The Human Factors of Implementing Shift Work in Logging Operations

D. L. Mitchell, T. V. Gallagher, R. E. Thomas

ABSTRACT. *A fairly recent development in the forest industry is the use of shift work in logging in the southeastern U.S. Logging company owners are implementing shift work as an opportunity to increase production and potentially reduce the cost of producing each unit of wood, without consideration of the potential impacts on the logging crew. There are many documented physiological and psychological impacts on workers from shift work in a variety of industries, although few address forestry workers in the U.S. Semi-structured interviews were performed to gather information about how logging company owners were implementing shift work in seven southeastern states. Data collected during the interviews included employee turnover, shift hours, shift scheduling, safety considerations, and production impacts. Various work schedules were employed. The majority of the schedules encompassed less than 24 hours per day. Permanent and rotating shift schedules were found. None of the logging company owners used more than two crews in a 24-hour period. Additional safety precautions were implemented as a result of working after dark. No in-woods worker accidents or injuries were reported by any of those interviewed. Results indicate that a variety of work schedules can be successfully implemented in the southeastern logging industry.*

Keywords. *Forestry workers, Harvesting, Human factors, Logging, Shift work.*

We live in a 24-hour society in the U.S. We expect grocery stores, motels, police stations, and other service providers to be open continuously. In some cases, these 24-hour providers sprouted as a result of other industries switching to 24-hour work. An example in the forest industry is pulp mill hours. Many pulp mills use continuous-feed digesters, which require raw material and chemicals to be continuously fed into the digesters. As a result, employees are needed 24 hours per day to oversee and monitor the pulp manufacturing process.

A fairly recent development in the forest industry is the need for logging company owners to extend their hours beyond the traditional daytime work hours. The driving forces for the extended working hours appear to be from two sources: the mills and the logging company owners. The mills are interested in having logging companies work extended shifts because they assume that extended work hours will reduce their costs for raw materials by encouraging the logging company owners to use their labor and equipment more efficiently. Some mill representatives intend to share in the reduced logging costs by paying the logging company owner less than traditional rates for their deliveries.

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The authors are **Dana L. Mitchell, ASABE Member,** PhD, Research Engineer, USDA Forest Service, Southern Research Station, Auburn, Alabama; **Tom V. Gallagher,** PhD, Assistant Professor, School of Forestry and Wildlife Sciences, Auburn University, Auburn, Alabama; and **Robert E. Thomas,** PhD, Professor, Department of Industrial and Systems Engineering, Auburn University, Auburn, Alabama. **Corresponding author:** Dana L. Mitchell, USFS Southern Research Station, 520 Devall Dr., Auburn, AL 36849-5418; phone: 334-826-8700, ext 23; fax 334-821-0037; e-mail: danamitchell@fs.fed.us.

Logging company owners are interested in extended work shifts because of the high capital investments in their logging equipment. Logging equipment has a fixed cost. The owner has to pay financed equipment payments whether the machines are working or not. The manufacturer's suggested retail price of a new 215 hp, rubber-tired grapple skidder ranges from $185,000 to over $200,000 (USD) depending on the options included. Most logging companies include several additional pieces of expensive heavy equipment, such as feller-bunchers and loaders. If logging costs are based on the unit cost of producing each ton of wood, then additional production lowers the per unit fixed costs of this equipment, thus reducing the cost of producing each ton of wood and, hopefully, making logging companies more profitable.

The decision to implement shift work is often based on economics, but what is the impact of shift work on the employees? This article attempts to address this issue by:

- Providing a basic understanding of the physiological and psychological impacts of shift work on workers.
- Reviewing shift work implementation schedules used in the southeastern U.S.
- Providing recommendations for implementing shift work in the logging industry.

Literature Review

Terminology is important when communicating between loggers, industry, and researchers. Generally, shift work hours are defined as those hours outside the normal daylight hours of 7:00 a.m. to 6:00 p.m. (0700 to 1800) (Rosa and Colligan, 1997). Some people in the logging industry use the term "double-shifting," but it does not provide any meaning as to hours of work for the two shifts, or whether the two shifts encompass a 24-hour period or less. "Extended hours" may mean that longer days are worked, but no additional shifts are implied. For this article, the term "shift work" will include hours outside of typical daylight hours (0700 to 1800) and signify that more than one shift is used in a scheduling period. The term "late shift" will signify a shift that begins in the afternoon or evening.

