete cost of production framework where income tax considerations are ignored, any future effect that inflation may have upon machinery values is ignored (thereby ignoring any capital gains or losses) and an attempt is made to remove the inflation component in the interest rate to arrive at a before-tax, real (inflation-free), end-of-year estimate of machinery costs for an explicit time point (when the price quotes were effective). For a complete discussion of inflation and after-tax costs, see Kastens.

Remaining Value

The most recent machinery cost publications developed in the north central region have based salvage values (the market values at trade) on equations published in the 1999 edition of <u>ASAE Standards</u> published by the American Society of Agricultural Engineers. These equations are a simplified version of equations published by Cross and Perry in their 1995 <u>American Journal of Agricultural Economics</u> (AJAE) article, with modifications based on additional work done by Cross and Perry after their 1995 article. The number of parameters in the ASAE equations was reduced to three from the six used in Cross and Perry's reduced form equations. Cross and Perry indexed both their initial list prices and their used equipment auction sales prices to a common year using the Producer Price Index[2], to put their estimated equations on a real basis.

Table 1 shows the remaining value percentages of list price predicted by the two sets of equations for machines after 12 years of use, assuming 500 annual hours of use for the tractors and 300 hours for combines. In general, the ASAE remaining value estimates are lower than those published in the AJAE. For 150+ horsepower tractors and planters, the predictions are within two percentage points. For some other types of equipment, however, the differences are disconcertingly large. For plows, the difference is 19 percentage points at 12 years of age, while there is only a one-percentage point difference for combines (Table 1). Tim Cross attributes the differences mainly to the small number of observations for some types of equipment in his database of used equipment auction prices[3]. The effect of years of use on the remaining value estimates is illustrated in Figures 1 and 2. As shown, the percentage point difference between equations is fairly consistent over years of use. The formulas permit adjustment for difference in annual usage for tractors, combines and skid steer loaders which are usually equipped with tachometers.

[2] See footnote 4 below.
[3]Tim Cross, Personal communication, August 1998.

The adjustment is fairly small, at least for mid-sized tractors of 80 to 149 horsepower. For example, after 12 years of use at 800 hours of annual use, remaining value is 33 percent of list compared to 36 percent at 300 hours (Figure 3). The form of the equation for remaining value is:

$$RV_t^n = LP_t \left(RV1 - RV2\left(n^{0.5}\right) - RV3\left(\frac{H_n}{n}\right)^{0.5} \right)^2 \qquad (1)$$

where

RV_t^n = remaining (trade) value in year t dollars at n years of age with H_n total hours of use

LP_t = List price in year t dollars

RV1, RV2, RV3 = equation parameters

Table 1. Remaining Values After 12 Years of Use, Based on 1995 AJAE and 1999 ASAE Equations

Equipment Type	Annual Hours	AJAE	ASAE
30-79 HP tractors	500	40%	28%
80-149 HP tractors	500	37%	34%
150+ HP tractors	500	29%	27%
Combines	300	19%	18%
Balers	-	39%	25%
Swathers	-	28%	23%
Planters	-	40%	38%
Plows	-	51%	32%
Disks	-	27%	26%
Manure spreaders	-	18%	31%
Skid steer loaders	300	32%	26%

Figure 1. Remaining Value as Percent of List Price, 80-149 Horsepower Tractors at 500 Hours Per Year

