

Changes in Logging Injury Rates Associated With Use of Feller-bunchers in West Virginia

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ABSTRACT - The objective of this study was to determine whether West Virginia logging companies experienced a reduction in injuries after beginning to use feller-bunchers during harvesting operations. Data from 1995-2000 were examined. West Virginia was chosen for the study because they have a monopolistic workers compensation system from which records could be obtained and the use of feller-bunchers is relatively new to the state. Eleven companies that had data available both before and after feller-buncher use were used in this analysis. Each company provided the date they began using a feller-buncher during harvesting operations. Data were then requested from the WV Bureau of Employment Programs. Injury rates were calculated before and after the feller-buncher start date in each company and pooled for analysis. There was an average of 2.4 years of pre-feller-buncher data and 2.2 years of post-feller-buncher data for the 11 companies. Logging companies had a significant decline in injury rates after beginning to use a feller-buncher. The pre-feller-buncher injury claims rate was 19.4 per 100 workers and the post-feller-buncher rate was 5.2 per 100 workers. This was a significant difference, with an adjusted rate ratio of 2.8 (95% CI: 1.8 - 4.5) of pre to post claims. 'Struck-by' injury claims also showed a significant decline pre (10.1 per 100 workers) to post (1.9 per 100 workers) feller-buncher use. The rest of the logging industry (non-feller-buncher companies) showed no significant change in injury rates, with a 6-year average of 16.6 claims per 100 workers. These data provide evidence that logging companies experienced a decline in injury claims after starting to use a feller-buncher during harvesting operations.

INTRODUCTION:

With an estimated lifetime fatality risk of 62.7 per 1,000 full-time workers, it is well-documented that logging is one of the most hazardous occupations (Leigh 1987, Marshall et al. 1994, Fosbroke et al. 1997, Myers et al. 1998). However, despite acknowledgment of the dangers of logging, fatality rates remain high (Myers and Fosbroke 1994, Bailer et al. 1998, Sygnatur 1998). In studies that have examined both fatal and nonfatal injuries in loggers, falling trees/snags/branches account for the greatest percentage of injuries, ranging from 34% to 86% of total injuries (Holman et al. 1987, Paulozzi 1987, Salisbury et al. 1991, West et al. 1996, Rodriguez-Acosta and Loomis 1997). Because so many loggers are injured by falling objects, it has been suggested that greater levels of mechanized harvesting could result in lower injury rates (Holman et al. 1987, Myers and Fosbroke 1994, Husberg et al. 1998). Tree fellers have the most dangerous job in the logging industry. Presumably, if machinery is used to harvest trees, the person operating the equipment will be protected by the cab of the machine, thus reducing the number of injuries caused by a falling object.

A feller-buncher is likely to have the strongest impact on injuries because it is used to cut down trees. The Occupational Safety and Health Administration describes a feller-buncher as a mobile machine with an operator enclosure and an articulating extensible arm onto which a

felling head (either a disc saw or chain saw) is attached. The operator moves the machine into position in front of a tree, grapples the tree with the felling head, cuts it from the stump, and then lowers the tree into a horizontal position onto a pile or bunch of trees on the ground, hence the term feller-buncher.

Conversely, it also is possible that using mechanized harvesting equipment could cause an increase in machinery-related accidents. Workers in the agriculture/forestry/fishing industry have been found to have high rates of machinery-related occupational fatalities (Pratt et al. 1996). Machinery-related incidents (such as struck-by moving equipment and rollovers) have been found to account for 14-19% of fatal injuries in certain logging injury studies (Paulozzi 1987, Salisbury et al. 1991, Myers and Fosbroke 1994, Rodriguez-Acosta and Loomis 1997), and less than 10% of nonfatal injuries requiring days away from work (U.S. Department of Labor 2001). Although the percentage of injuries caused by machinery is considerably lower than the percentage of injuries caused by falling objects, machinery-related incidents still represent an important source of injury for loggers. The objective of this study is to determine whether West Virginia logging companies experience a reduction in injuries after beginning to use feller-bunchers during harvesting operations.

METHODS:

Logging companies in the state of West Virginia that own and use feller-bunchers during harvesting were identified by timber-buying companies and non-profit research and extension agencies in the state. Procurement foresters from two major timber-buying companies in the state provided a list of logging companies that they knew of that used feller-bunchers in their operations. Researchers from the Appalachian Hardwood Center at West Virginia University also provided names of companies. The Appalachian Hardwood Center was established in 1987 by the West Virginia Legislature, in part to provide the wood products industry with technical, research, and training support. The West Virginia Forestry Association, a non-profit organization dealing with issues related to forest resources, also provided names of companies. These contacts indicated that use of feller-bunchers was generally recent to the state, so there would not be a large number of companies using them yet.

