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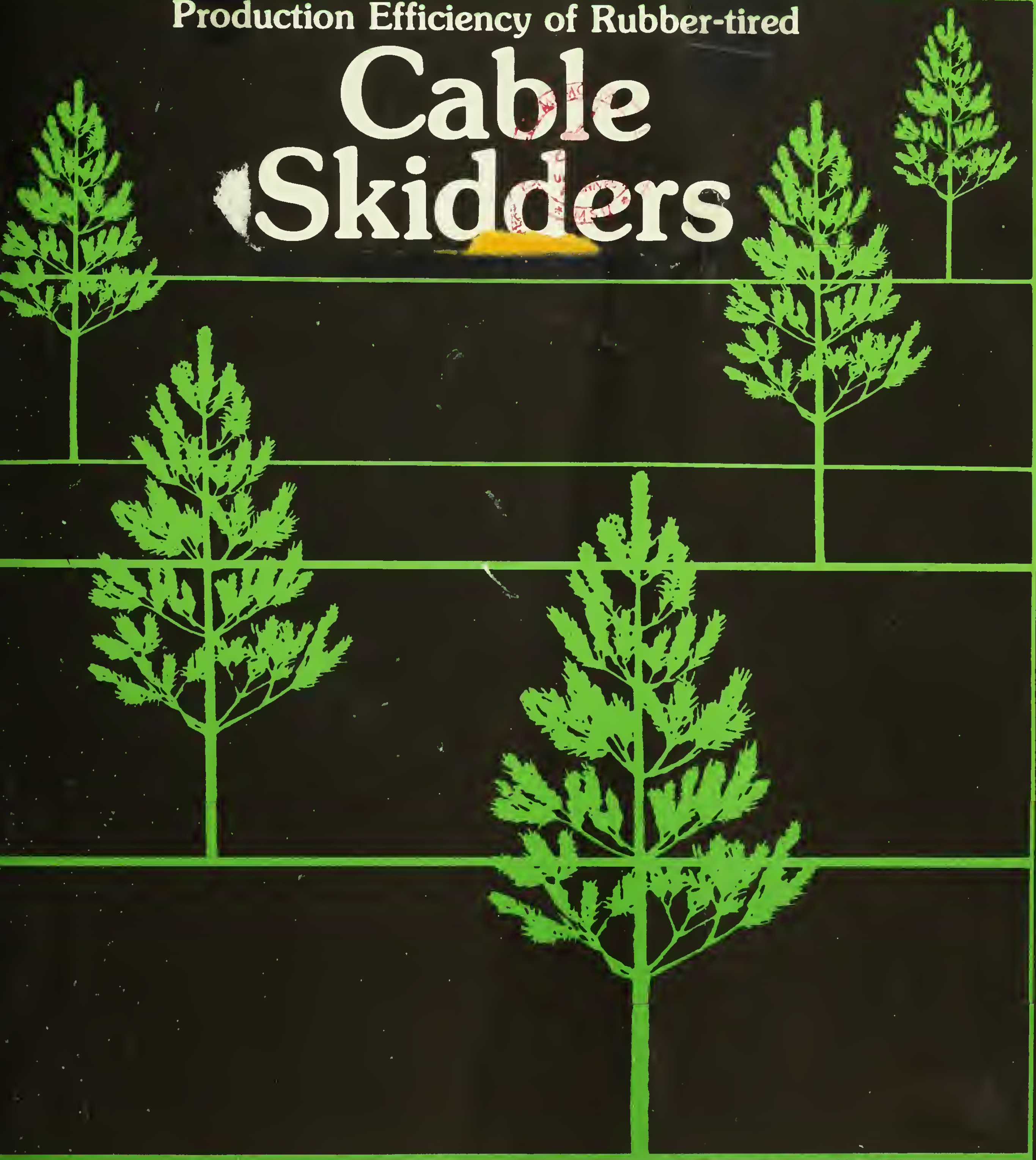

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Production Efficiency of Rubber-tired Cable Skidders

Skidding is a major determinant of the volume harvested and is the highest-cost component of mechanized timber harvesting in the South. The efficiency of timber-harvesting operations is reduced significantly if too many long skidder hauls are made (Kroger, 1976; Walbridge, 1960 and Jiles and Lehman, 1960), and/or if underpowered and overpowered skidders are used (Kroger, 1976). The effect of two or more skidders on the efficiency of an operation has not been reported, but it is known that the use of two or more of them at the same site requires more time for reconnaissance and planning of each load.

