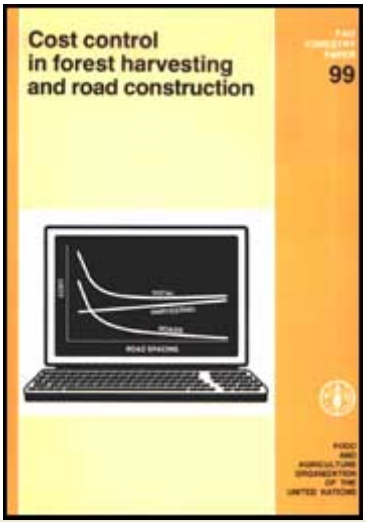
Cost Control in Forest Harvesting and Road Construction



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3. CALCULATION OF MACHINE RATES

3.1 Introduction

The unit cost of logging or road construction is essentially derived by dividing cost by production. In its simplest case, if you rented a tractor with operator for $60 per hour - including all fuel and other costs - and you excavated 100 cubic meters per hour, your unit cost for excavation would be $0.60 per cubic meter. The hourly cost of the tractor with operator is called the machine rate. In cases where the machine and the elements of production are not rented, a calculation of the owning and operating costs is necessary to derive the machine rate. The objective in developing a machine rate should be to arrive at a figure that, as nearly as possible, represents the cost of the work done under the operating conditions encountered and the accounting system in use. Most manufacturers of machinery supply data for the cost of owning and operating their equipment that will serve as the basis of machine rates. However, such data usually need modification to meet specific conditions of operation, and many owners of equipment will prefer to prepare their own rates.

3.2 Classification of Costs

The machine rate is usually, but not always, divided into fixed costs, operating costs, and labor costs. For certain cash flow analyses only items which represent a cash flow are included. Certain fixed costs, including depreciation and sometimes interest charges, are omitted if they do not represent a cash payment. In this manual, all fixed costs discussed below are included. For some analyses, labor costs are not included in the machine rate. Instead, fixed and operating costs are calculated. Labor costs are then added separately. This is sometimes done in situations where the labor associated with the equipment works a different number of hours from the equipment. In this paper, labor is included in the calculation of the machine rate.