Workers' compensation injury claims records for the entire logging industry, including the companies with feller-bunchers, were requested from the West Virginia Bureau of Employment Programs, Workers' Compensation Division. West Virginia is one of a few states that has a state-mandated workers' compensation insurance system (Islam et al. 2001). Because most West Virginia logging companies are small and have few employees, they are not required to keep OSHA 200 injury logs. Workers' compensation claims data were the only readily available source of injury data for the logging industry.

Denominator information in the form of employment data were requested from the WV Bureau of Employment Programs, Unemployment Compensation Division. With few exceptions, state law requires companies to report monthly number of employees to the Unemployment Compensation division. Injury claims and employment data were examined from 1995 - 2000.

Of the identified companies that used a feller-buncher, companies not found in the employment data files were excluded. Companies that were based out of state were also excluded. These companies only recently have been required to have West Virginia workers' comp coverage, so no historical data were available for these companies.

In order to calculate injury claims rates for each company before and after starting to use a feller-buncher, it was necessary to know the date each company began using their equipment. Eligible companies were contacted by mail and were asked to send back a form indicating the date (day, month, year) they first began using a feller-buncher during harvesting operations. The mailing process was modeled after the techniques suggested by Dillman (1978) for mail and phone surveys. The letter to the logging companies included an explanation of the goals of the research.

DATA ANALYSIS:

Injury rates were calculated with number of workers' compensation injury claims in the numerator and number of reported employees in the denominator, extrapolated to 100 workers per year. The date provided by each logging company noting when they first starting using a feller-buncher during harvesting operations was used to divide injury and employment data into pre and post timeperiods. Poisson regression, using SAS software (SAS 1993), was used to calculate rate ratios from the before and after time periods, and to assess statistical significance.

Generalized estimating equations (GEE) were used to account for within-company correlation in pre and post rates (Liang and Zeger 1986, SAS 1996). Companies identified as using feller-bunchers were also pulled out and compared to the rest of the WV logging industry in both their pre and post time periods. It was assumed that once the feller-buncher companies were pulled out of the industry as a whole, that the rest of the industry would represent companies not using feller-bunchers.

RESULTS:

Contacts from the two timber buying companies, the Appalachian Hardwood Center at West Virginia University, and the West Virginia Forestry Association provided a total of 28 logging companies. Of these 28, three were based out of state, and had no employment data. Of the 25 left, 20 companies provided information on their feller-buncher start date, one declined to participate, and four did not respond. Two of the four non-respondents were missing from the employment files. Four of the 20 companies that provided a feller-buncher date were missing from the employment files. This left 16 companies that both had useable data to calculate rates with, and provided date of feller-buncher use. Not all of these companies had data available prior to the time they started using a feller-buncher. Either due to missing data, or due to being new, five companies had post-feller-buncher data only. Eleven companies had data pre- and post-feller-buncher use.

On average, each of the 11 companies had 2.4 years of injury and employment data pre-feller-buncher, and 2.2 years post-feller-buncher. The companies began using their machines at varied points in time; two companies started using their machines in 1996, three in 1997, four in 1999, and two in 2000. The average number of employees reported per month prior to feller-buncher use was 5.2, the average number of employees reported per month after feller-buncher use was 6.5. The pre-feller-buncher injury claims rate for the 11 companies was 19.4 per 100 worker years (Table 1). The post-feller-buncher rate for the same companies was 5.2 per 100 worker years. Using Poisson regression there was a significant difference between the pre- and post time periods, with injury rate being 3.8 (95% CI: 1.7 - 8.3) times higher before feller-buncher use than after. After using GEE to account for within-company correlation, the adjusted rate ratio was 2.8 (95% CI: 1.8 - 4.5) between pre and post rates.

Table 1. Changes in injury claims rates before and after feller-buncher use in 11 West Virginia logging companies. Average amount of follow-up time was 2.4 years pre-feller-buncher and 2.2 years post-feller-buncher. Ratio is expressed as pre- rate divided by post- rate.