This study was initiated with the objective of developing information needed for increasing the efficiency of skidders used in timber-harvesting operations in Mississippi. Attainment of the objective required explanation of (1) the variation in numbers of stems skidded (stems per hour per skidder) in typical harvesting operations and (2) the reasons for these variations.

Procedure

Time study crews visited typical non-industrial timber-harvesting operations on 53 days in the spring and summer of 1976 and made 111 observations for periods of at least 30 minutes each. Data recorded included (1) the number of skidders in each operation; (2) flywheel horsepower of the skidders; (3) average skid distance; (4) numbers of stems skidded; (5) average volume of stems skidded; (6) time spent in the skidding operation, including locating logs to be skidded, in-woods positioning of logs for hook-up, hooking and unhooking chokers and travel time of skidders to and from the loading area; (7) time spent in other activities, such as lubricating and refueling equipment, pulling preventive maintenance and rest breaks; (8) tree sizes and stand conditons in the areas where skidders were operating and in similar areas where trees had not been felled; (9) slopes of skidding areas relative to loading areas and (10) drainage of the skidding areas.

Numbers of trees skidded per productive hour were regressed against each characteristic of the skidding operations and of the stands, and multiple regression was used to develop an equation that gave the best estimate of numbers of trees skidded per productive hour.

Estimates of the numbers of trees skidded per hour were multiplied by the average cubic foot-volume of stems to get the volume skidded per hour, and the cubic foot volume was divided by 80 to get the number of cords per productive hour. Skidder production per week then was determined by multiplying cords per productive hour by 28.5.[1]

Results

The equation that best explained the variation in skidder production accounted for 64% of the total variation and was as follows:

$$\hat{X} = 31.6 - 2.03\ Y_1 + 0.155\ Y_2 - 1.43\ Y_3 + 0.00116\ Y_4 - 0.461\ Y_5 + 0.0028\ Y_6$$

where

$\hat{X}$ = estimated number of trees per hour

Y_1 = number of skidders per operation

Y_2 = flywheel horsepower of skidder

Y_3 = average skid distance in 100 ft.

Y_4 = cube of average skid distance

Y_5 = average cubic-foot volume of stems

Y_6 = square of average cubic-foot volume of stems

(standard error = 5.4)

Estimated production per skidder per week ranged from 27 cords for operations using four 75-horsepower skidders to skid 40-cubic foot stems an average distance of 2000 feet to 457 cords for using one 125-horsepower skidder to skid 40-cubic foot stems an average distance of 200 feet (Tables 1, 2, and 3). Production by skidders of each horsepower decreased with each increase in the number used in an operation.

[1] *Skidders in the observed operations were used in production activities an average of 71.2% of the time (28.5 hrs/40-hr work week).*

Table 1. Estimated weekly productivity per skidder of 75-horsepower skidders used in productive activity for 28.5 hrs./week, by number of skidders, cubic foot volume of stems skidded and average skidding distance.