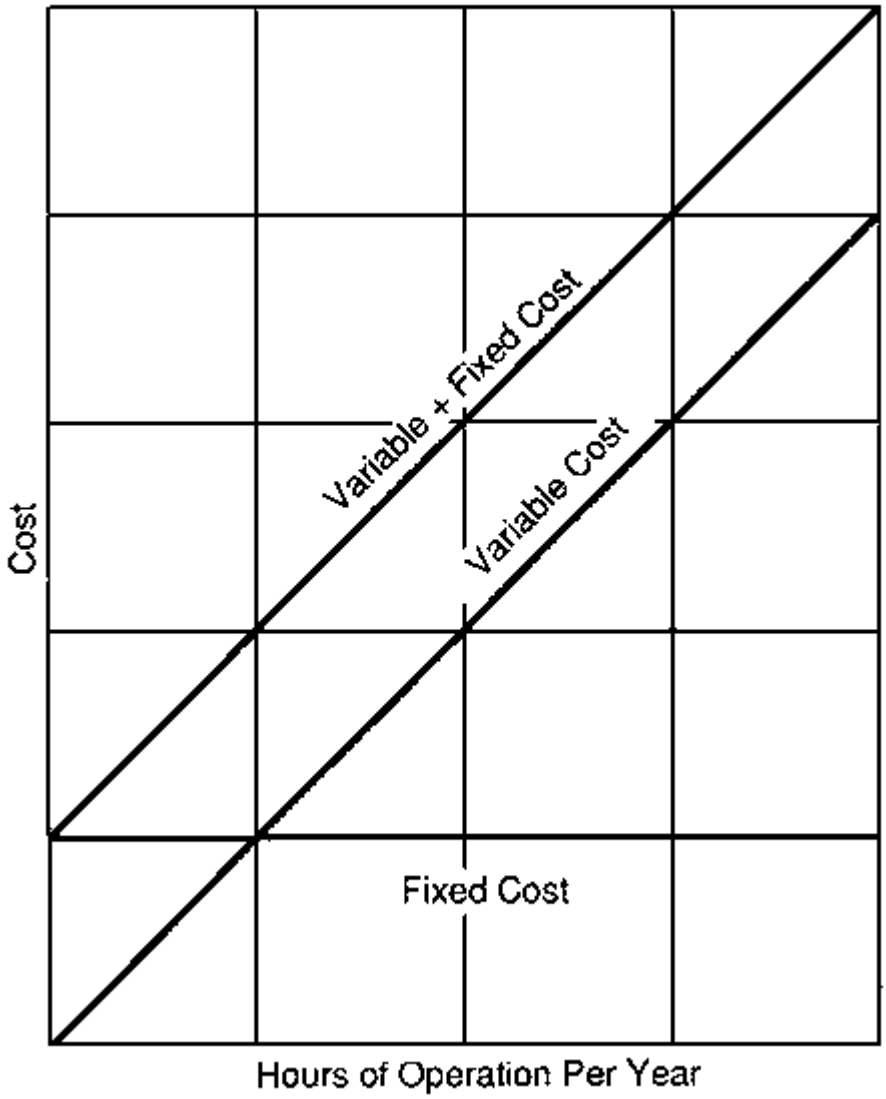
3.2.1 Fixed Costs

Fixed costs are those which can be predetermined as accumulating with the passage of time, rather than with the rate of work (Figure 3.1). They do not stop when the work stops and must be spread over the hours of work during the year. Commonly included in fixed costs are equipment depreciation, interest on investment, taxes, and storage, and insurance.

3.2.2 Operating Costs

Operating costs vary directly with the rate of work (Figure 3.1). These costs include the costs of fuel, lubricants, tires, equipment maintenance and repairs.

Figure 3.1 Equipment Cost Model.



3.2.3 Labor Costs

Labor costs are those costs associated with employing labor including direct wages, food contributions, transport, and social costs, including payments for health and retirement. The cost of supervision may also be spread over the labor costs.

The machine rate is the sum of the fixed plus operating plus labor costs. The division of costs in these classifications is arbitrary although accounting rules suggest a rigid classification. The key point is to separate the costs in such a way as to make the most sense in explaining the cost of operating the men and equipment. For example, if a major determinant of equipment salvage value is the rate of obsolescence such as in the computer industry, the depreciation cost is largely dependent on the passage of time, not the hours worked. For a truck, tractor, or power saw, a major determinant may be the actual hours of equipment use. The tractor's life could be viewed as

the sand in an hour glass which is only permitted to flow during the hours the equipment is working.

3.3 Definitions

3.3.1 Purchase Price (P)

This is the actual equipment purchase cost including the standard attachments, optional attachments, sales taxes, and delivery costs. Prices are usually quoted at the factory or delivered at the site. The factory price applies if the buyer takes title to the equipment at the factory and is responsible for shipment. On the other hand, delivered price applies if the buyer takes title to the equipment after it is delivered. The delivered price usually includes freight, packing, and insurance. Other costs such as for installation should be included in the initial investment cost. Special attachments may sometimes have a separate machine rate if their lives differ from the main equipment and form an important part of the equipment cost.