	Pre-feller-buncher injury rate	Post-feller-buncher injury rate	Unadjusted rate ratio	Adjusted rate ratio ¹	95% CI
Total injury claims	19.4 per 100 workers	5.2 per 100 workers	3.8	2.8	1.8 - 4.5
Struck-by injury claims	10.1 per 100 workers	1.9 per 100 workers	5.3	3.8	1.8 - 8.2

¹ Rate ratio and confidence interval were calculated using GEE-adjusted Poisson regression to adjust for within-company correlation between pre and post measurements

Of all injury types, ‘struck-by’ injuries comprised the greatest proportion of injuries in both the pre (51%) and post (38%) feller-buncher time periods. The rate of ‘struck-by’ injuries also showed a significant decline from the pre to post period (Table 1). The pre rate was 10.1 per 100 workers and the post rate was 1.9 per 100 workers. The pre rate was 5.3 (95% CI: 1.5 - 18.0) times greater than the post rate. After adjusting for within-company correlation, the rate ratio was 3.8 (95% CI: 1.8 - 8.2). Although the workers’ compensation database captures fatal injuries, there were no fatalities recorded for any of the fellerbuncher companies during the time period of this study.

Feller-buncher companies were removed from the injury and employment datasets for the entire WV logging industry. An average overall non-feller-buncher rate was then calculated from the 1995-2000 data. The injury claims rate for non-feller-buncher companies was 16.6 claims per 100 workers. The pre and post-feller-buncher time periods for the 11 companies were compared against this industry average. There was no significant difference between the pre-feller-buncher rate of feller-buncher companies and the average non-feller-buncher company claim rate (Table 2). The average non-feller-buncher company claim rate for 1995-2000 was significantly greater than the post-feller-buncher injury claims rate of feller-buncher companies. Non-feller-buncher companies reported an average of 3 employees per year, based on 1995-2000 data.

The injury claims trend for the entire WV logging industry (with feller-buncher companies removed) was calculated for 1995-2000. Yearly injury rates are shown in Figure 1. Poisson regression revealed a significant increase in the injury claims rate over this time period (slope estimate = 0.0338, P = 0.0325).

DISCUSSION:

The results of this study provide empirical evidence that companies using a feller-buncher during harvesting operations experience a decline in workers’ compensation injury claims. Three lines of evidence were used to reach this conclusion. First, a pre and post analysis was done which showed a significant decline in injury rates after feller-buncher start date. These companies began using their feller-bunchers at different points in time, thus staggering the pre-post data across a range of time periods. Second these companies were compared to the rest of the West Virginia logging industry; their rates were found to be similar to the industry average before they started using a feller-buncher, but significantly lower than the industry average after

they started using a feller-buncher. Third, there was no general decline in injury claims rates in the WV logging industry as a whole from 1995-2000, rather there was a slight increase in injuries over this time period.

Table 2. Comparison of the pre and post-feller-buncher injury claims rates of companies with feller-bunchers to the rest of the West Virginia logging industry's (non-feller-buncher companies) average rate based on 1995-2000 data. Ratio is expressed as the rest of the industry rate divided by feller-buncher company rate.

	Feller-buncher companies	WV logging industry	Rate ratio	95% CI
Pre-feller-buncher time period	19.4 per 100 workers	16.6 per 100 workers	0.9	0.6 - 1.3
Post-feller-buncher time period	5.2 per 100 workers		3.2	1.6 - 6.4

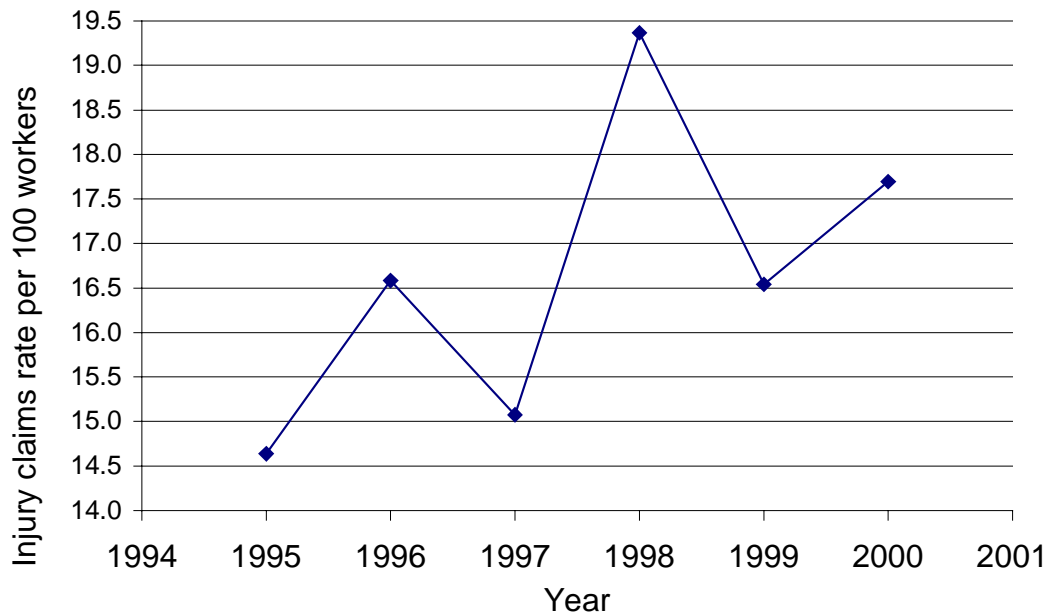


Figure 1. Injury claims rate for the rest of the West Virginia logging industry (non-fellerbuncher users)