NUMBER SKIDDERS IN THE OPERATION	STEM VOLUME	AVERAGE SKIDDING DISTANCE (feet) 200	400	600	800	1000	1200	1400	1600	1800	2000
	cubic feet	---cords per week---									
	10	121	111	102	93	85	77	71	67	64	63
	15	171	156	142	129	116	106	97	90	85	84
	20	215	195	176	158	142	128	116	107	101	99
1	25	254	229	206	183	163	145	130	119	111	108
	30	289	259	230	203	179	158	140	126	117	114
	35	319	285	251	220	192	167	146	130	119	115
	40	347	307	269	234	201	172	149	130	118	114
	10	114	104	94	85	77	70	64	60	57	55
	15	160	145	131	118	106	95	86	79	75	73
	20	201	181	162	144	128	113	102	92	86	84
2	25	236	211	187	165	145	127	112	101	93	90
	30	267	237	209	182	157	136	118	104	95	92
	35	294	259	226	195	166	141	120	104	94	90
	40	318	279	240	205	172	143	120	101	90	85
	10	107	97	87	78	70	63	57	52	49	48
	15	149	135	120	107	95	84	75	68	64	62
	20	186	166	147	130	113	99	87	78	72	70
3	25	218	193	169	147	127	109	94	83	75	72
	30	245	215	187	160	136	114	96	83	74	70
	35	269	234	201	169	141	116	95	79	69	64
	40	289	250	212	176	143	114	91	73	61	56
	10	99	89	80	71	63	56	50	45	42	41
	15	139	124	109	96	84	73	64	57	53	51
	20	172	153	133	115	99	85	73	64	58	55
4	25	200	175	151	129	109	91	76	64	57	54
	30	224	194	165	138	114	93	75	61	52	48
	35	243	209	175	144	116	91	70	54	43	39
	40	260	221	183	147	114	86	62	44	32	27

Interpretation of Results

The productivity estimates presented in the tables need to be adjusted for operations where skidders are used in productive activity for more or less than 28.5 hrs/week, and for operations where site conditions differ from those observed in this study. Almost all operations were skidding on flat ground or up gentle slopes to a loading area at the top of a hill, and they all minimized production decreases in rainy periods by moving to well-drained reserve areas.

The one variable that cannot be attained easily is average skid distance, because it increases with each increase in size of tracts of a given configuration and differs for different configurations of tracts of a given size and by location of the loading deck (Figure 1). Examples[2] are as follows:

40-acre circular tract
744.7 ft = R (radius)
496.5 ft = L (Average straight-line distance to trees = R)
923.4 ft = S (average skid distance = 1.24 R)

47-acre circular tract
807.3 ft = R
538.1 ft = L
1001.0 ft = S

40-acre square tract with loadi deck in the center
1320.0 ft = 2 D (length of ea side of tract)
660.0 ft = D
508.2 ft = L (average straig line distance to trees = 0.77
943.8 ft = S (average ski distance = 1.43 D)

40-acre square tract with loadi deck on one side
1320.0 ft = 2 D
660.0 ft = D
587.4 ft = (average straig line skid distance to trees 0.89 D)*
1095.6 ft = (average skid di tance = 1.66 D)*

[2]*Examples are based on Figure 1 which shows average straight-line distances and estimates of average skid differences derived from an equation by Kroger (1976) for stands with uniform distribution of trees.*

**Note that straight-line skid distance and average skid distance for a 20-acre rectangular tract with deck on one long side are the same as for a 40-acre tract with deck in the center (Figure 1 D)*