3.3.2 Economic Life (N)

This is the period over which the equipment can operate at an acceptable operating cost and productivity. The economic life is generally measured in terms of years, hours, or in the case of trucks and trailers in terms of kilometers. It depends upon a variety of factors, including physical deterioration, technological obsolescence or changing economic conditions. Physical deterioration can arise from factors such as corrosion, chemical decomposition, or by wear and tear due to abrasion, shock and impact. These may result from normal and proper usage, abusive and improper usage, age, inadequate or lack of maintenance, or severe environmental conditions. Changing economic conditions such as fuel prices, tax investment incentives, and the rate of interest can also affect the economic life of equipment. Examples of ownership periods for some types of skidding and road construction equipment, based upon application and operating conditions, are shown in Table 3.1. Since the lives are given in terms of operating hours, the life in years is obtained by working backwards by defining the number of working days per year and the estimated number of working hours per day. For equipment that works very few hours per day, the derived equipment lives may be very long and local conditions should be checked for the reasonableness of the estimate.

3.3.3 Salvage Value (S)

This is defined as the price that equipment can be sold for at the time of its disposal. Used equipment rates vary widely throughout the world. However, in any given used equipment market, factors which have the greatest effect on resale or trade-in value are the number of hours on the machine at the time of resale or trade-in, the type of jobs and operating conditions under which it worked, and the physical condition of the machine. Whatever the variables, however, the decline in value is greater in the first year than the second, greater the second year than the third, etc. The shorter the work life of the machine, the higher the percentage of value lost in a year. In agricultural tractors for example, as a general rule 40 to 50 percent of the value of the machine will be lost in the first quarter of the machine's life and by the halfway point of lifetime, from 70 to 75 percent of the value will be lost. The salvage value is often estimated as 10 to 20 percent of the initial purchase price.

3.4 Fixed Costs

3.4.1 Depreciation

The objective of the depreciation charge is to recognize the decline of value of the machine as it is working at a specific task. This may differ from the accountant's depreciation schedule-which is chosen to maximize profit through the advantages of various types of tax laws and follows accounting convention. A common example of this difference is seen where equipment is still working many years after it was "written off" or has zero "book value".

Depreciation schedules vary from the simplest approach, which is a straight line decline in value, to more sophisticated techniques which recognize the changing rate of value loss over time. The formula for the annual depreciation charge using the assumption of straight line decline in value is

$$D = (P' - S)/N$$

where P' is the initial purchase price less the cost of tires, wire rope, or other parts which are subjected to the greatest rate of wear and can be easily replaced without effect upon the general mechanical condition of the machine.

Table 3.1.a - Guide for selecting ownership period based on application and operating conditions.[1/]

	ZONE A	ZONE B	ZONE C
TRACK-TYPE TRACTORS	Pulling scrapers, most agricultural drawbar, stockpile, coalpile and landfill work. No impact. Intermittent full throttle operation.	Production dozing in clays, sands, gravels. Pushloading scrapers, borrow pit ripping, most landclearing and skidding applications. Medium impact conditions.	Heavy rock ripping. Tandem ripping. Pushloading and dozing in hard rock. Work on rock surfaces. Continuous high impact conditions.
Small	12,000 Hr	10,000 Hr	8,000 Hr
Large	22,000 Hr	18,000 Hr	15,000 Hr
MOTORGRADERS	Light road maintenance. Finishing. Plant and road mix work. Light snowplowing. Large amounts of traveling.	Haul road maintenance. Road construction, ditching. Loose fill spreading. Landforming, land-leveling. Summer road maintenance with medium to heavy winter snow removal. Elevating grader use.	Maintenance of hard pack roads with embedded rock. Heavy fill spreading. Ripping-scarifying of asphalt or concrete. Continuous high load factor. High impact.
	20,000 Hr	15,000 Hr	12,000 Hr

EXCAVATORS	Shallow depth utility construction where excavator sets pipe and digs only 3 or 4 hours/shift. Free flowing, low density material and little or no impact. Most scrap handling arrangements.	Mass excavation or trenching where machine digs all the time in natural bed clay soils. Some traveling and steady, full throttle operation. Most log loading applications.	Continuous trenching or truck loading in rock or shot rock soils. Large amount of travel over rough ground. Machine continuously working on rock floor with constant high load factor and high impact.
	12,000 Hr	10,000 Hr	8,000 Hr

[1/]Adapted from Caterpillar Performance Handbook, Caterpillar Inc.

