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Observed Methods for Felling Hardwood Trees with Chain Saws

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SUMMARY

The angles and lengths of the cutting surfaces made by chain saw operators on hardwood tree stumps are described by means, standard deviations, ranges, and regression equations. Recommended felling guidelines are compared with observed felling methods used by experienced timber cutters in the southern Appalachian Mountains.

Additional keywords: Chain saws, felling.

INTRODUCTION

Chain saws are commonly used by loggers in the southern Appalachian Mountains to fell, limb, top, and buck trees. The relatively low initial cost, light weight, and fast cutting speed of chain saws favor their use for felling trees on rough and often steep mountain slopes. Detailed information concerning the felling methods used by timber cutters in this region is very limited.

The felling methods observed in this study are typical of those used by experienced timber cutters in the southern Appalachian Mountains. After determining the direction of tree lean, the brush around the base is usually cleared and the **facecut** is made. In this study, only the conventional **facecut** (fig. **1**), consisting of an approximate horizontal **basecut** made toward the tree center and a downward sloping **notchcut** that intersects the **basecut,** was observed. Generally, the **facecut** is made on the side of the tree having the greatest lean, preponderance of crown, or desired direction of fall. On steep slopes, the **facecut** is almost always on the downhill side of the tree. Next, the **backcut,** an approximate horizontal cut located on the opposite side of the tree, is made toward the center of the tree.

METHODS AND MATERIALS

Stump height, diameter, and cutting surface measurements were made to the nearest tenth of an inch. Merchantable stem length measurements were made to the nearest tenth of a foot. Diameter measurements of the felled trees were made at the butt and merchantable ends, at dbh, and at approximately **8-foot** sections along the stems. Angle measurements of the cutting surfaces and ground slope were made with a clinometer to the nearest one degree. in addition, the distance the felled tree was separated from the stump and the distance the timber cutter moved away from the stump were measured.

The data on the cutting surfaces were collected during a study on the production rates of chain saws (Koger 1980). Cutting surface data were collected on 82 hardwood trees in north Georgia, western North Carolina, eastern Kentucky, eastern Tennessee, and southeastern Virginia.

Definition of Variables

The following definitions were used in this study to describe cutting surfaces and tree characteris-

Figure 1.—*Virginia timber* *cutter making a conventional* ***facecut.***

tics. The relationships of the cutting surfaces and variable names to the tree are shown in figures 2 and 3.

Facecut:

Basecut:

- $\theta 3$ = the angle that cutting surface A (fig. 3) with the **Y-Z** axis.
- $\theta 4$ = the angle that cutting surface A (fig. 3) makes with the Y-X axis.
- SHL = the height from the base of the **facecut** to the ground.
- LUC = the length of the base of the **facecut,** measured from the outside of the bark toward the center of the tree.
- DC = the distance from the intersection of the **basecut** and **notchcut** to the center of the tree.

Notchcut:

- $\theta 1$ = the angle that surface B (figs. 2 & 3) makes with the Y-Z axis.
- $\theta 2$ = the angle that surface B (figs. 2 & 3) makes with the Y-X axis.
- T = the maximum thickness of the pie-shaped notch.
- VN = the volume of the pie-shaped notch.

$$= \frac{2T(RB-DC)}{3} \sqrt{RB*RB - DC*DC}$$

Backcut:

- $\theta 5$ = the angle that surface C (fig. 3) makes with the **Y-Z** axis.
- $\theta 6$ = the angle that surface C (fig. 3) makes with the Y-X axis.
- SHU = the height from the base of the **backcut** to the ground.