There is no single perfect work schedule for shift operations, and in logging, shift scheduling is often done through a trial-and-error approach. A myriad of work shifts are available, and many are fine-tuned to the specific jobs to be accomplished. The merit of any specific work system is relative and can depend on many factors, including worker productivity, safety, and health (Popkin et al., 2006). Worker physiological and psychological considerations are also operative.

Physiology

Typically, humans are in a state of wakefulness during the daytime hours and resting or sleeping during the night hours. This behavior is regulated by the body's circadian rhythms (Costa, 1996). A circadian rhythm is the natural body rhythm that provides an oscillating pattern of bodily functions that occur over a period of 24 to 25 hours.

Some of the body functions regulated by circadian rhythms are body temperature, blood pressure, and hormone excretions. As such, circadian rhythms control when workers are sleepy or alert. Further, there are physical and societal time cues that aid in resetting the daily circadian rhythm to a 24-hour schedule. Some examples are mealtime, external thermal conditions, and sunlight. Some work schedules can disrupt these circadian cues.

A typical circadian rhythm includes one major low and one high point each day. The low point occurs between 0300 and 0500 when oral temperatures are at their lowest, and the high occurs between 1500 and 2000. These fluctuations are often referred to as a

normal "active–rest" cycle (Costa, 1996) where the low point is considered rest time and the high point is the active time. When scheduling work during the very early morning hours (circadian low), factors to be considered may include job workload, safety criticality, environment, and staffing levels (Popkin et al., 2006).

When the sleep cycle is adjusted to an earlier time of day than the normal night sleep times, it is referred to as an advanced circadian rhythm phase shift. An example of an advanced phase shift would be when workers sleep just prior to their night shift. An example of a phase delay is when sleep is postponed from the normal night/darkness sleep time to a time in the morning.

Some workers tolerate phase shifts better than others. For example, people commonly referred to as "night owls" normally go to bed later than others, so they delay their sleep. Adjustment to night work may not be as difficult for these people as for others (Burgess et al., 2002). Long–term effects of phase shifts are difficult to assess from a research standpoint because those workers who do not tolerate shift work typically quit their jobs, leaving only those individuals who are able to adapt in the available research study groups.

Health Disorders

Shift work can be associated with specific pathological disorders (Knutsson, 2003), such as gastrointestinal disorders and peptic ulcer disease. Shift workers are also at higher risk for cardiovascular disease as compared to day workers. Shift work does not appear to have an adverse effect on longevity (mortality) or on risk of cancer.

Logging machine operators work in a seated position inside the machine's cab. The lack of physical exercise can create additional health disorders, such as weakened immune systems, sore neck muscles from bracing, and risks associated with increasing blood sugar levels (Berger, 2003).

Sleep Schedules

The rate of sleep complaints is higher in shift workers than in the general population (Ohayon et al., 2002). The main sleep period for shift workers can be from 1 to 4 hours shorter than typical night sleep schedules. There are factors other than circadian rhythms that can cause deterioration of sleep quality: fatigue, stress, daylight, health, and age. Problems from working rotating shifts can arise with the length of time it takes to fall asleep, inability to wake up at the time wanted, and disrupted sleep (nocturnal awakenings).

Santhi et al. (2005) analyzed the role of scheduled sleep in adjusting the human circadian system to shift work. One group of subjects was scheduled to sleep periods that are typical of what night workers do. This sleep schedule began one hour after the night shift and lasted for eight hours. These workers were then awake for seven hours prior to the night shift (also known as "extended prior waking"). This typical sleep schedule was compared to one in which subjects sleep for an 8–hour period that ends one hour prior to their scheduled night shift. The circadian rhythm adjusted more on the pre–work sleep schedule as compared to the post–work sleep schedule. However, the adjustment was modest and work performance could still be compromised by circadian misalignment.

Psychology

Psychological influences of shift work are often studied by use of self–assessment questionnaires. These questionnaires frequently include questions to determine assessment of negative emotionality, mood, sleep, and general state of health (Tamagawa et al., 2007). These types of studies typically find that rotating shift schedules and permanent night shifts often result in negative influences on job satisfaction,

psychological well-being, self-esteem, and job stress. Koo and Kim (2006) measured job stress and psychosocial well-being of police officers in Korea. They found that shift (night) work was a factor negatively affecting the mental and psychological health of the workers.