Table 3.1.b - Guide for selecting ownership period based on application and operating conditions.[1/]

	ZONE A	**ZONE B**	**ZONE C**
WHEEL SKIDDERS	Intermittent skidding for short distances, no decking. Good underfoot conditions: level terrain, dry floor, few if any stumps.	Continuous turning, steady skidding for medium distances with moderate decking. Good underfooting: dry floor with few stumps and gradual rolling terrain.	Continuous turning, steady skidding for long distances with frequent decking. Poor underfloor conditions: wet floor, steep slopes and numerous stumps.
	12,000 Hr	10,000 Hr	8,000 Hr
WHEEL TRACTOR SCRAPERS	Level or favorable hauls on good haul roads. No impact. Easy-loading materials.	Varying loading and haul road conditions. Long and short hauls. Adverse and favorable grades. Some impact. Typical road-building use on a variety of jobs.	High impact condition, such as loading ripped rock. Overloading. Continuous high total resistance conditions. Rough haul roads.
Small	12,000 Hr	10,000 Hr	8,000 Hr
Large	16,000 Hr	12,000 Hr	8,000 Hr
OFF HIGHWAY TRUCKS & TRACTORS	Mine and quarry use with properly matched loading equipment. Well maintained haul roads. Also construction use under above conditions.	Varying loading and haul road conditions. Typical road-building use on a variety of jobs.	Consistently poor haul road conditions. Extreme overloading. Oversized loading equipment.
	25,000 Hr	20,000 Hr	15,000 Hr
WHEEL TRACTORS & COMPACTORS	Light utility work. Stockpile work. Pulling compactors. Dozing loose fill. No impact.	Production dozing, pushloading in clays, sands, silts, loose gravels. Shovel cleanup. Compactor use.	Production dozing in rock. Pushloading in rocky, bouldering borrow pits. High impact conditions.

	15,000 Hr	12,000 Hr	8,000 Hr

[1/]Adapted from Caterpillar Performance Handbook, Caterpillar Inc.

Table 3.1.c - Guide for selecting ownership period based on application and operating conditions.[1/]

	ZONE A	ZONE B	ZONE C
WHEEL LOADERS	Intermittent truck loading from stockpile, hopper charging on firm, smooth surfaces. Free flowing, low density materials. Utility work in governmental and industrial applications. Light snowplowing. Load and carry on good surface for short distances with no grades.	Continuous truck loading from stockpile. Low to medium density materials in properly sized bucket. Hopper charging in low to medium rolling resistance. Loading from bank in good digging. Load and carry on poor surfaces and slight adverse grades.	Loading shot rock (large loaders). Handling high density materials with counterweighted machine. Steady loading from very tight banks. Continuous work on rough or very soft surfaces. Load and carry in hard digging; travel longer distances on poor surfaces with adverse grades.
Small	12,000 Hr	10,000 Hr	8,000 Hr
Large	15,000 Hr	12,000 Hr	10,000 Hr
TRACK-TYPE LOADERS	Intermittent truck loading from stockpile. Minimum traveling, turning. Free flowing, low density materials with standard bucket. No impact.	Bank excavation, intermittent ripping, basement digging of natural bed clays, sands, silts, gravels. Some traveling. Steady full throttle operation.	Loading shot rock, cobbles, glacial till, caliche. Steel mill work. High density materials in standard bucket. Continuous work on rock surfaces. Large amount of ripping of tight, rocky materials. High impact condition.
	12,000 Hr	10,000 Hr	8,000 Hr

[1/]Adapted from Caterpillar Performance Handbook, Caterpillar Inc.