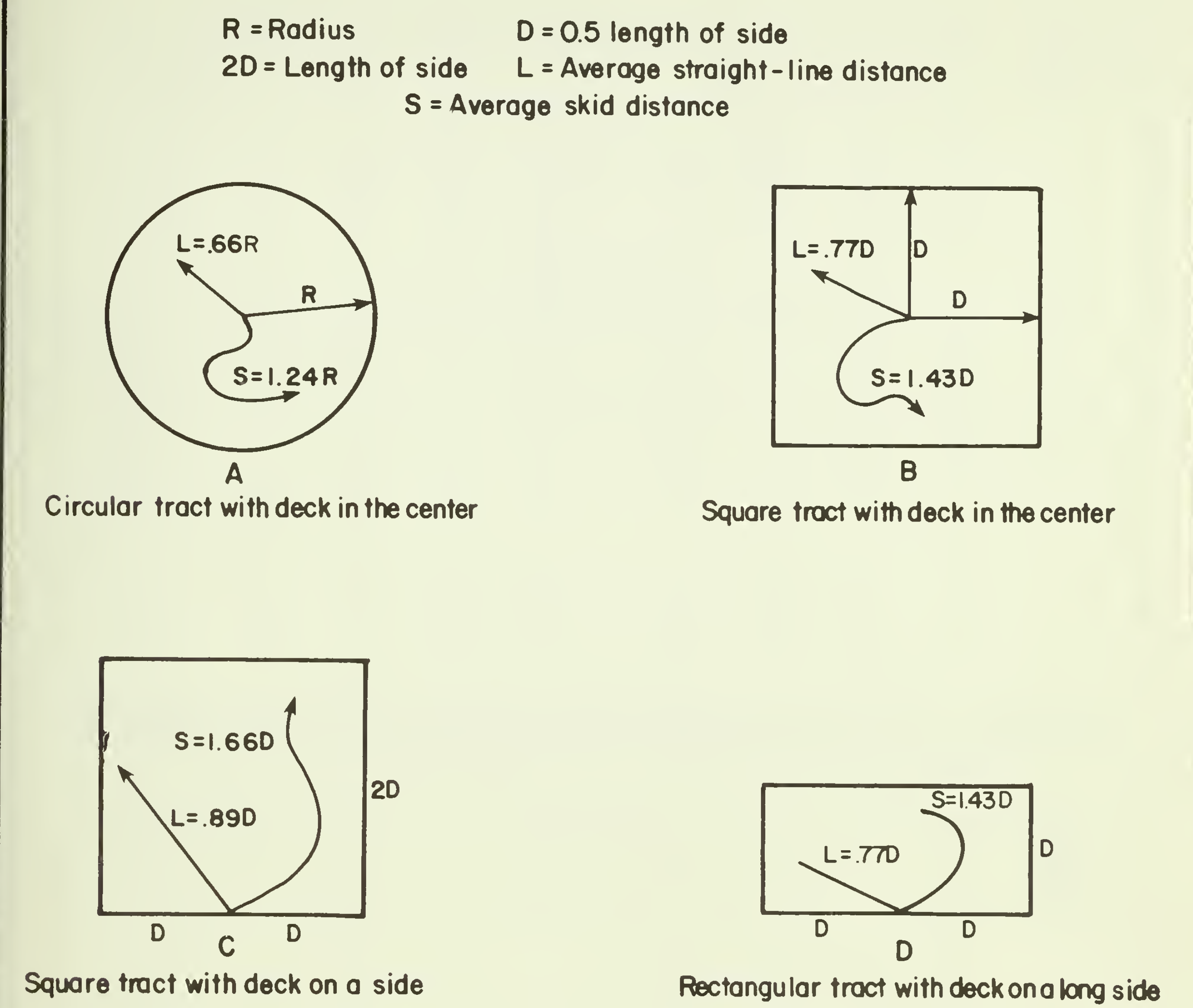

Figure 1. Guidelines for estimating average skid distance on circular tracts, on square tracts with loading deck in the center or on one side of the tract and on rectangular tracts with loading deck on one long side of the tract
(Derived from an equation by Kroger, 1976 for stands with uniform distribution of trees.)

Examples for keying average kid distances to expected volume roduced/skidder per week are as ollow:

Assume a 47-acre circular tract with average volume of 20 cubic feet per stem. Expected production of two 75-horsepower skidders is 128 cords/skidder/week (line 10 under 1000-ft average skidding distance, Table 1). Expected production of two 100-horsepower or two 125-horsepower skidders is 155 and 183 cords/skidders/week, respectively (Table 2-3).

Table 2. Estimated weekly productivity per skidder of 100-horsepower skidders used in productive activity for 28.5 hrs./week, by number of skidders, cubic foot volume of stems skidded and average skidding distance.