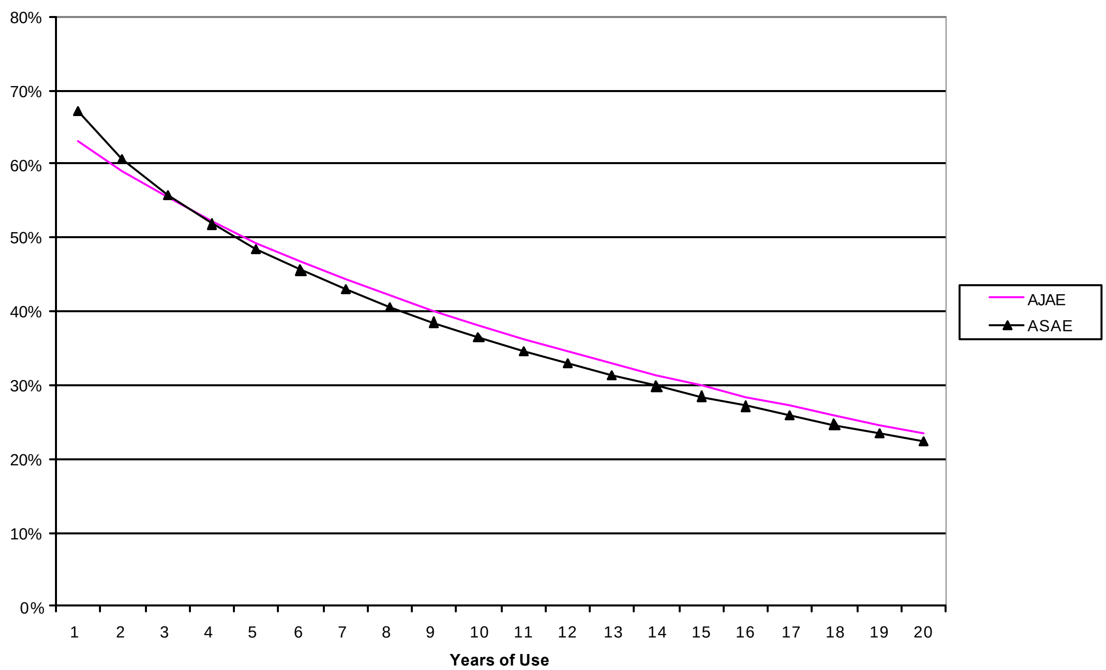


Figure 2. Remaining Value as Percent of List Price, Balers

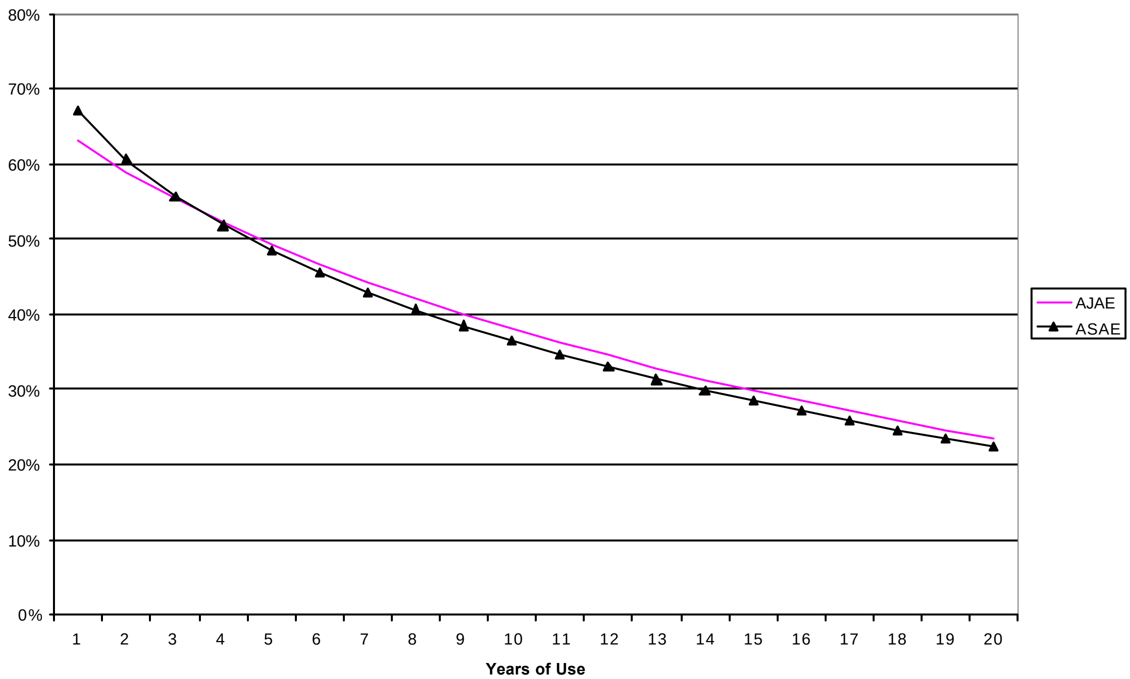
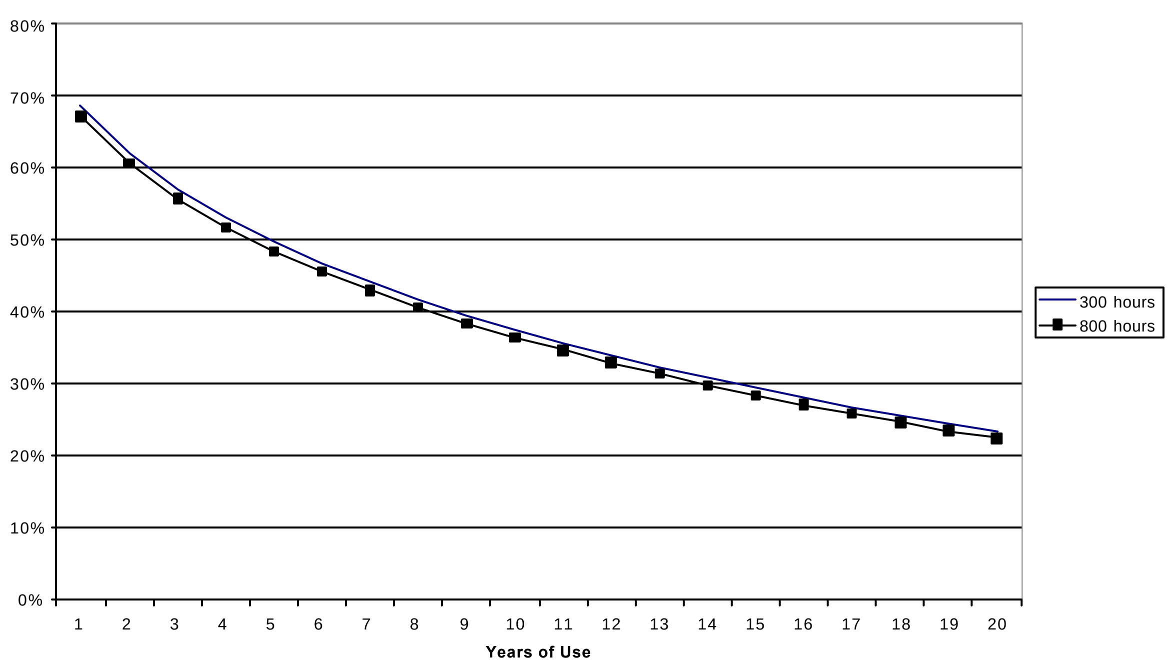


Figure 3. Annual Usage Effect on Remaining Value, 80-149 Horsepower Tractors, Using ASAE Equation



Years of Ownership and Annual Usage

The number of years that a newly purchased machine is owned before trading and annual usage can have a large impact on average per-unit ownership costs. The Minnesota fact sheet costs are based on a uniform 12-year ownership life on all machines, with hours of annual use varying by machine. These assumed values have been developed over time and are revised based on feedback received. The only formal survey work to validate them was a brief supplement to a late-1998 custom rate survey which asked how old the most-recently-traded tractor and combine had been. Seventeen responses were received for tractors and 23 were received for combines. The tractor responses averaged 10.4 years and 3,424 hours, with medians of 8 years and 3,000 hours. The combine responses averaged 7.8 years and 2,003 hours, with medians of 6 years and 1,700 hours.

A set of two-part sensitivity tables has been added to the accompanying spreadsheet template for the Minnesota fact sheet in order to analyze the impact of varying ownership life and usage. Table 2 shows the table for an example 130-horsepower, mechanical-front-wheel-drive tractor. While ownership life is often expressed in terms of years, our experience leads us to believe that producers might be more likely to trade on the basis of accumulated hours of usage rather than years. That is, a heavily-used machine gets traded in fewer years while one seeing lighter usage is kept around longer. The top panel of the sensitivity table shows different ownership lives across the top, expressed as accumulated hours. Different amounts of annual usage are shown on the left side. The body of the table shows the years to trade that would be implied for any combination of hourly life and usage. For example, a tractor used 450 hours per year and owned for 5,400 hours would be traded at 12 years. If used 1,350 hours per year, it would reach the same 5,400-hour trade-in point in only four years. The ASAE Standards estimated wear-out life for four-wheel-drive tractors is 16,000 hours. If the example tractor were to be kept until a 16,000-hour trade-in point while being used only 225 hours per year, its ownership life would be a whopping 71 years. The impact of varying ownership life on unit cost at a constant annual usage rate can be seen by following one of the lines across the lower panel of the table. At 450 hours of use per year, keeping the tractor for 18 years rather than 12 years reduces the cost from $26.06 per hour to $24.51. On the other hand, the effect of keeping it for more years but using it less per year can be seen by moving up or down the column. Keeping the tractor for 16 years but using it for only 338 hours per year would increase the cost to $29.17 per hour.

Table 2. Sensitivity Analysis of Ownership Life and Total Cost Per Hour for an Example 130-Horsepower, Mechanical-Front-Wheel-Drive Tractor.