3.4.2 Interest

Interest is the cost of using funds over a period of time. Investment funds may be borrowed or taken from savings or equity. If borrowed, the interest rate is established by the lender and varies by locality and lending institution. If the money comes from savings, then opportunity cost or the rate this money would earn if invested elsewhere is used as the interest rate. The accounting practice of private firms may ignore interest on equipment on the ground that interest is a part of profits and, therefore, not a proper charge against operating equipment. Although this is sound from the point of view of the business as a whole, the exclusion of such charges may lead to the development of unrealistic comparative rates between machines of low and high initial cost. This may lead to erroneous decisions in the selection of equipment.

Interest can be calculated by using one of two methods. The first method is to multiply the interest rate by the actual value of the remaining life of the equipment. The second simpler method is to multiply the interest rate times the average annual investment.

For straight-line depreciation, the average annual investment, AAI, is calculated as

$$AAI = (P - S)\ (N + 1)/(2N) + S$$

Sometimes a factor of 0.6 times the delivered cost is used as an approximation of the average annual investment.

3.4.3 Taxes

Many equipment owners must pay property taxes or some type of usage tax on equipment. Taxes, like interest, can be calculated by either using the estimated tax rate multiplied by the actual value of the equipment or by multiplying the tax rate by the average annual investment.

3.4.4 Insurance

Most private equipment owners will have one or more insurance policies against damage, fire, and other destructive events. Public owners and some large owners may be self-insured. It could be argued that the cost of insurance is a real cost that reflects the risk to all owners and some allowance for destructive events should be allowed. Not anticipating the risk of destructive events is similar to not recognizing the risk of fire or insect damage in planning the returns from managing a forest. Insurance calculations are handled in the same way as interest and taxes.

3.4.5 Storage and Protection

Costs for equipment storage and off-duty protection are fixed costs, largely independent of the hours of use. Costs of storage and protection must be spread over the total hours of equipment use.

3.5 Operating Costs

Operating costs, unlike fixed costs, change in proportion to hours of operation or use. They depend upon a variety of factors, many of which are, to some extent, under the control of the operator or equipment owner.

3.5.1 Maintenance and Repair

This category includes everything from simple maintenance to the periodic overhaul of engine, transmission, clutch, brakes and other major equipment components, for which wear primarily occurs on a basis proportional to use. Operator use or abuse of equipment, the severity of the working conditions, maintenance and repair policies, and the basic equipment design and quality all affect maintenance and repair costs.

The cost of periodically overhauling major components may be estimated from the owner's manual and the local cost of parts and labor, or by getting advice from the manufacturer. Another owner's experience with similar equipment and cost records under typical working conditions is a

valuable source. If experienced owners or cost records are not available, the hourly maintenance and repair cost can be estimated as a percentage of hourly depreciation (Table 3.2).

TABLE 3.2. Maintenance and repair rates as a percentage of the hourly depreciation for selected equipment.

Machine	Percentage Rate
Crawler tractor	100
Agricultural tractor	100
Rubber-tired skidder with cable chokers	50
Rubber-tired skidder with grapple	60
Loader with cable grapple	30
Loader with hydraulic grapple	50
Power saw	100
Feller-buncher	50

3.5.2 Fuel

The fuel consumption rate for a piece of equipment depends on the engine size, load factor, the condition of the equipment, operator's habit, environmental conditions, and the basic design of equipment.

To determine the hourly fuel cost, the total fuel cost is divided by the productive time of the equipment. If fuel consumption records are not available, the following formula can be used to estimate liters of fuel used per machine hour,

$$LMPH = \frac{K \times GHP \times LF}{KPL}$$

where LMPH is the liters used per machine hour, K is the kg of fuel used per brake hp/hour, GHP is the gross engine horsepower at governed engine rpm, LF is the load factor in percent, and KPL is the weight of fuel in kg/liter. Typical values are given in Table 3.3. The load factor is the ratio of the average horsepower used to gross horsepower available at the flywheel.

TABLE 3.3. Weights, fuel consumption rates, and load factors for diesel and gasoline engines.