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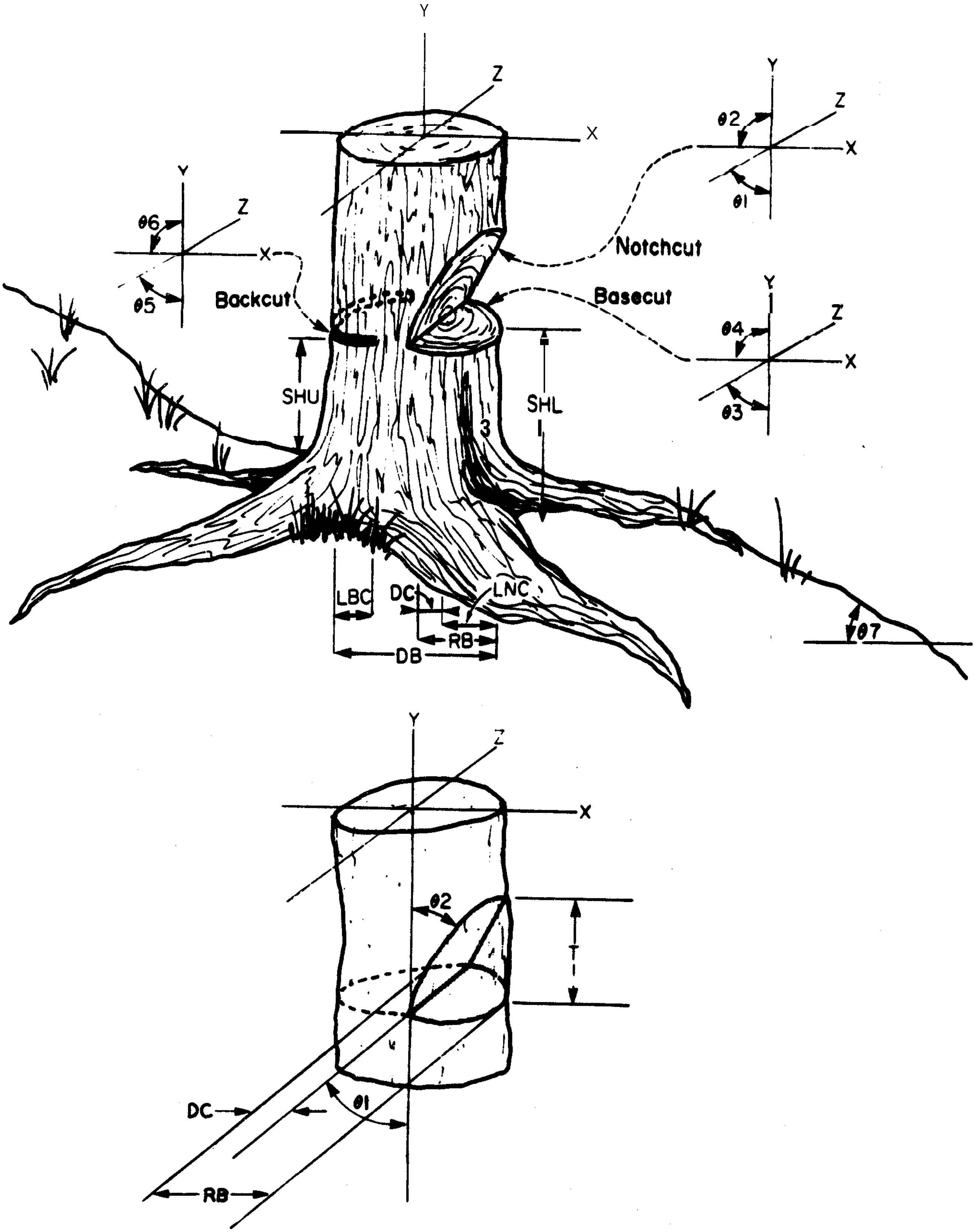