	Accumulated hours at trade-in					
Annual hours of use	2,700	4,050	5,400	8,100	10,800	16,000
	Expected years to trade-in					
225	12	18	24	36	48	71
338	8	12	16	24	32	47
450	6	9	12	18	24	36
675	4	6	8	12	16	24
900	3	5	6	9	12	18
1,350	2	3	4	6	8	12
	Total cost per hour					
225	$ 42.00	$ 37.27	$34.57	$31.72	$30.47	$30.09
338	$ 34.83	$ 31.18	$29.17	$27.15	$26.34	$26.29
450	$ 30.75	$ 27.69	$26.06	$24.51	$24.00	$24.25
675	$ 26.18	$ 23.74	$22.51	$21.49	$21.32	$21.96
900	$ 23.63	$ 21.51	$20.50	$19.77	$19.78	$20.65
1,350	$ 20.85	$ 19.05	$18.26	$17.83	$18.03	$19.15

Property Taxes and Insurance Costs

The appropriate procedure to follow in estimating personal property tax on machinery will depend upon the schedule used. In Nebraska, for example, personal property tax is assessed on the undepreciated balance used for IRS. In some cases the remaining value equations discussed above will provide a satisfactory assessed value.

There is reason to question whether insurance costs should be included in estimating the cost of machine services since insurance is a means of shifting (managing) risk and some machinery owners may chose to self insure. Where insurance costs are included in machinery costs there is also a question of level of coverage. Some insurance companies, for example, provide replacement cost coverage while others provide coverage up to the current value of the machine in which case the remaining value equations would provide a reasonable estimate of the insured value over time. Insurance costs will be discussed further under financing.

Financing Costs

Machinery investment can be self-financed, financed with borrowed funds or with a combination of own and borrowed funds. The financing alternatives will be reflected in the respective cash flows required of the owner. Similar to insurance, it could be argued that financing is a separate consideration that would best be evaluated as a part of the entire farm financial and risk management package rather than being considered in calculations of machinery costs for typical situations. One situation where it would be important to consider financing costs would be when the financing arrangement and the purchase choice are linked, such as buying one tractor with company financing or a different tractor with a different purchase price through bank financing. The machinery cost shown in the Minnesota fact sheet and those compared in the main body of this paper ignore financing considerations. However, since machine purchases are often partly self-financed and partly self-insured and partly commercially financed and insured, we have chosen to consider the impact of the financing and risk management alternatives on the cost estimates in Appendix tables A1 through A5, which are discussed below in the section "Alternative Methods for Calculating Machinery Costs." In particular, we show how the net present value of cash flows differs when the debt interest rate differs from the opportunity cost of equity capital.

Repair Costs

Repair equations for farm machinery published by the ASAE are of the following form:

$$C_t = (RF1)(LP_t)\left(\frac{H_n}{1000}\right)^{RF2} \tag{2}$$

where

H_n = cumulative hours of use at n years of age

C_t = cumulative repair cost in year t dollars at the end of H_n hours of use

LP_t = List price in year t dollars

RF1 = repair factor 1

RF2 = repair factor 2

Repair costs in the nth year of use in year t dollars can be calculated as follows:

$$R_t[n] = C_t[H_n] - C_t[H_{n-1}] \tag{3}$$

The ASAE repair equations result in at least a small cost from the very first hour of use. Warranties on new equipment typically cover the cost of repairs for the first year or so of use. While the practical significance may be small, for completeness the Minnesota fact sheet calculations incorporate warranty considerations by subtracting the first year's component from the total lifetime accumulated repair cost.

Another display-related issue is the effect of field speed on repair cost. Implement repairs are shown in the Minnesota publication on a per-acre basis, and are calculated assuming a typical field speed. If repair cost per acre was calculated at two different speeds using the standard economic-engineering model and compared keeping constant the annual hours of operation, the higher speed would reduce the per-acre repair cost as acres covered per hour increase. A reduction in calculated per-acre repairs as speed increases is probably not realistic, as a higher speed would likely increase breakage and wear. This line of reasoning leads us to recommend that repair costs be displayed on a per-acre basis in extension publications where possible rather than displaying per-hour costs. Using our constant per-acre cost estimates with higher or lower field speeds is expected to more accurately capture the effects of speed differences than starting with per-hour costs and using their field speed to calculate per-acre costs.

Adjusting Prices and Costs for Inflation

The remaining value and repair cost equations are based on current list prices and provide estimates in current (year t) dollars. An inflation adjustment would be required if a cost estimate is needed for a different base period. A price index such as the "U.S. Producer Price Index for Finished Goods: Capital Equipment" could be used to make any needed adjustment as follows[4]:

$$A_k = A_j \times \frac{PI_k}{PI_j} \qquad (4)$$

where

A_k = the amount in period k dollars,

A_j = the amount in period j dollars,

PI_k = the price index for period k,

PI_j = the price index for period j, and

$\frac{PI_{k+1}}{PI_k} =$ i, the rate of inflation from k to k+1.

Regardless of the method of analysis, all prices and costs should be expressed in the same base before aggregating since estimates can be substantially distorted by adding costs from one period to costs from another even with relatively low inflation rates. In many budget applications using current list prices will suffice to express all costs in current dollars. However, as indicated above, it can be a challenge to convince an audience that depreciation should be adjusted to current dollars.

Alternative Methods for Calculating Machinery Costs

Four alternative methods for calculating machinery costs are compared in Table 2 for an example tractor. The first column, labeled "exact method", is calculated using the capital recovery or annuity method which the CAR Task Force recommends if estimates of the timing and amounts of costs are available. The other three columns show the results using three approximations which are described below.

Additional details of the exact method's cash flow (excluding housing) for the tractor in the example are presented in Appendix Table A1. Since inflation is assumed zero, the list price used to calculate the remaining value and repairs for each period remains at $77,800. This table illustrates the simplest case, where the purchase is self-financed. Sales tax is added to the purchase price on the difference between the purchase price and the assumed trade. Repairs are calculated in Table A1 assuming repairs in Year 1 are covered by the warranty. Insurance (and personal property tax) is calculated as a percent of the remaining value at the beginning of each year. Since the inflation rate is assumed zero, the annual cash flows are the same in Year t and Year 0 dollars. Appendix Table A1 also illustrates discounting the cash flows to

[4] See the Producer Commodity Price Index database in the Federal Reserve Bank of St. Louis. FRED data base (http://www.stls.frb.org/fred).

reflect the preference for a dollar today over a dollar a year later. The value of a dollar received n years from now is expressed in today's dollars by discounting:

$$V_o = \frac{V_n}{(1+d)^n} \tag{5}$$

Where

V_o = the present value amount

V_n = amount received at end of period n

d = the discount rate

The discount rate is an interest rate that would result in an individual being indifferent between receiving V_o now or V_n at the end of period n.

The annual payment of $7,940 shown in Appendix Table A1 is the equal annual payment at the end of each year that is equivalent to the sum of the discounted annual net cash flows, $66,566, or the net present value (NPV) of the cash stream. The annual payment or so-called annuity payment (PMT) of $7,940 is calculated from the following formula:

$$PMT = NPV \frac{d}{1 - \frac{1}{(1+d)^N}} \tag{6}$$

where

PMT = annual payment,

$$NPV = \sum_{n=o}^{N} \frac{A_n}{(1+d)^n} \tag{7}$$

A_n = the net cash flow received at the end of period n expressed in current (period 0) prices,

d = the discount rate, and

N = total number of periods.