Engine	Weight (KPL) kg/liter	Fuel Consumption (K) kg/brake hp-hour	Load Factor (LF)		
			Low	Med	High
Gasoline	0.72	0.21	0.38	0.54	0.70
Diesel	0.84	0.17	0.38	0.54	0.70

3.5.3 Lubricants

These include engine oil, transmission oil, final drive oil, grease and filters. The consumption rate varies with the type of equipment, environmental working condition (temperature), the design of the equipment and the level of maintenance. In the absence of local data, the lubricant consumption in liters per hour for skidders, tractors, and front-end loaders could be estimated as

Q = .0006 × GHP (crankcase oil)
Q = .0003 × GHP (transmission oil)
Q = .0002 × GHP (final drives)
Q = .0001 × GHP (hydraulic controls)

These formulas include normal oil changes and no leaks. They should be increased 25 percent when operating in heavy dust, deep mud, or water. In machines with complex and high pressure hydraulic systems such as forwarders, processors, and harvesters, the consumption of hydraulic fluids can be much greater. Another rule of thumb is that lubricants and grease cost 5 to 10 percent of the cost of fuel.

3.5.4 Tires

Due to their shorter life, tires are considered an operating cost. Tire cost is affected by the operator's habits, vehicle speed, surface conditions, wheel position, loadings, relative amount of time spent on curves, and grades. For off-highway equipment, if local experience is not available, the following categories for tire life based upon tire failure mode could be used as guidelines with tire life given in Table 3.4.

In Zone A, almost all tires wear through to tread from abrasion before failure. In Zone B, most tires wear out - but some fail prematurely from rock cuts, rips, and non-repairable punctures. In Zone C, few if any tires wear through the tread before failure due to cuts.

TABLE 3.4. Guidelines for tire life for off-highway equipment

Equipment	Tire Life, hours		
	Zone A	Zone B	Zone C
Motor graders	8000	4500	2500
Wheel scrapers	4000	2250	1000
Wheel loaders	4500	2000	750
Skidders	5000	3000	1500
Trucks	5000	3000	1500

3.6 Labor Costs

Labor costs include direct and indirect payments such as taxes, insurance payments, food, housing subsidy, etc. Labor costs need to be carefully considered when calculating machine rates since the hours the labor works often differs from the hours the associated equipment works. What is important is that the user define his convention and then to use it consistently. For example, in felling, the power saw rarely works more than 4 hours per day, even though the cutter may work 6 or more hours and may be paid for 8 hours, including travel. If felling production rates are based upon a six-hour working day, with two hours of travel, the machine rate for an

operator with power saw should consider 4 hours power saw use and eight hours labor for six hours production.

3.7 Variable Effort Cycles

The concept that men or equipment work at constant rates is an abstraction that facilitates measurements, record keeping, payments and analysis. However, there are some work cycles which require such variable effort that it is more useful to construct machine rates for parts of the cycle. One important case is the calculation of the machine rate for a truck. When a log truck is waiting to be loaded, is being loaded, and is being unloaded, its fuel consumption, tire wear, and other running costs are not being incurred. Or, if these costs are incurred, they are at a much reduced rate. For the standing truck, a different machine rate is often constructed using only the fixed cost and the labor cost for this part of the cycle. Part or all of the truck depreciation may be included.

If a single machine rate were used to estimate the unit cost for truck transport and this value was converted to a ton-km cost or $\$/m^3$-km cost without removing the "fixed" cost of loading and unloading then the "variable" cost of transport would be overestimated. This could lead to erroneous results when choosing between road standards or haul routes.

3.8 Animal Rates

The calculation of the animal rate is similar to the machine rate, but the types of costs differ and merit additional discussion.

3.8.1 Fixed Cost

The fixed cost includes the investment cost of the animal or team, harness, yoke, cart, logging chains and any other investments with a life more than one year. Other fixed costs include the upkeep of the animals.