Tamagawa et al. (2007) was able to distinguish traits that made some New Zealand police officers less tolerable of night shifts and others intolerant to rotating shifts. This study reported that police officers who possess a repressive emotional style and negative mood showed intolerance to night shift work that was exhibited in physical health and sleep problems. Tolerance to rotating shifts was impacted more by mood states rather than personality traits (emotional style).

Safety

Typically, the most experienced, highest seniority employees are assigned to the day shift (Penkala, 1994). Staffing levels at night are often less than during the day shift, so some night workers may take more chances and perform jobs for which they are unqualified in order to maintain night production. It is often difficult for night workers to participate in regular safety meetings, which may increase their accident risk.

In a study of 3,470 accidents in the textile industry, Nag and Patel (1998) found a difference in the timing of accidents between morning and night shift workers. About 60% of the morning shift (0700 to 1530) accidents occurred in the first half of the shift, and accidents were evenly spread across the hours of the late shift (1530 to 2400). On the night shift, 57% of the accidents occurred during the second half of the shift and were more severe than on the other shifts. Accumulated fatigue and circadian effects may be the reason for the timing of the majority of the night shift accidents (Nag and Patel, 1998; Levin et al., 1985).

Another type of accident risk posed by sleepiness from shift work is driving to and from work. Many studies report that sleepiness reduces vigilance while driving and increases the risk of a motor vehicle collision (MacLean et al., 2003; George, 2003; Philip and Akerstedt, 2006). Some of the most common changes in driving performance related to sleepiness are increased variability of speed and lateral lane position.

Performance

In an assessment of work load (Gellerstedt et al., 2005), researchers found that the addition of work tasks can increase the variety of work and decrease the repetitiveness and monotony of mechanized forest harvesting work. Researchers used a system of work load points in which consecutive hours of work on a specific task increased work load points through a work period. The addition of other tasks could add or subtract work load points. More points mean more effort and fatigue. The result of the added task assignments and consequent spacing of the tasks in a work shift was a reduction in work load points for forest workers and an improvement in operator performance and productivity.

Multiple tasks can reduce the monotony and prove to be more stimulating for shift workers (Persson et al., 2001; Gillberg et al., 2003). In a plant environment, passive tasks, such as watching a monitor for changes, can be monotonous for workers, resulting in less job satisfaction (Persson et al., 2001). If the assigned tasks are active and require some sort of planning, control, or problem solving, then operators will feel as if they have more control over their workload. These active operators will experience a higher level of job satisfaction and increased control over the work process, as well as physiological differences such as higher body temperatures and adrenaline hormone excretion.

Shift work implementation can have psychological and physiological impacts on workers. Shift length and rotation speed can cause physiological impacts in workers.

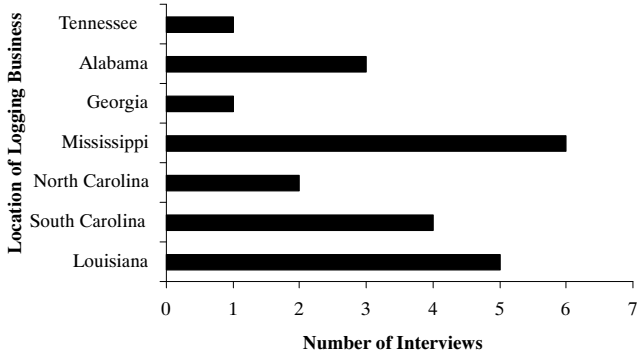

Figure 1. Number of interviews by state.

Psychological impacts can include influences on job satisfaction, psychological well-being, and even result in home conflicts. Understanding shift work scheduling and its impacts on workers should be a priority for a logging company owner that is considering implementing shift work.

Study Methodology

In a study partially funded by the Wood Supply Research Institute (WSRI), semi-structured interviews were performed to gather information about how logging company owners were implementing shift work in seven southeastern states. The interview process began in the spring of 2006. Twenty-two interviews across seven southeastern states were completed with logging company owners who have made efforts to implement shift work (fig. 1). Selection of interviewees was not random. Logging company owners were selected for interviewing because they had tried or were currently using shift work. Logging company owners to be interviewed were found by referring to trade journal articles, contacting state forestry and forest industry representatives, and through discussions with loggers and others at regional forestry-related meetings. Data collected during the interviews included employee turnover, shift hours, shift scheduling, safety considerations, and production of each shift. All of the owners operated their company's in fairly flat terrain, consisting mostly of various types of southern pine trees, and with ground-based harvesting systems.