Figure *P.-Measured variables and axis orientation.*

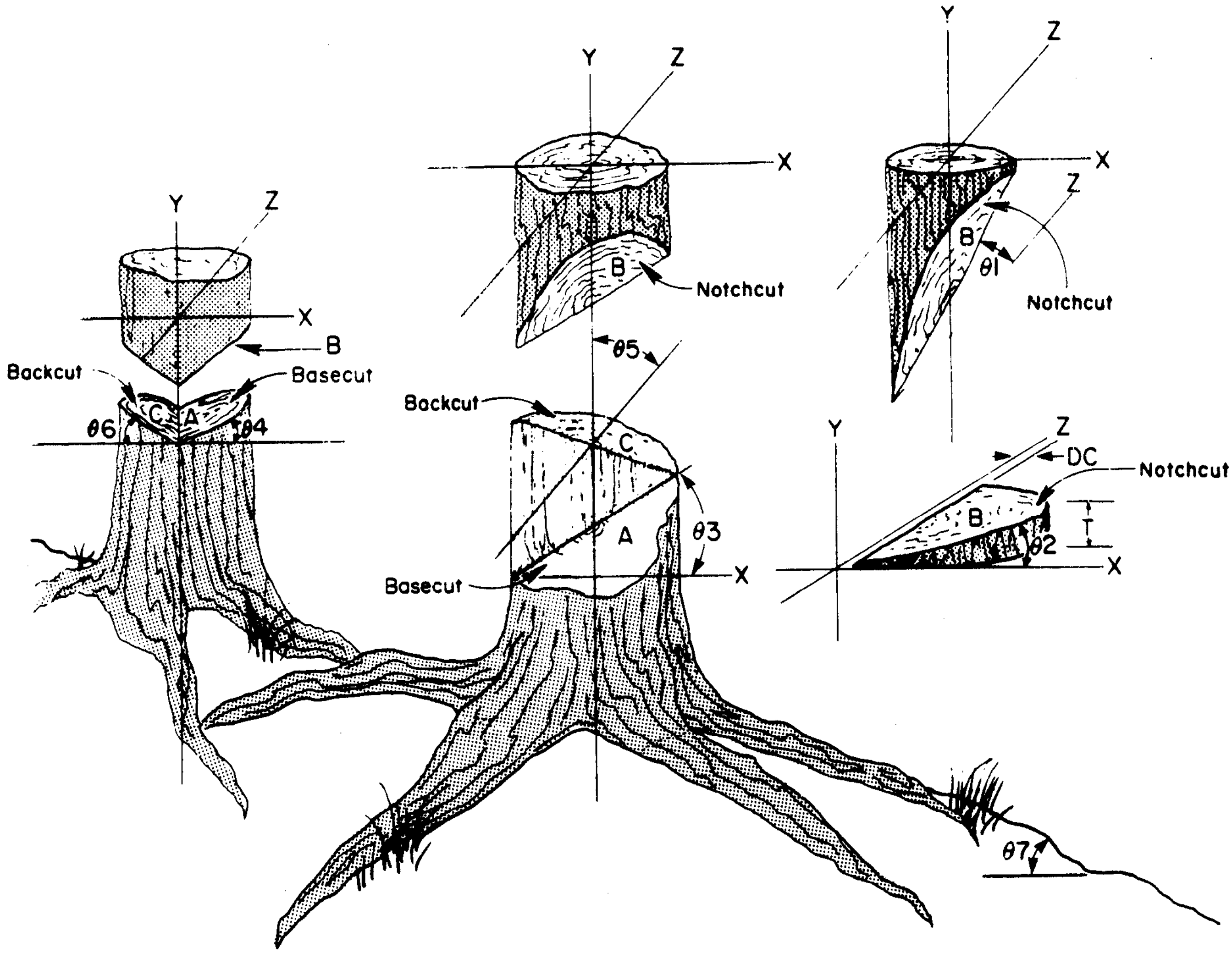

Figure *3.-Selected views of the* **cutting** ***surfaces.***

Table **1.—*Summary*** ***of observed variable characteristic8***

Variable **location**	Variable	Unit	Minimum	Average	Maximum	Std	#
Facecut							
Undercut	**$\theta 3$**	**deg**	***0***	8.8	18	5.2	80
	$\theta 4$	**deg**	***0***	8.1	34	5.9	81
	SHL	in	4.0	17.3	48	8.2	81
	LUC*	in	4.0	10.9	24.0	4.7	82
Notchcut	**$\theta 3$**	**deg**	0	8.8	28	8.3	80
	$\theta 2$	**deg**	2	30.2	58	10.1	71
	T	**in**	0.0	3.1	8.8	1.4	72
	VN	cu in	0.0	172.8	1019.5	190.1	72
Backcut	**$\theta 5$**	**deg**	0	8.0	28	5.3	80
	$\theta 6$	de9	0	10.2	32	8.3	81
	SHU	in	4.0	13.7	48.0	8.1	81
	LBC'	in	5.0	11.0	21.8	3.8	82
Miscellaneous	DB	in	11.8	22.7	37.1	6.0	82
	DBH	in	8.1	18.4	33.3	5.3	82
	TML	**ft**	12.1	41.0	80.3	13.8	82
	DSE	In	3.5	13.0	25.8	4.8	82
	DM	**ft**	1.7	5.8	8.7	1.2	23
	DF	ft	0.0	7.2	121.2	8.2	35
	$\theta 7$	**deg**	0	15	35	11	81
	$\theta 8$	**%**	0	28	70	19	**61**

'Is the length along the cut surface

LBC = the length of the base of the **backcut**, measured from the outside of the bark toward the center of the tree.

Non Cutting Surface:

DB = the diameter of the tree at stump height (outside bark).

RB = the radius of the tree at stump height (DB/2).

DBH = the diameter of the tree measured at 4.5 feet above the ground on the uphill side of the tree (outside bark).

TML = the merchantable length of the tree as determined by the timber cutter.

DSE = diameter of the tree, measured at the end of the merchantable length (small end, outside bark).

DM = the distance the timber cutter moved away from the stump as the tree started to fall (measured with ground slope).

DF = the slope distance from the butt of the felled tree to the center of its stump.

$\theta 7$ = the angle, in degrees, of the ground near the tree stump.

$\theta 8$ = the percent slope of the ground near the tree stump.

