Are You OVERLOADING Your SKIDDER TIRES?

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THE TIRES USED on most log skidders for Appalachian logging jobs are too small for the loads they have to carry, and most are underinflated.

These were the main conclusions from a study completed at the Forestry Sciences Laboratory maintained by the USDA Forest Service's Northeastern Forest Experiment Station at Morgantown, West Virginia.

The undersize and underinflated tire is one of the costliest problems in Appalachian logging. Overloaded and underinflated tires cause excessive wear and expensive early replacement (fig. 1).

In seeking a solution to this problem, we have developed a method that can be used for choosing the correct tire size and inflation pressure for a particular skidder.

THE STUDY

To study skidder tire performance, we used a Pettibone Master-8 skidder as a test machine. (Mention of a particular make of skidder is for information only, and should not be considered as an endorsement by the Forest Service.) This study was set up to determine what effect different depths of tread have on the amount of load a skidder can pull.

In these tests, we used a tire inflation pressure of 22 p.s.i., even though the manufacturer suggested 16 to 18 p.s.i. for tires of this size. Even at 22 p.s.i., we found that we were

Figure 1. — A typical underinflated and overloaded tire on a log skidder. This kind of abuse leads to serious and costly damage.

overloading the tires. The rear tires were squashing out, which would eventually cause breakdown of the sidewalls. Since a skidder tire may cost $800, this kind of damage can be a serious cost problem for the logger.

This overloading of the tires raised a question: How can you determine the proper size and inflation for skidder tires? To determine this we studied the forces exerted on the tires in relation to the loads to be carried.

THE FORCES ON THE TIRE

A log skidder is a heavy machine. The tires must bear not only the weight of the machine, but also part of the weight of the load carried. And the weight of the machine on the front tires shifts toward the rear tires as the load is applied.

For example, in our study, our loads peaked out at 10,500 pounds line-tension load. At this loading, and on level ground, the machine was hard to steer and the front end began to lift off the ground, throwing the major force onto the rear tires.

So the main force we are concerned with is the normal force on the rear tires. This is made up of three elements (fig. 2):

1. The empty machine weight on the rear tires.
2. The shifting of machine weight onto the rear tires.
3. The part of the load that acts downward onto the rear tires.

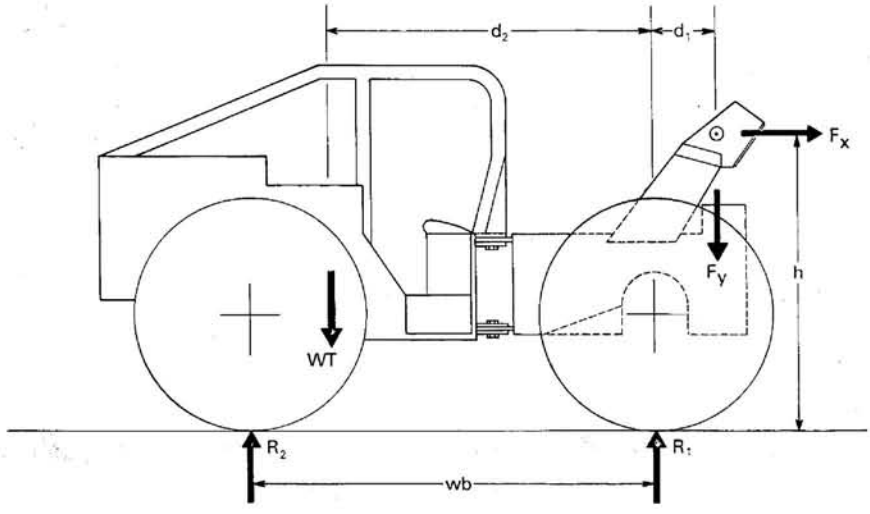
These three elements constitute the total force on the rear tires. It is this total force that must be used as a basis for calculating the proper size of tire and the proper inflation pressure.

CALCULATING THE FORCES

To calculate the forces exerted on the rear tires, we collected data on winch-line pull and angle. A computer was used to get angle of skidder winch line as a least-squares-fit polynominal function of the log load (fig. 3 and fig. 4).