Additionally, companies that started using a feller-buncher reported an increase in the number of employees. One might expect that increased mechanization might lead to a reduction in the number of employees, but this did not appear to be the case.

In their analysis of logging-related fatalities, Myers and Fosbroke (1994), found higher rates in the eastern portion of the United States, including West Virginia, and suggested this may be due in part to forest type (primarily hardwood tree species) and low levels of mechanization in harvesting. Other papers describing logging injuries have hypothesized that increased mechanization should reduce numbers of injuries (International Labour Organisation 1981, Holman et al. 1987, Nordansjo 1988, Axelsson and Ponten 1990, Husberg et al. 1998, Slappendel et al. 1993), but did not address the issue quantitatively.

Two studies have looked quantitatively at the relationship between mechanization and injuries in the logging industry (Laflamme and Cloutier 1988, Shaffer and Milburn 1999). Both of these studies took the approach of comparing conventional or partially mechanized logging operations to fully mechanized logging operations during the same time period. Laflamme and Cloutier (1988) examined the relationship between the mechanization of delimiting and debranching activities in two logging companies. They found sites logged with conventional logging methods to have almost three times the injury rate as sites logged with mechanized methods, however they do not specifically mention mode of felling or feller-bunchers. They also found that injuries in mechanized sites were more likely to occur to skidder operators, and during maintenance and repair activities, and that in conventionally logged sites, injuries were more likely to occur to fellers.

Shaffer and Milburn (1999) compared workers compensation injury claims between partially mechanized and fully mechanized logging operations. They found that fully mechanized operations had a lower proportion of injuries due to manual chainsaw delimiting, and a higher proportion of injuries due to equipment maintenance and repair. There was no statistical difference in the proportion of the manual chain saw felling injuries between the two types of logging operations. Similar to the current study, they found that the proportion of 'struck by' injuries was lower in more mechanized operations, but that 'struck by' injuries were still the most predominant injury type. However without denominator data, it cannot be determined whether injury rates were lower in fully mechanized companies.

Although several lines of reasoning were used to reach the conclusions in the current study, this study is not without its limitations. These include the fact that this is based on a convenience sample; every company in the state was not contacted and asked about feller-buncher use. However, to get the list of companies with feller-bunchers, entities that are dispersed geographically throughout the state, and that work closely with the WV logging community were contacted.

Because the use of feller-bunchers is still relatively uncommon in the state of WV, these results are based on a small number of companies. More solid results could be obtained by continuing to add new companies to the analysis, as feller-buncher use becomes more widespread in the state of West Virginia. Similar data from other states could also be added and analyzed.

The study does not include data on other potential confounding factors such as changes in other pieces of equipment (cable vs. grapple skidders for example) or training programs. However, West Virginia's Certified Logger Program was initiated in 1992, before the 1995 start date of this study. All logging operations are required to have one Certified Logger on site for at least part of the day, thus presumably affecting all companies equally. In the state of West Virginia, a newer safety training program was initiated in July of 1999. In the future as data become available, the potential confounding effect of the new training program and feller-buncher use will be assessed. The injury rates described in this study are subject to the biases associated with the use of any workers' compensation injury data. For example, if companies

underreport number of employees, but report whatever injuries may occur in their actual workforce, then this may make rates appear higher. However, there is no evidence to suggest that these biases would have changed over the time period of this study. Most logging companies, particularly in the east, are relatively small, and are not required to keep OSHA 200 injury logs. Because of a lack of structured injury records, it is difficult to track non-fatal injuries in this industry. Despite the limitations of workers' compensation claims data, they are the only data source through which injuries in this population can be monitored.