Appendix Tables A2 and A3 extend the example to compare self-financing of the machine purchase to using an amortized loan and making equal annual principal payments. Appendix Tables A2 and A3 illustrate that as long as the discount rate of the borrower is the same as the discount rate of the lender (the real lending rate), the cost of financing the purchase is unaffected by the financing arrangement. The NPV of all alternatives with and without inflation is $58,218. Appendix Tables A4 and A5 illustrate that if the borrower discount rate and lender rate are not identical, the financing arrangement affects the real cost to the borrower and introducing inflation results in a difference in NPV between financing alternatives.

Approximations

Preparing a cash flow as presented in Appendix Table A1 may require more detail than is available. Also, a simpler method may be desirable if the calculations are easier to explain and the results are not significantly different. For example, capital investment cost estimation has been presented in many farm management textbooks and extension materials as calculating interest on average mid-period investment. This is referred to below as the "mid-year approximation" or (E_{mid}):

$$E_{mid} = \frac{PC - SV}{N} + \frac{PC + SV}{2}\left(r + p + s\right) + \frac{C_0}{N} \qquad (8)$$

where

PC = purchase cost

SV = salvage (trade) value

PC-SV = total depreciation for use period

N = use period

$$\frac{PC - SV}{N} = annual\ \ straightline\ depreciation$$

$$\frac{PC + SV}{2} = midperiod\ average\ investment$$

r = interest rate

p = personal property tax rate

s = insurance rate

C_o = cumulative repairs based on Equation (2)

Calculating interest on the undepreciated balance at the beginning of each period following straight-line depreciation results in the following, referred to below as the "beginning-of-year method" or (E_{beg}):

$$E_{beg} = \frac{PC - SV}{N} + \frac{PC + SV + \frac{PC - SV}{N}}{2}\left(r + p + s\right) + \frac{C_0}{N} \qquad (9)$$

where:

$$\frac{PC + SV + \dfrac{PC - SV}{N}}{2} = beginning\ of\ \ period\ \ average\ investment$$

The AAEA Task Force expresses a clear preference with respect to methods of calculating ownership costs: "The Task Force recommends the capital recovery (annuity) method of calculating annual depreciation and interest costs over the traditional method." (CARE Handbook, p. 6-24)

The recommendations on repair costs are more ambiguous: "The Task Force recommends that repair costs be estimated using either equations……. which do not adjust for repair costs changing over time, or equations……which create a constant real annuity that reflects changing costs over time. If the latter….equations (based on capital budgeting) are used to estimate repair cost, it is important these equations also be used for depreciation, taxes and other costs that may vary substantially through time." (CARE Handbook, p. 5-29)

In addition the Task Force observed: "Normally, estimates of property taxes and insurance are based on tax and insurance rates multiplied by the asset midvalue. For economic costing only an average value over the asset's lifetime is of interest. This is given by an average of the initial and salvage values." (CARE Handbook, p. 6-24)

The above recommendations and observations of the Task Force suggest a third approximation, referred to below as the "mixed method" (E_{mix})because it utilizes the annuity approach for depreciation and interest but does not annualize repairs, taxes or insurance:

$$E_{mix} = \frac{r}{1 - \dfrac{1}{(1+r)^N}} \left[PC - \frac{SV}{\left((1+r)^N\right)} \right] + \frac{PC + SV}{2}(p + s) + \frac{C_0}{N} \qquad (10)$$

Table 3 provides a comparison of the method using Equations (2) through (7), referred to as the "exact method", with the approximations from Equations (8) through (10) for an example 130 horsepower mechanical-front-wheel-drive tractor and a 6 bottom moldboard plow. Table 4 compares per-acre costs across a representative set of operations, including power units and implements. The per-acre costs are shown for the exact method followed by the percentage differences that result from using each different approximation. Repairs are also shown as a percentage of the depreciation amounts to provide a representation of the relative importance of late-period cash flow. The larger repairs are as a percentage of depreciation, the greater the portion of the cost that falls into the later periods. In several cases the mid-year approximation overestimates the capital-budgeted result because repairs are a relatively large proportion of total costs and are discounted heavily under capital budgeting because repairs are larger toward the end of the budgeting period. The implement types in Table 4 include items from all twelve ASAE remaining value equations and 30 of the 40 repair equations. The costs are calculated based on the 1997 Minnesota fact sheet purchase prices and other assumptions, including an 0.85 percent insurance rate, a fuel price of $0.80/gallon, lubrication 15 percent of fuel cost, a sales tax rate of 2.5% of purchase price net of trade-in, storage cost of $0.33/square foot of space, and labor rates of $9.50/hour for unskilled and $12.00/hour for skilled labor.

It is apparent that the difference between methods varies from one machine to another, because of different shapes of the remaining value and repair cost equations. For the majority of machines, the beginning-of-year approximation comes closest to the exact method. Notable exceptions are for the moldboard plow, combines, combine heads, balers, and the hay stacker, where annual repairs are more than half of annual depreciation and the mid-year approximation is closer to the ideal.

Table 3. Comparison of Four Methods of Calculating Total Costs of a Plowing Operation, Six Percent Real Interest Rate

Alternative Methods:	**Exact Method**	**Mid-year Approximation**	**Beginning of year Approx-imation**	**Mixed Method Approximation**
Power Unit (130 Horsepower MFWD Tractor) used 500 hours/year				
Overhead costs (per year):				
Interest	$3,181	$2,913	$3,025	$3,181
Insurance	383	413	429	413
Housing	43	43	43	43
Property Tax	0	0	0	0
Total OverheadCosts Per Year	$3,606	$3,368	$3,497	$3,637
per hour for 500 hours	$7.21	$6.74	$6.99	$7.27
Use-related costs: (per hour)				
Depreciation	$7.53	$7.53	$7.53	$7.53
Repairs and maintenance	1.23	1.39	1.39	1.39
Fuel and oil	5.26	5.26	5.26	5.26
Total Use-Related Costs	$14.01	$14.18	$14.18	$14.18
Total for 500 hours	$7,007	$7,090	$7,090	$7,090
Total Power Cost per Hour	$21.23	$20.92	$21.17	$21.45
Total for 500 hours	$10,614	$10,458	$10,587	$10,726
Implement (6-18" Moldboard Plow) used 130 hours/year, 4.2 acres/hour, 542 acres/year				
Overhead costs (per year):				
Interest	$639	$583	$607	$639
Insurance	64	83	86	83
Housing	44	44	44	44
Property Tax	0	0	0	0
Total Overhead Costs Per Year	$747	$709	$736	$765
per acre for 542 acres	$1.38	$1.31	$1.36	$1.41
Use-related costs: (per acre)				
Depreciation	$1.46	$1.46	$1.46	$1.46
Repairs and maintenance	1.41	1.57	1.57	1.57
Total Use-Related Costs	$2.87	$3.02	$3.02	$3.02
Total for 542 acres	$1,555	$1,640	$1,640	$1,640
Total Implement Cost per Acre	$4.24	$4.33	$4.38	$4.43
Total for 542 acres	$2,302	$2,349	$2,376	$2,405
Plowing Cost per Acre @ 4.2 acres per hour				
Power	$5.09	$5.01	$5.07	$5.14
Implement	4.24	4.33	4.38	4.43
Labor at $9.69/hour	2.32	2.32	2.32	2.32
Total Plowing Cost per Acre	$11.65	$11.66	$11.78	$11.90