The purchase price of the animal may include spare animals if the working conditions require that the animal receive rest more than overnight, such as every other day. To allow for the possibility of permanent injury, the animal purchase price may be increased to include extra animals. In other cases, accidents can be allowed for in the insurance premium. The salvage cost for the animal has the same definition as for a machine rate but in the case of the animal, the salvage value is often determined by its selling value for meat. Average annual investment, interest on investment, and any taxes or licenses are treated the same as for equipment. To find the total fixed costs for the animals, the fixed costs for the animal, cart, harness, and miscellaneous investments can be calculated separately since they usually have unequal length lives and the hourly costs added together.

Animal support costs which do not vary directly with hours worked include pasture rental, food supplements, medicine, vaccinations, veterinarian services, shoes, ferrier services and any after-hours care such as feeding, washing or guarding. It could be argued that food and care requirements are related to hours worked and some part of these costs could be included in operating costs. Pasture area (ha/animal) can be estimated by dividing the animal consumption rate (kg/animal/month) by the forage production rate (kg/ha/month). Food supplements,

medicine, vaccinations, and veterinarian schedules can be obtained from local sources such as agricultural extension agents.

3.8.2 Operating Costs

Operating costs include repair and maintenance costs for harnesses, carts, and miscellaneous equipment.

3.8.3 Labor Costs

The labor cost in the animal rate is for the animal driver (and any helpers). For full year operations it is calculated as the labor cost per year including social costs divided by the average number of working days or hours for the driver (and any helpers).

3.9 Examples

Examples of machine rates for a power saw, a tractor, a team of oxen, and a truck are in the following tables. Although the machine rates in Tables 3.5 to 3.8 share the same general format, there is flexibility to represent costs that are specific to the machine type, particularly in the calculation of the operating costs. For the power saw (Table 3.5), major operating expenses are identified with the chain, bar, and sprocket so they have been broken out separately. For the oxen (Table 3.7), the fixed costs have been divided into major cost components specific to maintaining animals, in addition to depreciation. For the truck (Table 3.8), costs have been divided in standing costs and traveling costs to differentiate between costs when the truck is standing by, being loaded, or unloaded as compared to traveling costs.

TABLE 3.5 Machine Rate Calculation for a Power Saw[1]

Machine:	Description - McCulloch Pro Mac 650 Power Saw			
	Motor cc	60	Delivered Cost	400
	Life in hours	1000	Hours per year	1000
Fuel:	Type		Gas Price per liter	0.56
Oper:	Rate per day	5.50	Social Costs	43.2%

Cost Component		**Cost/hour**
(a) Depreciation	$= \frac{\text{delivered cost} \times .9}{\text{life in hours}}$	0.36
(b) Interest (@ 10%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	0.03
(c) Insurance (@ 3%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	0.01
(d) Taxes	$= \frac{\text{annual tax amount}}{\text{average hours per year}}$	-

(e) Labor	$= \frac{\text{labor cost per year} \times (1+f)}{\text{average hours per year}}$	1.89[2]
	where f = social costs of labor as decimal	
	SUB-TOTAL	2.29
(f) Fuel	= 0.86 l/hr × .95 × CL +0.86 l/hr × .05 × CO)	0.51
	where CL = cost of gas, CO = cost of oil	
(g) Lube oil for bar and chain = Fuel cons/2.5 × CO		0.45
(h) Servicing and repairs = 1.0 × depreciation		0.36
(i) Chain, bar, and sprocket		0.67
(j) Other		0.22
	TOTAL	4.50[3]

[1] All costs are in US$.
[2] Labor based on 240 days per year.
[3] Add 0.04 if standby saw is purchased.