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LITERATURE CITED

- Axelsson, S-A, and B. Ponten 1990. New ergonomic problems in mechanized logging operations. *Int. J. Ind. Ergonomics* 5:267-273.
- Bailer, A.J., L.T. Stayner, N.A. Stout, L.D. Reed, and S.J. Gilbert. 1998. Trends in rates of occupational fatal injuries in the United States (1983-92). *Occup. Environ. Med.* 55:485-489.
- Dillman, D. 1978. *Mail and telephone surveys: the total design method*. New York, Wiley.
- Fosbroke, D.E., S.M. Kisner, and J.R. Myers. 1997. Working lifetime risk of occupational fatal injury. *Am. J. Ind. Med.* 31:459-467.
- Holman, R.G., A. Olszewski, and R.V. Maier. 1987. The epidemiology of logging injuries in the northwest. *J. Trauma.* 27:1044-50.
- Husberg, B.J., G.A. Conway, M.A. Moore, and M.S. Johnson. 1998. Surveillance for nonfatal work-related injuries in Alaska, 1991-1995. *Am. J. Ind. Med.* 34:493-498.
- International Labour Organization. 1981. *Occupational safety and health problems in the timber industry. Third Tripartite Technical Meeting for the Timber Industry*. International Labour Office, Geneva, Switzerland.
- Islam, S.S., A.M. Velilla, E.J. Doyle, and A.M. Ducatman. 2001. Gender differences in work-related injury/illness: analysis of workers compensation claims. *Am. J. Ind. Med.* 39:84-91.
- Laflamme, L., and E. Cloutier 1988. Mechanization and risk of occupational accidents in the logging industry. *J. Occup. Accidents* 10: 191-198.
- Leigh, J.P. 1987. Estimates of the probability of job-related deaths in 347 occupations. *J. Occup. Med.* 29: 510-519

- Liang, K.Y., S.L. Zeger. 1986. Longitudinal data analysis using generalized linear models. *Biometrika* 73:13-22.
- Marshall, S.W., I. Kawachi, P.C. Cryer, D. Wright, C. Slappendel, and I. Laird. 1994. The epidemiology of forestry work-related injuries in New Zealand, 1975-88: fatalities and hospitalisations. *N. Z. Med. J.* 107:434-7
- Myers, J.R., and D.E. Fosbroke. 1994. Logging Fatalities in the United States by region, cause of death, and other factors B 1980 through 1988. *J. Safety Res.* 25:97-105.
- Myers, J.R., S.M. Kisner, and D.E. Fosbroke. 1998. Lifetime risk of fatal occupational injuries within industries, by occupation, gender, and race. *Human Ecol.Risk Assess.* 4:1291-1307.
- National Occupational Research Agenda. 1996. US Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.
- Nordansjo, I. 1988. Training and working conditions in Swedish forestry (Skogsarbeten Results No. 1). Stockholm: Logging Research Foundation.
- Paulozzi, L.J.. Fatal logging injuries in Washington State, 1977 to 1983. *J.Occup.Med.* 29:103-108.
- Pratt S.G., S.M. Kisner, and J.C. Helmkamp. 1996. Machinery-related occupational fatalities in the United States, 1980 to 1989. *J.Occup. Environ. Med.* 38:70-76.
- Rodriguez-Acosta, R.L., and D.P. Loomis. 1997. Fatal occupational injuries in the forestry and logging industry in North Carolina, 1977-91. *Int. J. Occup. Environ. Health.* 3:259-265.
- Salisbury, D.A., R. Brubaker, C. Hertzman, and G.R. Loeb. 1991. Fatalities among British Columbia fallers and buckers 1981-7. *Can. J. Pub.Health* 82:32-37.
- SAS Institute Inc. 1993. SAS Technical Report P-243, SAS/STAT Software: the GENMOD Procedure, Release 6.09, Cary, NC: SAS Institute Inc..
- SAS Institute Inc. 1996. SAS/STAT software: changes and enhancements for release 6.12. Cary, NC: SAS Institute, Inc.
- Slappendel, C., I. Laird, I. Kawachi, S. Marshall, and C. Cryer. 1993. Factors affecting work-related injury among forestry workers: a review. *J. Safety Res.* 24:19-32.
- Shaffer, R.M., and J.S. Milburn. 1999. Injuries on feller-buncher / grapple skidder logging operations in the southeastern United States. *Forest Prod. J.* 49:24-26.
- Sygnatur, E.F. 1998. Logging is perilous work. *Compensation and Working Conditions* Winter 3-9.
- U.S. Department of Labor. 2001. Occupational injuries and illnesses in the United States: Profiles data 1992-1999 (CD-ROM Version 7.6, National Data). Washington, DC: Bureau of Labor Statistics.

West, R., M.J. Shkrum, and J.G. Young. 1996. Commercial logging fatalities in Ontario, 1986-1991. *Am. J. Forensic Med. Pathol.* 174:299-304.