Assumptions Underlying the Calculations in Table 3:

POWER UNIT INFORMATION	130 Horsepower MFWD Tractor	
Expected years owned	12	
Annual hours of use	500	
Fuel gallons/Tractor HP/hr.	0.044	(gal/hr = 5.7)
Expected purchase price discount off list price	10%	
Storage shed space required, sq. ft.	130	
Estimated accum. hours at trade-in	6,000	
Estimated trade-in value % of list price	33.4%	
Estimated accumulated repair cost, % of list	10.8%	
Tractor purchase price	$70,020	
Purchase price including 2.5% sales tax on "boot"	$71,121	
List Price	$77,800	
Remaining value at trade-in	$25,965	
Boot amount	$45,156	
Insurance rate	0.85%	
IMPLEMENT INFORMATION	Moldboard Plow 6-18”	
Expected years owned	12	
Annual hours of use	130	
Expected purchase price discount off list price	10%	
Storage shed space required, sq. ft.	132	
Labor hours % of tractor hours	1.02	
Estimated accumulated hours at trade-in	1,560	
Estimated trade-in value, % of list	32%	
Estimated accumulated repair cost, % of list	64.6%	
Implement purchase price	$14,220	
Purchase price including 2.5% sales tax on "boot"	$14,451	
List price	$15,800	
Remaining value at trade-in	$4,978	
Boot amount	$9,473	
Insurance rate	0.85%	

Table 4. Comparison of Total Cost Per Acre by Operation With Exact Method and Three Simpler Alternatives, Six Percent Opportunity Interest Cost Rate

Implement	Power Unit	Exact Method Total Cost Per Acre	Difference From Exact Method: Mid-Year Approx	Beginning-of-Year Approx	Mixed Method Approx	Repairs As % of Deprec.
Tillage Equipment						
Chisel Plow, Front Dsk 18.75 Ft Fold	260 4WD	6.42	-1.22%	-0.02%	1.28%	26
Moldboard Plow 6-18, 9 Ft	130 MFWD	11.65	0.09%	1.05%	2.08%	58
Field Cultivator 47 Ft	260 4WD	2.45	-0.79%	0.33%	1.54%	45
Tandem Disk H.D. 12 Ft Rigid	130 MFWD	6.29	-1.04%	-0.04%	1.05%	34
Offset Disk 16 Ft	130 MFWD	6.20	-1.05%	0.01%	1.15%	27
Disk,Fld Cult Finish 30 Ft	260 4WD	5.45	-1.21%	0.03%	1.36%	28
Roller Harrow 12 Ft	75	4.44	-0.52%	0.43%	1.44%	38
Springtooth Drag 48 Ft	75	1.58	-1.21%	0.01%	1.32%	19
Planting Equipment						
Row Crop Planter 8-30, 20 Ft	75	7.18	-0.31%	0.75%	1.90%	41
Grain Drill 25 Ft	130 MFWD	6.82	-0.31%	0.74%	1.88%	42
Crop Maintenance Equipment						
Cultivator 8-30, 20 Ft	130 MFWD	3.75	-0.76%	0.19%	1.21%	26
Rotary Hoe 15 Ft	75	1.45	-0.42%	0.37%	1.22%	42
Boom Sprayer, 50 Ft	60	1.27	-0.22%	0.37%	1.02%	66
Fert Spreader 4 T, 40 Ft	60	2.40	-1.24%	-0.18%	0.98%	32
Stalk Shredder, 20 Ft	130 MFWD	6.64	-0.96%	0.11%	1.27%	37
Harvesting Equipment						
Mower-Conditioner, 9 Ft	40	8.49	-0.93%	0.20%	1.43%	27
Hay Rake (Hyd), 9 Ft	40	5.70	-0.14%	0.50%	1.19%	56
Hay Swather-Cond, 12 Ft	60	8.74	-1.08%	0.21%	1.60%	27
Grain Swather, Pull Type, 18 Ft	75	4.19	-1.02%	0.08%	1.27%	18
Grain Swather, Self-Prop, 21 Ft	None	7.62	-1.95%	-0.39%	1.30%	8
Hay Baler PTO Twine, 12 Ft Swath	40	7.90	1.31%	1.96%	2.67%	123
Round Baler 1500 Lb, 12 Ft Swath	60	11.09	2.99%	3.63%	4.33%	214
Rd Baler/Wrap 1000 Lb, 9 Ft Swath	60	15.79	3.15%	3.80%	4.51%	221
Large Rectangular Baler, 24 Ft Swath	130 MFWD	9.29	-2.34%	-0.72%	1.04%	7
Forage Harvester 2 Row, 6 Ft	105 MFWD	36.49	-1.17%	-0.01%	1.24%	27
Forage SP Harvstr 3 Row, 9 Ft	None	43.64	-2.41%	-0.83%	0.87%	14
Combine Grain Head , 20 Ft	220 HP Combine	14.08	0.94%	2.06%	3.27%	75
Soybean Combine Hd, 15 Ft	220 HP Combine	21.97	0.89%	2.02%	3.25%	74
Corn Combine 8-30, 20 Ft	220 HP Combine	21.37	0.69%	1.87%	3.16%	68
Potato Windrower 2 Row, 6 Ft	75	40.56	-1.01%	0.25%	1.62%	36
Potato Harvester 2 Row, 6 Ft	130 MFWD	58.37	-0.55%	0.30%	1.22%	56
Disk Bean Top Cutter 6R, 11 Ft	105 MFWD	7.54	-1.15%	-0.12%	1.00%	25
Sugar Beet Lifter 6 Row, 11 Ft	130 MFWD	25.77	-0.41%	0.66%	1.82%	97
Sugar Beet Topper 6 Row, 11 Ft	75	9.86	-0.96%	0.15%	1.34%	40
Sugar Beet Wagon 20 Ton, 11 Ft	200 MFWD	16.83	-1.42%	-0.13%	1.26%	32
Manure Spreader 150 Bu, 6 Ft Swath	75	9.21	-0.16%	0.62%	1.45%	82
Gravity Grain Box 240 Bu, 6 Ft Swath	75	15.54	-0.38%	0.38%	1.20%	43
Forage Wagon 16 Ft, 6 Ft Swath	40	17.21	-0.40%	0.52%	1.52%	46
3 Ton Hay Stacker, 12 Ft Swath	75	11.70	2.11%	2.88%	3.71%	150

Table 5 shows how different real interest rates affect the relative differences among the methods. It seems evident that, first, if we intend to use an approximation, then the mixed method is least preferred at lower interest rates. Only at a very high real interest rate of 20 percent (included to represent a credit-rationing situation) is the mixed method preferable. Second, there is not very much difference between the beginning-of-year and mid-year approximation methods. At interest rates below 7%, the traditional mid-year approximation looks a little better, and at higher rates (7% and above) the beginning-of-year approximation looks slightly preferable. The beginning-of-year approximation is preferred for 23 of the 39 operations evaluated in Table 4. The machinery task force members have decided to use the beginning-of-year approximation method for our extension publications, as long as real interest rates are at current single digit levels. At real interest rates above 10%, one would want to use the exact method if at all possible.