Results

Some of the logging company owners interviewed have successfully implemented shift work, while others have tried implementation and abandoned their efforts. A few are considering trying shift work a second time, but are currently operating traditional work schedules. On average, the interviewees had 19 years of logging experience (fig. 2).

Shift Rotation

Of the 22 logging company owners interviewed, ten are no longer using shift work. Twelve are currently using some type of shift work. None of the logging company owners surveyed used more than two shifts per day. A summary of the work schedules used is shown in table 1. One logger uses one long shift per day (schedule A), but the workers

Figure 2. Years of logging experience of logging business owners interviewed.

rotate so that they have seven days on followed by seven days off. The remaining 21 interviewees used two shifts per day. Sixteen logging company owners used schedule B. The remaining schedules shown in table 1 were each used by one or two logging company owners.

Shift Hours

Various schedules of shift hours have been used by logging company owners. Five tried working two 12-hour shifts in a 24-hour period. Three of those subsequently quit using shift work. One of the two logging company owners currently using two 12-hour shifts per day rotates shifts every two weeks (schedule C, table 1). The remaining logging company owner uses a permanent shift schedule (schedule B, table 1) for 12-hour shifts.

Seventeen logging company owners used some version of shift hours that did not have workers on site for 24 hours each day. Fourteen of these have the first shift (day shift)

Table 1. Work schedules.

Schedule	Work Day Pattern[a]
A: 12-hour work days with weekly rotation (*n* = 1)	
Shift 1	DDDDDDD ooooooo
Shift 2	ooooooo DDDDDDD
B: Permanent shifts with weekends off (*n* = 16)	
Shift 1	DDDDD oo DDDDD oo
Shift 2	NNNNN oo NNNNN oo
C: Bi-weekly rotation with weekends off (*n* = 1)	
Shift 1	DDDDD oo DDDDD oo NNNN ooo NNNN ooo
Shift 2	NNNN ooo NNNN ooo DDDDD oo DDDDD oo
D: Permanent shifts with weekends off (*n* = 2)	
Shift 1	DDDDD oo DDDDD oo
Shift 2	NNNN ooo NNNN ooo
E: Rotating weeks with weekends off (*n* = 1)	
Shift 1	DDDDD oo NNNNN oo
Shift 2	NNNNN oo DDDDD oo
F: Rotating daily for extra second shift (*n* = 1)	
Shift 1	DDDDDD o DDDDDD o
Shift 2	NNNNN oo NNNNN oo

[a] D = day shift, N = night shift, and o = day off.

Table 2. Ending clock hours for schedules using two shifts and less than 24 working hours per day.

	Current Status	
Ending Clock Hour	Quit Shift Work	Currently Implementing Shift Work
≤2300	1	4
2400	1	1
0100	2	3
0200	3	0
0300	0	1
Total	7	9

starting between 0600 and 0700 and ending 8 to 10 hours later. One starts at 0600 and ends 12 hours later without a second shift (schedule A, table 1). Two others begin the first shift before 0600. Sixteen started the late shift between 1400 and 1700 and ended it between 2100 and 0200. Nine owners provided a daily overlap period of 15 minutes or more for performing equipment maintenance between shifts. Ending clock hours varied and are shown in table 2. Of the nine logging company owners currently using shifts of less than 12 hours, five end the night shift at or before midnight, three end their shift by 0100, and one ends the night shift at 0300. Of the seven logging company owners that quit implementing shift work, only two ended the night shift at or before midnight. The remaining five that returned to traditional working hours ended their night shift between 2400 (midnight) and 0200.

Generally, the day shift lengths were longer than the night shift lengths. The day shift length ranged from 8 to 12 hours, including meal and rest breaks. The average day shift length was 10.4 hours. The night shift lengths ranged from 7.5 to 12 hours with an average length of 9.5 hours.