NUMBER SKIDDERS IN THE OPERATION	STEM VOLUME	AVERAGE SKIDDING DISTANCE (feet)									
		200	400	600	800	1000	1200	1400	1600	1800	2000
	cubic feet	---cords per week---									
	10	135	125	115	106	98	91	85	81	78	76
	15	192	177	163	149	137	126	117	110	106	104
	20	243	223	204	186	170	155	144	134	128	126
1	25	289	264	240	218	197	179	165	153	146	143
	30	330	300	272	245	220	199	181	167	158	155
	35	368	333	299	268	240	215	194	178	167	163
	40	402	363	324	289	256	228	204	185	174	169
	10	128	118	108	99	91	84	78	73	70	69
	15	181	166	152	138	126	115	106	100	95	93
	20	228	208	189	172	155	141	129	120	114	112
2	25	271	246	222	200	179	161	146	135	128	125
	30	308	278	250	223	199	177	155	146	137	133
	35	342	308	274	243	214	189	169	153	142	138
	40	373	334	296	260	227	199	175	157	145	140
	10	120	110	101	92	84	77	71	66	63	62
	15	170	155	141	128	115	105	96	89	84	83
	20	214	194	175	157	141	127	115	105	100	97
3	25	252	228	204	181	161	143	128	117	110	107
	30	287	257	228	201	171	156	138	124	115	111
	35	317	282	249	218	189	164	143	127	117	113
	40	344	305	267	231	198	170	146	128	116	111
	10	113	103	94	85	77	69	63	59	56	55
	15	159	144	130	117	104	94	85	78	73	72
	20	199	180	161	143	126	112	100	91	85	83
4	25	234	210	186	163	143	125	110	99	91	88
	30	265	235	207	180	155	134	116	102	93	90
	35	292	257	224	192	164	139	118	102	92	87
	40	315	276	238	202	169	141	117	99	87	82

Table 3. Estimated weekly productivity per skidder of 125-horsepower skidders used in productive activity for 28.5 hrs./week, by number skidders, cubic foot volume of stems skidded and average skidding distance.

NUMBER SKIDDERS IN THE OPERATION	STEM VOLUME	AVERAGE SKIDDING DISTANCE (feet)									
		200	400	600	800	1000	1200	1400	1600	1800	2000
	cubic feet	---cords per week---									
	10	149	139	129	120	112	105	99	94	91	90
	15	212	198	183	170	158	147	138	131	127	125
	20	270	250	231	214	197	183	171	162	156	154
1	25	323	298	274	252	232	214	199	188	180	177
	30	371	341	313	286	262	240	222	209	200	196
	35	416	381	348	316	288	263	242	226	216	211
	40	457	418	379	344	311	283	259	241	229	224
	10	141	131	122	113	105	98	92	87	84	83
	15	202	187	172	159	147	136	127	120	116	114
	20	256	236	217	199	183	169	157	147	142	139
2	25	305	280	256	234	214	196	181	169	162	159
	30	350	320	291	264	240	219	201	187	178	174
	35	390	356	322	291	263	238	217	201	190	186
	40	428	389	351	315	282	254	230	212	200	195
	10	134	124	115	106	98	90	84	80	77	76
	15	191	176	162	148	136	125	116	109	105	103
	20	241	222	202	185	168	154	142	133	127	125
3	25	287	262	238	216	196	178	163	151	144	141
	30	328	298	269	243	218	197	179	165	156	153
	35	365	330	297	266	237	212	191	175	165	161
	40	399	360	322	286	253	225	201	183	171	166
	10	127	117	107	98	90	83	77	73	70	69
	15	180	165	151	137	125	114	105	99	94	92
	20	227	207	188	170	154	140	128	119	113	110
4	25	269	244	220	198	177	160	145	133	126	123
	30	206	276	248	221	197	175	157	144	135	131
	35	340	305	272	240	212	187	166	150	140	136
	40	371	331	293	257	224	196	172	154	142	137

References

s, R. A. and J. W. Lehman. 1960. Hardwood logging methods and costs in the Tennessee Valley. Tennessee Valley Authority Report No. 232-60, Norris, Tenn. 40 pp.

ger, J. L. 1976. Factors affecting the production of rubber-tired skidders. Tennessee Valley Authority Technical Note B18. Norris, Tenn. 5 pp.

lbridge, T. A. 1960. The design of harvesting systems and machines for use in the Tennessee Valley as dictated by extensive forest management. Unpublished Ph.D. dissertation, University of Michigan. 293 pp.