Table 5. Comparison of Operation Cost Per Acre With Exact Method and Three Approximations, Simple Average of All Machines

	Difference Between Alternatives and Exact Method		
Interest Rate	Mid Year Approximation	Beginning-of-Year Approximation	Mixed Method Approximation
3%	0.49%	1.16%	1.37%
6%	-0.42%	0.62%	1.74%
7%	-0.81%	0.34%	1.84%
9%	-1.66%	-0.33%	2.02%
10%	-2.12%	-0.70%	2.09%
20%	-7.08%	-5.10%	2.46%

Housing Costs

The current Minnesota fact sheet uses 33 cents per year per square foot of shelter space needed. The 33 cent number dates back at least to 1992, but its exact source is uncertain. It has been kept the same since then partly because it seems in line with the most recent Iowa State building rental survey report, which found an average of 25 cents per square foot in 1998 (Edwards and Baitinger). A Minnesota building supplier reported that a new metal building for machinery storage would cost in the range of $6 to $8 per square foot to construct in 2001, which would translate into an annual rental rate of at least twice the 33 cent rate. So, we conclude that the 33 cent number is probably still current as an estimate for older buildings, but would need to be increased to represent rental of a newly constructed building.

The default space requirement data for the machines were estimated from their transport dimensions and are available in the spreadsheet template accompanying the fact sheet.

The 1999 ASAE Standards suggests a housing charge of 0.75% of purchase price. The ASAE charge looks high compared to the percentages resulting from the per foot charge. The simple average for the machines in the Minnesota data set is 0.416% (Table 6). More expensive machines cost less to store relative to their purchase price, so an average weighted by purchase price was also calculated. The weighted average is 0.228%. Housing costs as a percentage of purchase price are highest for wagons, which cost over 2%, and the sprayers, swathers, and some tillage equipment which calculated to more than 1% of purchase price. We conclude from Table

5 that there is enough variation in the percentages that it is worth the extra effort to continue to calculate housing costs on a square footage basis, although the cost is small relative to the other costs of owning and operating machinery.

Table 6. Housing costs based on 33 cents per year per square foot of shelter space for machines in Minnesota data set

	Simple Average	Weighted Average	Minimum	Maximum
	percent of purchase price			
Tractors	0.085%	0.072%	0.055%	0.157%
Combines	0.108%	0.109%	0.095%	0.121%
Other implements	0.445%	0.283%	0.054%	2.821%
All machines	0.416%	0.228%	0.054%	2.821%
	$ per year			
Tractors	$61.27	$71.30	$30.36	$82.50
Combines	$132.00	$134.87	$99.00	$165.00
Other Implements	$61.40	$70.61	$9.24	$148.50
All machines	$62.53	$75.34	$9.24	$165.00

Fuel Consumption

One display-related issue is that when calculating costs for several sizes of a given type of implement matched to different tractor sizes, it is not usually possible to match tractor horsepower to implement size exactly so that horsepower per foot of width is the same for every implement size. Past *Minnesota Farm Machinery Economic Cost Estimates* publications have calculated fuel consumption using a constant rate per horsepower-hour for every power unit, even though load conditions may vary from one implement to another. Under this method, calculated fuel consumption and fuel cost per acre varies across implement sizes. For example, in the 2000 publication, the 11 foot chisel plow is matched with a 75 HP tractor, which is 6.8 HP/foot and calculates to 0.56 gallons of diesel fuel/acre at a rate of 0.044 gallons/hour/tractor HP. The 15 foot chisel plow is matched with a 130 HP tractor, giving 8.67 HP/foot and 0.72 gallons/acre. This difference in fuel cost has not been a particular issue with users of the publication, but it is probably not as realistic as it could be. The fuel consumption rate per HP should probably be reduced as HP/foot increases, because the tractor is operating under a lighter load. Another alternative we have considered is to use The American Society of Agricultural Engineers formula for estimating fuel use by type of fuel and percent load on the engine (see the 1999 ASAE Standards publication). The ASAE formula as laid out in the ASAE Standards has at least two drawbacks, however: 1) complexity, and 2) the need to arrive at data on load conditions for each implement type and size which we do not currently have in the database. To get around the need for load condition data, we could average HP/foot across sizes. We could then use the standard 0.044 rate at that average, and use the ASAE formula to adjust the consumption rate as HP/foot varies above or below the average. In the case of the chisel plows discussed above, the new procedure results in a value of 0.60 gallons/acre at 6.8 HP/foot and 0.69 gallons/acre at 8.67 HP/foot. So, the difference is reduced from 25% using the standard 0.044, to 14% with the ASAE formula (expressing the differences as a percentage of the average of the high and low numbers, 0.56 and 0.72 in the first case, 0.60 and 0.69 in the second). The ASAE formula approach is appealing in that it has a basis in the engineering literature, but it may not be worth the extra complexity it adds to the calculations. The 2001 version of the Minnesota publication takes a simpler approach of averaging HP/foot across sizes for each operation and then uses that number together with the 0.044 fuel consumption rate/HP to calculate fuel consumption/acre for all sizes regardless of the HP/foot match for any given size.

Labor Requirements

Extension estimates of machinery operating costs per acre have typically considered field efficiency (an upward adjustment in machine operating time for failure to utilize the theoretical operating width of the machine, and time lost turning). The field efficiencies used in the Minnesota calculations are based on the estimates provided in the ASAE Standards. It has also been customary to factor in an additional labor requirement for such tasks as adjustments in the field, which increases labor costs but is not factored into machinery operating time. The labor multipliers were last updated around 1990 based partly on input from a farm management consultant. The field efficiencies, labor requirement adjustments, and labor classifications currently used in the Minnesota calculations are shown in Table 7. Also, the Minnesota fact sheet numbers are based on two different labor wage rates – a higher rate for operations that are generally thought to require a higher level of operator skill, and a lower rate for other operations. The 2000 Minnesota fact sheet assumed wage rates of $9.50 per hour for unskilled labor and $12 per hour for skilled labor.