RESULTS AND DISCUSSION

The means, standard deviations, and ranges for the variables measured are shown in table 1. There are several differences between the recommended (Wackerman 1949; Simmons 1951; Employers Insurance of Wausau 1965; Pearce and Stenzel 1972; Conway 1973; Pollini 1982; Bentley 19??) method of felling trees and those observed in the study. The major differences between the observed methods (table 1) and the recommended methods involved the slope of the facecut and backcut and the length of the facecut. The base of the observed facecut sloped downward at 6.1 degrees and the base of the backcut sloped downward at 10.2 degrees. Further, the length of the base of the facecut was made almost to the center of the tree. A comparison of several recommended methods versus those observed in this study are shown in figure 4. Since the existing recommendations were not developed specifically for hardwood trees, direct comparisons between the recommended and observed methods may not be meaningful.

The timber cutters in this study often continued making the backcut after the tree had started to fall. This could explain their moving only a short distance (5.6 feet) from the base of the tree after completing the backcut. Their apparent purpose was to: (1) reduce splitting of the butt log and possible kickbacks and (2) fine tune the direction of tree fall.

The falling momentum of the tree combined with the slope and nature of the ground surface can cause the butt of the felled tree to be separated from its stump by several feet. In this study the average slope distance separating the center of the stump and the butt of the felled tree was 7.2 feet.

The general equation model, $\theta 3, \theta 4$, SHL, etc. = f(DBH, TML, & GSD), was used in the STEPWISE procedure and FORWARD selection option of SAS

Table 2.-*Developed regression equations*

Location	Variable*	Equation	R-SQ	C.V.
Facecut				
Undercut	$\theta 3$ =	7.27—0.21*DBH+0.08*TML	0.09	73.80
	$\theta 4$ =	10.74—0.35*DBH+0.15*$\theta 7$	0.10	94.73
	SHL =	6.20+0.32*DBH+0.36*$\theta 7$	0.30	41.43
	LUC =	0.49+0.62*DBH—0.02*TML	0.47	31.75
Notchcut	$\theta 1$ =	6.32—0.12*DBH+0.11*TML	0.07	70.65
	$\theta 2$ =	24.16+0.54*DBH—0.26*$\theta 7$	0.06	35.36
	T =	-0.24+0.18*DBH	0.57	25.79
	VN =	1.60+9.42*DBH	0.49	89.76
Backcut	$\theta 5$ =	9.15—0.27*DBH+0.06*TML+0.09*$\theta 7$	0.08	70.00
	$\theta 6$ =	14.04—0.05*DBH—0.15*TML+0.19*$\theta 7$	0.16	61.61
	SHU =	9.59+0.2[illegible] DBH+O.O04*TML	0.04	44.17
	LBC =	3.17+0.40*DBH	0.31	28.80
Miscellaneous	DM =	2.80+0.17*DBH	0.18	18.86
	DF =	1.26+0.21*$\theta 8$	0.44	53.73

*See table 1 for variable units (in, ft, etc.)