From our data on loads, we assumed 8,000 pounds as a reasonable winch-line load. Using a winch-line angle of 37.5 degrees below the horizontal (fig. 3), and converting the

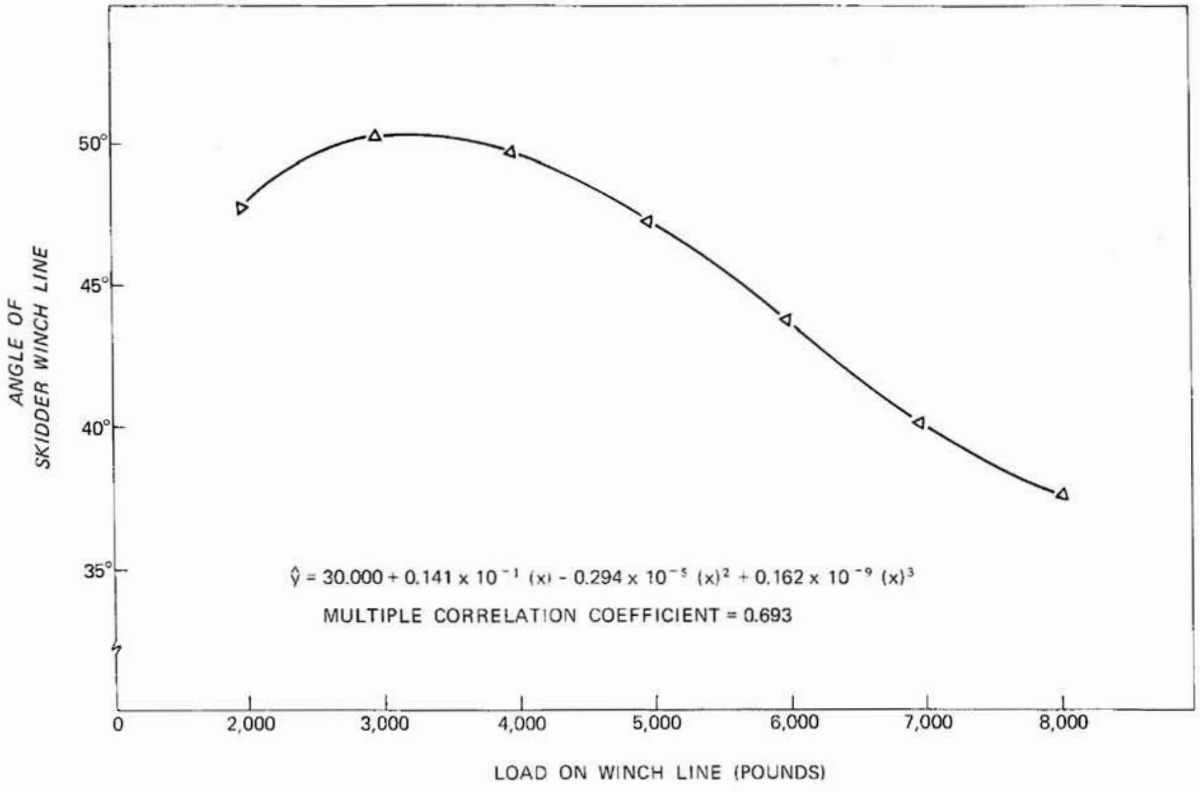
Figure 2. — Diagram of a log skidder, showing the major forces exerted during skidding.



$$\Sigma F_y = 0 \qquad F_y + WT = R_1 + R_2$$

$$\Sigma M_{r_1} = 0 \qquad -F_x(h) - F_y(d_1) + WT(d_2) - R_2(wb) = 0$$

Figure 3. — Curve of the regression equation for winch-line angle versus winch-line load. Based on data for a Pettibone Master-8 skidder.



8,000-pound load to a force in the X direction and a force in the Y direction, we have:

$$F_x = F \ (\cos 37.5°) = 8{,}000 \ (0.79335)$$
$$F_x = 6347 \text{ (pounds of force) (lbf.)} \quad (1)$$

$$F_y = F \ (\sin 37.5°) = (0.60876) \ 8{,}000$$
$$F_y = 4870 \text{ lbf.} \quad (2)$$

We also need to know the ground forces, R_1 and R_2 (fig. 2). Summing the forces in the Y direction and setting them equal to zero:

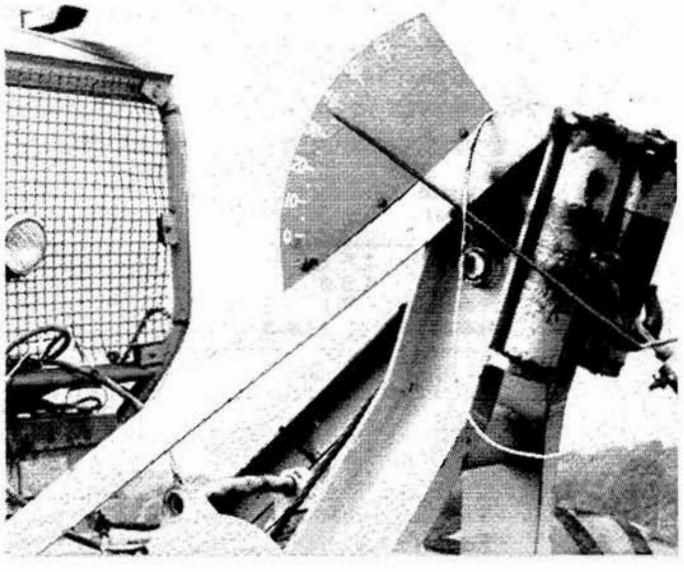
$$\Sigma F_y = 0$$

$$-F_y - W_t + R_1 + R_2 = 0 \ \therefore \quad (3)$$
$$F_y + W_t = R_1 + R_2$$

Taking moments about the point where R_1 acts and setting them equal to zero:

$$\Sigma M_{R_1} = 0$$
$$-F_x (h) - F_y (d_2) + W_t (d_1)$$
$$- R_2 (wb) = 0 \quad (4)$$

Figure 4. — Method used for determining winch-line angle.



Substituting in machine characteristics for the Pettibone Master 8-A skidder used in the tests (table 1) and solving for R_2:

$$R_2 = -F_x\,(0.80208) - F_y\,(0.1770) + 10{,}240$$
$$= -6{,}347\,(0.80208) - 4{,}870\,(0.1770) + 10{,}240$$
$$= 4{,}287 \text{ lbf. or } 2{,}143 \text{ pounds force on each front wheel.}$$

Substituting the answer from equation 4 back into equation 3 and solving for R_1:

$$R_1 = F_y + 14{,}240 - R_2$$
$$= 4{,}870 - 14{,}240 - 4{,}287$$

Force on rear wheels R_1 = 14,823 or 7,411 lbf. on each rear tire.

This machine was equipped with 10-ply 18.4 x 26 tires. From table 2, we can see that tires of this size cannot efficiently carry a force or load of 7,411 lbf. These tires should be replaced with 12-ply 28.1 x 26 tires, with an inflation pressure of 20 psig.

DETERMINING TIRE SIZE

This method can be used to determine proper tire size and inflation for other makes of skidders. We have applied this method to

Table 1.—*Machine characteristics of log skidders*

Make & model	Wheel base	Fairlead height	Distance from center of rear axle to fairlead roller	Empty weight, front	Empty weight, rear
	Inches	*Inches*	*Inches*	*Lbf.*	*Lbf.*
Pettibone Master 8-A 97 hp.	96	77	17	10,240	4,000
Clark 666 130 hp.	104	73.35	18	8,770	5,980
Can Car C5-BD 97 hp.	101	70.5	19	7,660	5,200
Franklin 130-B 97 hp.	114	78.0	19	8,870	4,010
Taylor S-112 130 hp.	108	80	12.3	8,900	4,400
Timberjack 230 "D" 97 hp.	110	77.5	20.7	8,430	4,770

Table 2.— *Tire-load limits, in pounds, at various inflation pressures*[1]
(Maximum speed 20 mph)

Tire size (inches)	Tire type	Ply rating	Inflation pressures (psig) of —			
			15	20	25	30
16.9-30	LS-1	6,8,10	3,760(6)[2]	4,450(8)	5,070	5,640(10)
16.9-30	LS-2	8,10	3,760	4,450(8)	5,070	5,640(10)
18.4-26	LS-1	8,10	4,230	5,000(8)	5,700(10)	—
18.4-26	LS-2,LS-3	10	4,230	5,000	5,700(10)	—
18.4-30	LS-1	10	4,500	5,330	6,070(10)	—
18.4-34	LS-1,LS-2	10	4,780	5,650	6,440(10)	—
23.1-26	LS-1,LS-2,LS-3	10	6,050	7,160(10)	—	—
23.1-34	LS-1,LS-2	10	6,840	8,090(10)	—	—
24.5-32	LS-1,LS-2,LS-3	10,12	7,350	8,700(10)	9,910(12)	—
28.1-26	LS-1,LS-2,LS-3	10,12	7,010(10)	8,290(12)	—	—
30.5-32	LS-1	12	8,780	10,390(12)	—	—

[1] The Tire and Rim Association, Inc., Akron, Ohio.

[2] Figures in parentheses show ply rating for which underlined loads and inflations are maximum.