Table 7. Suggested Adjustments for Field Efficiency and Labor Requirements Relative to Implement Operating Time, by Type of Implement

Implement Type	Field Efficiency	Labor Per Implement Time	Labor Type
Tillage Equipment (all)	0.85	102%	unskilled
Planting Equipment			
Row Crop Planter	0.70	116%	skilled
Grain Drill	0.70	111%	skilled
Crop Maintenance Equipment			
Cultivator or Rotary Hoe	0.85	104%	unskilled
Boom Sprayer	0.65	125%	skilled
Fertilizer Spreader	0.70	133%	unskilled
Stalk Shredder	0.80	110%	unskilled
Harvesting Equipment			
Mower-Conditioner, Hay Rake or Grain Swather	0.80	110%	unskilled
Hay Baler, PTO, Twine	0.75	111%	skilled
Round Baler	0.65	111%	skilled
Large Rectangular Baler	0.80	111%	skilled
Hay Stacker	0.70	111%	skilled
Forage Harvester, Pull Type	0.65	111%	skilled
Combine or Self-Propelled Forage Harvester	0.70	111%	skilled
Potato Windrower	0.65	108%	unskilled
Potato Harvester	0.60	125%	skilled
Disk Bean Top Cutter	0.80	111%	skilled
Sugar Beet Lifter	0.65	111%	skilled
Sugar Beet Topper	0.80	100%	skilled
Manure Spreader	0.80	102%	unskilled

Use-Related Costs

The *Minnesota Farm Machinery Economic Cost Estimates* publications have until recently shown cost data summarized in two ways: "total cost per hour" (for power units) or "total cost per acre" (for implements), and "operating expenses per hour" or per acre. Operating expenses included fuel and oil, and repairs and maintenance. Labor was listed separately. A change in terminology was made in the 2000 publication. The operating expense category was dropped and replaced by a category called "use-related cost per acre", including fuel and oil, and repairs and maintenance, labor, and depreciation. The change was made to avoid under-estimating variable costs in circumstances where an operator already owns a machine and is attempting to arrive at a cost that covers the use-related component of depreciation.

Summary

One of the goals of the North Central Farm Machinery Task Force was to help evaluate alternative methods for estimating farm machinery ownership and operating costs and to make recommendations for the development of extension materials. The purpose of this paper is to describe the procedures agreed upon by task force members, and to explain the rationale for the procedures chosen. This paper also provides detailed documentation of the methods used in recent versions of the widely used *Minnesota Farm Machinery Economic Cost Estimates* publication, focusing mainly on the 2000 version.

The impetus for a comparison of cost calculation methods contained in this paper and in Selley and Lazarus was an ambiguity in the report of the AAEA Costs and Returns Task Force. The task force recommended that the annuity approach be used for calculating depreciation and interest costs rather than the traditional method, but offered two methods for calculating repair costs - either using equations which do not adjust for repair costs changing over time, or equations which create a constant real annuity that reflects changing costs over time. We compared the annuity approach for all costs, referred to as the "exact method" against three approximations. Our analysis shows that the difference between methods varies from one machine to another, because of different shapes of the remaining value and repair cost equations. For the majority of machines, the beginning-of-year approximation comes closest to the exact method. The machinery task force members have decided to use the "beginning-of-year approximation" method for our extension publications, as long as real interest rates are at current single digit levels. Adopting the AAEA CAR Task Force's recommendation to use the annuity method for interest and depreciation but using the simpler of the two methods they recommend for repair costs results in what we refer to as the "mixed method". Our comparison shows that the mixed method is the least preferred of the approximations at lower interest rates. At higher real interest rates above 10%, one would want to use the exact method if at all possible.

The procedures and assumptions used for calculating housing costs, labor requirements, and fuel consumption are also discussed, along with several issues related to the format used for displaying the costs in the Minnesota publication.

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Appendix Table A1. Example amortized cash flow with self-financing, 6% discount rate, 0% inflation, 130 HP MFWD Tractor.

		Formula Projections for:			Cash Flow					Present Value @ 6% Discount Rate			
t	List Price LP	Remaining Value RV	Repairs Accum. C	Repairs Marginal R	Purchase and trade	Repairs*	Insurance and PPtax	Total in Year t $	Total in Year 0 $	Purchase and trade	Repairs*	Insurance and PPtax	Total
0	77,800	71,121	0*		71,121		605	71,726	71,726	71,121	0	605	71,726
1	77,800	52,839	58	58		0	449	449	449	0	0	424	424
2	77,800	47,661	233	175		175	405	580	580	0	156	360	516
3	77,800	43,868	525	292		292	373	665	665	0	245	313	558
4	77,800	40,793	934	408		408	347	755	755	0	324	275	598
5	77,800	38,177	1,459	525		525	325	850	850	0	392	243	635
6	77,800	35,886	2,101	642		642	305	947	947	0	452	215	667
7	77,800	33,842	2,859	759		759	288	1,047	1,047	0	504	192	696
8	77,800	31,993	3,734	875		875	272	1,147	1,147	0	549	171	720
9	77,800	30,304	4,726	992		992	258	1,250	1,250	0	587	153	740
10	77,800	28,749	5,835	1,109		1,109	244	1,353	1,353	0	619	136	755
11	77,800	27,307	7,060	1,225		1,225	232	1,457	1,457	0	645	122	768
12	77,800	25,965	8,402	1,342	-25,965	1,342		-24,623	-24,623	-12,904	667	0	-12,237
		33.4%	10.8%						NPV	58,218	5,140	3,209	66,566
									Annual Payment in year 0 $	*$6,944*	*$613*	*$383*	*$7,940*

*Repairs in year 1 assumed covered under warranty

Appendix Table A2. Cash flows for purchase, trade-in, principal and interest under different financing alternatives, assuming equal 6% dis count and borrowing rates, 0% inflation, 130 HP MFWD Tractor.

	Self Finance			Equal Amortized Payments						Equal Annual Principal Payments					
	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PVwith 6% Discount	Balance	6% Interest	Principal	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 6% Discount	Balance	Principal	6% Interest	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 6% Discount
0 PC	71,121	71,121	71,121	71,121			0	0		71,121				0	
1				66,906	4,267	4,216	8,483	8,483	8,003	65,195	5,927	4,267	10,194	10,194	9,617
2				62,437	4,014	4,469	8,483	8,483	7,550	59,268	5,927	3,912	9,838	9,838	8,756
3				57,700	3,746	4,737	8,483	8,483	7,123	53,341	5,927	3,556	9,483	9,483	7,962
4				52,679	3,462	5,021	8,483	8,483	6,719	47,414	5,927	3,200	9,127	9,127	7,230
5				47,356	3,161	5,322	8,483	8,483	6,339	41,487	5,927	2,845	8,772	8,772	6,555
6				41,714	2,841	5,642	8,483	8,483	5,980	35,561	5,927	2,489	8,416	8,416	5,933
7				35,734	2,503	5,980	8,483	8,483	5,642	29,634	5,927	2,134	8,060	8,060	5,361
8				29,395	2,144	6,339	8,483	8,483	5,322	23,707	5,927	1,778	7,705	7,705	4,834
9				22,676	1,764	6,719	8,483	8,483	5,021	17,780	5,927	1,422	7,349	7,349	4,350
10				15,553	1,361	7,123	8,483	8,483	4,737	11,854	5,927	1,067	6,994	6,994	3,905
11				8,003	933	7,550	8,483	8,483	4,469	5,927	5,927	711	6,638	6,638	3,497
12 SV	-25,965	-25,965	-12,904	0	480	8,003	-17,482	-17,482	-8,688	0	5,927	356	-19,683	-19,683	-9,782
NPV			58,218						58,218						58,218

Appendix Table A3. Cash flows for purchase, trade-in, principal and interest under different financing alternatives, equal 6% discount and real borrowing rates, 2% inflation, 8.12% nominal borrowing rate, 130 HP MFWD Tractor.