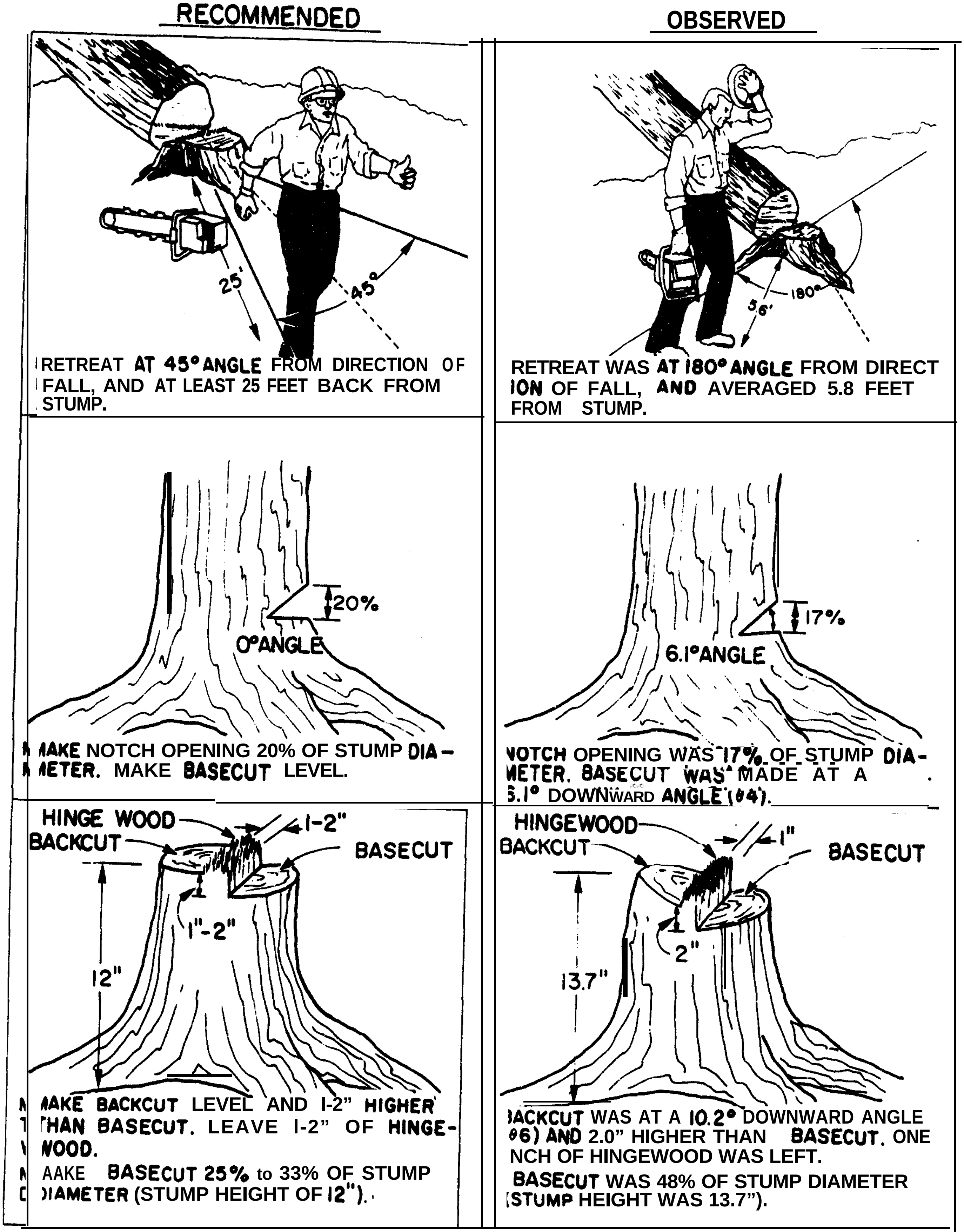

Figure 4.—*Recommended versus observed felling* techniques.

(SAS Institute Inc. 1979). Only variables that met the 0.5 significant level for entry into the model are shown in table 2. Significant differences (Duncan's multiple range test) in cutting surface measurements were caused by different chain saw operators and tree species. However, class or dummy variable codes were not used, because a meaningful and consistent grouping could not be found.

The dbh of the tree was a significant variable in all the equations predicting cutting surface angles and lengths. In the three equations predicting cutting angles between the x-y surfaces ($\theta 2, \theta 4, \theta 6$), the variables dbh and ground slope were significant. in the three equations predicting the cutting angles between the x-z surfaces ($\theta 1, \theta 3, \theta 5$), the variables dbh, ground slope, and merchantable tree length were significant.

CONCLUSIONS

The angles and lengths of the different cutting surfaces made by chain saw operators when felling hardwood trees have been described by means, standard deviations, ranges, and regression equations. The low r-squares in the regression equations indicate that factors other than those measured influenced felling techniques. For example, tree lean, not measured, would certaintly have an influence on felling technique. Time consuming measurements of tree lean would have interfered with the timber cutter. In addition, felling accuracy was not measured.

The major difference between recommended and observed felling methods was that the base of the facecut was made to 48 percent of stump diameter. A facecut between 25 percent to 33 percent is commonly recommended. Another recommendation is that the base of the facecut and the base of the backcut be horizontal. In this study the base of the facecut sloped downward at a 6.1 degree angle and the backcut sloped downward at a 10.2 degree angle.

Other average findings based on the results of this study were:

1. Stump 'height on the uphill side of the tree was 13.7 inches (12.0 inches recommended).
2. One inch of hinge wood was left between the facecut and backcut (one inch to two inches recommended).
3. The base of the backcut was two inches higher than the base of the facecut (one inch to two inches recommended).
4. The notch opening was 17 percent of stump diameter (20 percent recommended).
5. The timber cutter moved 5.6 feet away from the stump as the tree was failing (25 feet recommended).
6. The momentum of the falling tree combined with ground conditions caused the butt of the felled tree to be separated from the stump by a distance of 7.2 feet.

The average values determined in this study for the different cuts used in felling hardwood trees are not given as recommendations. However, these averages do reflect the cutting techniques of experienced timber cutters in this region,

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