Table 3.—*Weight on single rear tire (normal force, in pounds) for different winch-line loads and several makes of skidders*

Winch-line load skidded (lbs.)	Approx. payload (lbs.)	Pettibone Master 8-A	Clark 666	Can Car C5-BD	Franklin 130-B	Taylor	Timberjack 230
2,000	2,962	3,411	4,333	3,949	3,329	3,523	3,739
3,000	4,612	4,126	5,019	4,639	4,006	4,195	4,431
4,000	6,106	4,833	5,692	5,315	4,670	4,858	5,109
5,000	7,344	5,522	6,341	5,966	5,308	5,502	5,762
6,000	8,296	6,180	6,951	6,577	5,907	6,115	6,376
7,000	9,028	6,802	7,524	7,148	6,468	6,695	6,951
8,000	9,740	7,411	8,085	7,708	7,017	7,263	7,514

the six makes of skidders commonly used in Appalachian logging.

For the different skidders, at various winch-line loads, the force on each rear tire is shown in table 3. These forces were derived from table 1 (machine characteristics) and figure 2.

Graphic plots were made for each of the six skidder models, using winch-line load, winch-line angle, and machine characteristics for calculating the vertical force on each rear tire (fig. 5).

To get the approximate weight of the load to convert into cords and board feet, we used twice the F_y (fig. 2) component of the load (table 4), since it was estimated that about one-half of the log was lifted off the ground. For the weight per board feet and the pounds per cord we used 9 pounds/board foot and 9,000 pounds/cord. (Massey-Ferguson Industrial and Construction Machinery Wood Conversion Chart, 1967.)

Bear in mind, however, that figure 5 will yield an *approximate* value. But with this figure you can estimate the force on a skidder tire. Daily production divided by the trips per day will yield the board feet or cords per trip. From the curves for each machine you can get the tire size and inflation pressure needed on that particular machine.

From the figure 5 plots, table 5 was prepared for determining what size tire should be used on different brands of log skidders, using an assumed maximum winch-line load of 8,000 pounds at an angle of 37.5 degrees. This is a realistic winch-line load for a log skidder; and the winch-line load may go a little higher on some operations.

The last two columns of table 5 show the recommended tire sizes and tire inflation pressures, based on tire manufacturer's literature.

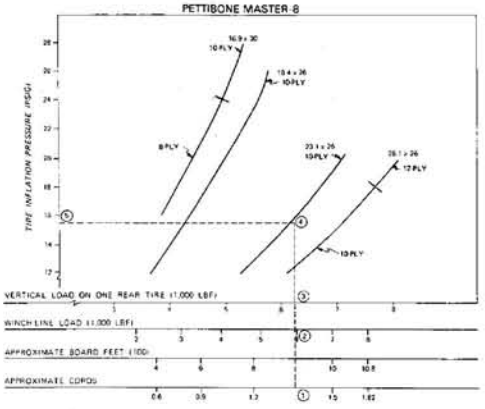
CONCLUSIONS

The logger pays a high cost for using the wrong size of tires on his skidder. The overloaded and underinflated tire breaks down long before it has served its full service life. Then the logger pays the extra cost of having to buy new tires prematurely. By using the information offered in this report, the logger can determine the proper size of tires for his logging job. He can also determine the proper

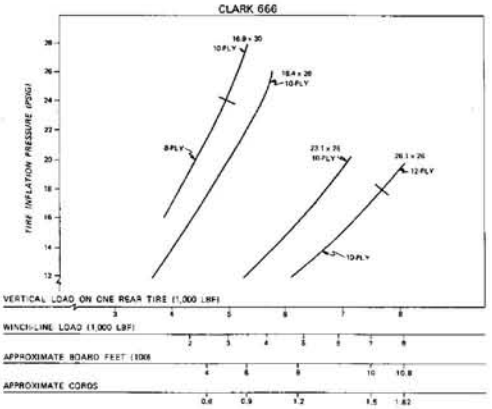
Table 4.—*Approximate board feet or cords per winch-line load of Appalachian hardwoods*

Winch-line load	F_y	Load weight (2 F_y)	Board feet	Cords
2,000	1,481	2,962	329	0.494
3,000	2,306	4,612	512	.769
4,000	3,053	6,106	678	1.018
5,000	3,672	7,344	816	1.224
6,000	4,148	8,296	922	1.383
7,000	4,514	9,028	1,003	1.505
8,000	4,870	9,740	1,082	1.623