	Self Finance			Equal Amortized Payments						Equal Annual Principal Payments					
	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PVwith 6% Discount	Balance	8.12% Interest	Principal	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 6% Discount	Balance	Principal	8.12% Interest	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 6% Discount
0 PC	71,121	71,121	71,121	71,121			0	0		71,121				0	
1				67,400	5,775	3,721	9,496	9,310	8,783	65,195	5,927	5,775	11,702	11,472	10,823
2				63,377	5,473	4,023	9,496	9,127	8,123	59,268	5,927	5,294	11,221	10,785	9,598
3				59,027	5,146	4,350	9,496	8,948	7,513	53,341	5,927	4,813	10,739	10,120	8,497
4				54,324	4,793	4,703	9,496	8,773	6,949	47,414	5,927	4,331	10,258	9,477	7,507
5				49,239	4,411	5,085	9,496	8,601	6,427	41,487	5,927	3,850	9,777	8,855	6,617
6				43,740	3,998	5,498	9,496	8,432	5,944	35,561	5,927	3,369	9,296	8,254	5,819
7				37,796	3,552	5,944	9,496	8,267	5,498	29,634	5,927	2,888	8,814	7,673	5,103
8				31,369	3,069	6,427	9,496	8,105	5,085	23,707	5,927	2,406	8,333	7,112	4,462
9				24,420	2,547	6,949	9,496	7,946	4,703	17,780	5,927	1,925	7,852	6,570	3,889
10				16,906	1,983	7,513	9,496	7,790	4,350	11,854	5,927	1,444	7,371	6,046	3,376
11				8,783	1,373	8,123	9,496	7,637	4,023	5,927	5,927	963	6,889	5,541	2,919
12 SV	-25,965	-25,965	-12,904	0	713	8,783	-23,434	-18,477	-9,183	0	5,927	481	-26,522	-20,912	-10,393
NPV			58,218						58,218						58,218

Appendix Table A4. Cash flows for purchase, trade-in, principal and interest under different financing alternatives, 8% discount and 6% borrowing rate, 0% inflation, 130 HP MFWD Tractor.

	Self Finance			Equal Amortized Payments						Equal Annual Principal Payments					
	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PVwith 8% Discount	Balance	6% Interest	Principal	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 8% Discount	Balance	Principal	6% Interest	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 8% Discount
0 PC	71,121	71,121	71,121	71,121			0	0		71,121				0	
1				66,906	4,267	4,216	8,483	8,483	7,855	65,195	5,927	4,267	10,194	10,194	9,439
2				62,437	4,014	4,469	8,483	8,483	7,273	59,268	5,927	3,912	9,838	9,838	8,435
3				57,700	3,746	4,737	8,483	8,483	6,734	53,341	5,927	3,556	9,483	9,483	7,528
4				52,679	3,462	5,021	8,483	8,483	6,235	47,414	5,927	3,200	9,127	9,127	6,709
5				47,356	3,161	5,322	8,483	8,483	5,773	41,487	5,927	2,845	8,772	8,772	5,970
6				41,714	2,841	5,642	8,483	8,483	5,346	35,561	5,927	2,489	8,416	8,416	5,304
7				35,734	2,503	5,980	8,483	8,483	4,950	29,634	5,927	2,134	8,060	8,060	4,703
8				29,395	2,144	6,339	8,483	8,483	4,583	23,707	5,927	1,778	7,705	7,705	4,163
9				22,676	1,764	6,719	8,483	8,483	4,244	17,780	5,927	1,422	7,349	7,349	3,676
10				15,553	1,361	7,123	8,483	8,483	3,929	11,854	5,927	1,067	6,994	6,994	3,239
11				8,003	933	7,550	8,483	8,483	3,638	5,927	5,927	711	6,638	6,638	2,847
12 SV	-25,965	-25,965	-10,311	0	480	8,003	-17,482	-17,482	-6,942	0	5,927	356	-19,683	-19,683	-7,816
NPV			60,810						53,619						54,196

Appendix Table A5. Cash flows for purchase, trade-in, principal and interest under different financing alternatives, 8% discount rate, 6% real and 8.12% nominal borrowing rates, 2% inflation, 130 HP MFWD Tractor.

	Self Finance			Equal Amortized Payments						Equal Annual Principal Payments					
	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PVwith 8% Discount	Balance	8.12% Interest	Principal	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 8% Discount	Balance	Principal	8.12% Interest	Net Cash Flow in Year t $	Net Cash Flow in Year 0 $	PV with 8% Discount
0 PC	71,121	71,121	71,121	71,121			0	0		71,121				0	
1				67,400	5,775	3,721	9,496	9,310	8,620	65,195	5,927	5,775	11,702	11,472	10,623
2				63,377	5,473	4,023	9,496	9,127	7,825	59,268	5,927	5,294	11,221	10,785	9,246
3				59,027	5,146	4,350	9,496	8,948	7,104	53,341	5,927	4,813	10,739	10,120	8,034
4				54,324	4,793	4,703	9,496	8,773	6,448	47,414	5,927	4,331	10,258	9,477	6,966
5				49,239	4,411	5,085	9,496	8,601	5,854	41,487	5,927	3,850	9,777	8,855	6,027
6				43,740	3,998	5,498	9,496	8,432	5,314	35,561	5,927	3,369	9,296	8,254	5,202
7				37,796	3,552	5,944	9,496	8,267	4,824	29,634	5,927	2,888	8,814	7,673	4,477
8				31,369	3,069	6,427	9,496	8,105	4,379	23,707	5,927	2,406	8,333	7,112	3,842
9				24,420	2,547	6,949	9,496	7,946	3,975	17,780	5,927	1,925	7,852	6,570	3,287
10				16,906	1,983	7,513	9,496	7,790	3,608	11,854	5,927	1,444	7,371	6,046	2,801
11				8,783	1,373	8,123	9,496	7,637	3,276	5,927	5,927	963	6,889	5,541	2,376
12 SV	-32,930	-25,965	-10,311	0	713	8,783	-23,434	-18,477	-7,338	0	5,927	481	-26,522	-20,912	-8,305
NPV			60,810						53,889						54,575