TABLE 3.6 Machine Rate Calculation for a Tractor[1]

Machine: Description - CAT D-6D PS

	Gross hp	140	Delivered cost	142,000[2]
	Life in hrs	10,000	Hrs per year	1,000
Fuel:	Type	Diesel	Price per liter	.44
Oper:	Rate per day	12.00	Social Costs	43.2%
Help:	Rate per day	5.00	Social Costs	43.2%

Cost Component		**Cost/hour**
(a) Depreciation	$= \frac{\text{delivered cost} \times .9}{\text{life in hours}}$	12.78
(b) Interest (@ 10%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	8.52
(c) Insurance (@ 3%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	2.56
(d) Taxes (@ 2%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	1.70
(e) Labor	$= \frac{\text{labor cost per year} \times (1+f)}{\text{average hours per year}}$	5.84[3]
	where f = social costs of labor as decimal	
	SUB-TOTAL	31.40
(f) Fuel	= .20 × GHP × LF × CL	6.65
	where GHP = gross engine horsepower CL = cost per liter for fuel LF = load factor (.54)	

(g) Oil and grease = 0.10 × fuel cost		0.67
(h) Servicing and repairs = 1.0 × depreciation		12.78
(i) Other (cable, misc)		5.00
	TOTAL	56.50

[1] All costs are in US$.
[2] With blade, ROPS, winch, integral arch.
[3] Labor based upon 240 days per year.

TABLE 3.7 Machine Rate Calculation for a Team of Oxen[1]

Description - Pair of oxen for skidding

	Gross hp	- Delivered cost	2,000	
	Life in years	5 Days per year	125	
Labor	Rate per day	7.00 Social Costs	43.2%	

Cost Component		**Cost/day**
(a) Depreciation	$= \frac{\text{delivered cost} \times .65}{\text{life in days}}$	2.08[2]
(b) Interest (@ 10%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hours per year}}$	0.96
(c) Taxes	$= \frac{\text{annual tax amount}}{\text{average hours per year}}$	-
(d) Pasture	$= \frac{\text{pasture rental per year}}{\text{average days per year}}$	1.10
(e) Food supplements		1.36
(f) Medicine and veterinary services		0.27
(g) Driver	$= \frac{\text{labor cost per year} \times (1+f)}{\text{average days per year}}$	10.02[3]
where f = social costs of labor as decimal		
(h) After-hours feeding and care		2.62
(i) Other (harness and chain)		1.00
	TOTAL	19.41

[1] All costs are in US$.
[2] Oxen sold for meat after 5 years.
[3] Driver works with two pair of oxen, 250 day year.

TABLE 3.8 Machine Rate Calculation for a Truck[1]

Machine: Description - Ford 8000 LTN

	Gross hp	200	Delivered cost	55,000
	Life in hrs	15,000	Hrs per year	1,500
Fuel:	Type	Diesel	Price per liter	.26

Tires: Size 10 × 22 Type Radial Number 10

Labor Rate per day 12.00 Social Costs 43.2%

Cost Component		**Cost/hour**
(a) Depreciation	$= \frac{\text{delivered cost} \times .9}{\text{life in hours}}$	3.12
(b) Interest (@ 10%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hrs per year}}$	2.20
(c) Insurance (@ 3%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hrs per year}}$	0.66
(d) Taxes (@ 2%)	$= \frac{\text{delivered cost} \times .6 \times \text{rate}}{\text{average hrs per year}}$	0.44
(e) Labor	$= \frac{\text{labor cost per year} \times (1+f)}{\text{average hrs per year}}$	3.30[2]
where f = social costs of labor as decimal		
Standing Cost	SUB-TOTAL	9.72
(f) Fuel	= .12 × GHP × CL	6.24
where CL = cost per liter for fuel		
(g) Oil and grease = 0.10 × fuel cost		0.62
(h) Servicing and repairs = 1.5 × depreciation		4.68
(i) Tires =	$= 1.2 \times \frac{\text{replacement cost}}{1500\,\text{hrs}}$	2.40
(j) Other (chains, tighteners)		0.20
Traveling Cost	TOTAL	23.86

[1] All costs are in US$.

[2] Labor is for 240 days plus 20% overtime