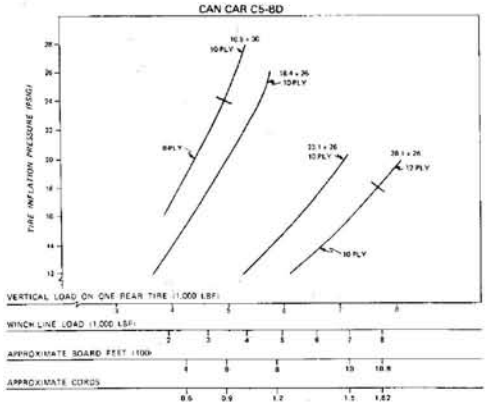
PETTIBONE MASTER-8



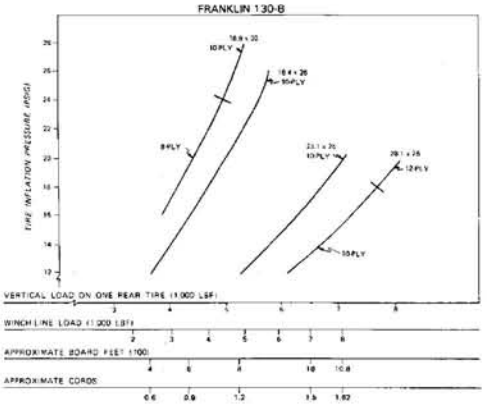
CLARK 666



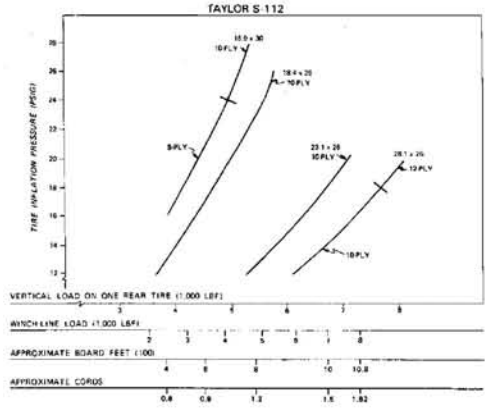
CAN CAR C5-8D



FRANKLIN 130-8



TAYLOR S-112



TIMBERJACK 230

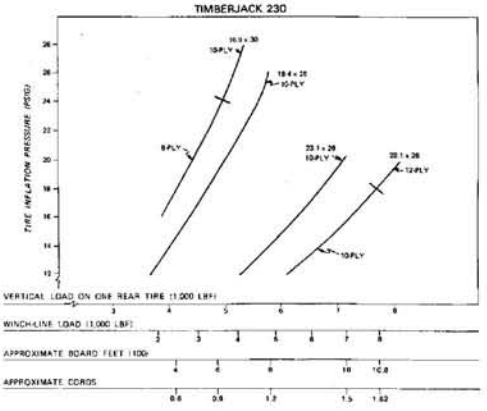


Figure 5.—Graphic plots for determining tire size and inflation pressure, for six makes of log skidders. How to use the plots:

1. Select the plot for your machine. Take the Pettibone Master-8 skidder as an example.
2. On the bottom scale, locate your average cords or board feet skidded per trip. Assume 1.35 cords (1).
3. From this point, extend a line straight up till it strikes the tire-size curve. The tire size in this case would be 10 ply 23.1 x 26. (4)
4. Read left across to the tire-pressure scale. The proper inflation pressure would be about 16 psig. (5)

Where the vertical line crosses the winch-line load scale (2) shows you the winch-line load, in this case about 6,000 lbf. Where the vertical line crosses the vertical load scale (3) shows you the load or force on each rear tire, in this case about 6,100 lbf. You can use this figure to select proper tire size from table 2. (Data for these curves are from the 1970 Tire and Rim Association Yearbook.)

Table 5.—*Recommended tire sizes for assumed load*
(Winch-line load assumed at 8,000 pounds, at winch-line angle of 37.5°)

Make & model	Load on each rear tire	Load on each front tire	Tire size and ply rating	Tire pressure
	Lbs.	*Lbs.*		*Psig.*
Pettibone Master 8-A 97 hp.	7,411	2,144	28.1 x 26 12-ply	20
Clark 666 130 hp.	8,085	1,725	28.1 x 26 12-ply	20
Can Car C5-BD 97 hp.	7,708	1,157	28.1 x 26 12-ply	20
Franklin 130-B 97 hp.	7,017	1,858	23.1 x 26 10-ply	20
Taylor S-112 130 hp.	7,263	1,822	28.1 x 26 12-ply	20
Timberjack 230 97 hp	7,514	1,521	28.1 x 26 12-ply	20

inflation pressure for his tires. And this is important: it is up to the logger to make sure he uses the right inflation pressure to get the best service out of his tires.

Many of the skidders sold today are equipped with tires that are too small. By using the information in this report, skidder manufacturers, sales personnel, and users can determine the proper size of tire for specific load conditions and can properly equip each machine.

If skidders were equipped with the proper size of tires, properly inflated, many of the problems that loggers have with skidder tires would vanish.

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