Only three logging company owners mentioned that employee turnover was a problem. All three of these have quit shift work on their logging operations. Some of the other interviewees mentioned that turnover was a problem when they first implemented shift work, but that once they had the correct mix of operators on the night shift, the turnover problems subsided. Two logging company owners used fairly complicated equipment in their businesses that required highly trained employees. One of these quit using shift work because he could not find a night operator that was skilled in using and repairing the specialized equipment. Most of the logging company owners reported that finding truck drivers for night hauling was their biggest issue.

Safety

Some safety-related changes were made when implementing shift work on logging operations. Some logging company owners purchased new equipment with the manufacturer's additional lighting package. Others added extra lights to existing equipment. Most felt that the extra manufacturers lighting package was needed for employees to accomplish their tasks after dark. One logging company's crew used a generator with a light pole at the ramp. Others purchased headlamps to fit on hardhats and required crew members to wear high-visibility vests. Several instituted new policies to protect workers when they exited their machine cabs at night. Some required all other moving equipment to be stilled while an operator was out of a machine's cab. Others purchased two-way radios and required machine operators to contact other crew members before exiting their machine after dark.

None of the logging business owners had experienced any employee accidents or injuries on the late shift. However, two owners reported vehicular accidents that occurred after dusk. One crew was moving a large piece of equipment on a public road at night.

The machine was being towed and a car ran into the back of it. The machine did not have tail lights. The other accident also involved moving a piece of equipment at night. The machine was being hauled on a trailer and, due to total height, tore down some power lines that were hanging low over the road. Neither of these accidents would have happened during the day, as towed equipment and low-hanging power lines would have been visible during daylight hours.

Production

While six of the ten logging company owners who quit using shift work were unhappy with the production from the late shift crew, the remaining owners implementing shift work found that increased production was within their acceptable limits. Many of the logging company owners stated that skidding at night is slower. At night, lights from the light generators on the logging decks may not extend as far as the furthest skid distance, which slows the night skidding operation. Skidder drivers often gear down the machines at night so that they do not "outrun their headlights," which further contributes to lower production at night.

Few of the interviewees scheduled felling timber at night. Many cited inability to see through the underbrush as a deterrent to felling at night. Others indicated that machine operators working in planted pine thinnings could not keep the removal rows straight when felling after dark. One owner indicated that glare from the machine's lighting caused problems with the equipment operator's depth perception. Only two owners continue to schedule felling timber after dark.

Discussion

The first thing learned during the interviews was that logging company owners are very inventive when it comes to determining the length of a shift, how many shifts are in a 24-hour period, shift rotations, and what work is performed during each shift.

Logging operations vary widely. Some operations use cut-to-length equipment, while others use traditional ground-based feller-bunchers and skidders. Some operate on flat terrain, while others work in steeper areas. The type of cut (harvest cut, first thinning, or second thinning) and products to be removed also vary. In response to these and numerous other variables, a variety of working schedules is used.

Shift Rotation

Shift rotation speed refers to the speed with which a worker rotates among shifts. If a worker rotates in some manner through the various shifts in about a week, the rotation is considered a fast rotation. Rotating shifts, such as that seen in schedule E (table 1), are considered a fast, but acceptable, rotation speed in the U.S. (Popkin et al., 2006). In Europe, a fast rotation schedule is one in which a worker rotates through three shifts in one week. Schedule E may allow time for circadian rhythms to partially adjust.

Many workers working a shift rotation or permanent night shift with weekends off will often revert to daytime schedules on weekends. Any night shift circadian adjustment made during the week is offset during the weekend. Those logging company owners offering permanent night schedules could maintain circadian adjustments if employees did not revert to daytime hours on weekends. However, this may be unrealistic, given social demands.

Employees working 12-hour shifts under schedules A and C may experience long recovery times (table 1). Research has found that sleepiness is often at its peak during the first day of recovery, not the last day of the working week (Akerstedt et al., 2000). Shift workers working in 12-hour shifts in 2 to 3 day sequences reported that recovery was

complete on the first day off. However, for people working long shifts in long sequences, more recovery time, up to 3 days, was needed to feel alert and fresh. Schedule C appears to offer enough days off after four consecutive 12-hour night shifts for recovery (table 1). Workers should be informed about the different sleep schedules, such as sleeping just prior to their shift, so they may better adjust to the late shift.

Some of the logging company owners interviewed were using fixed shifts, and others were using rotating shifts. Research shows that workers with rotating shifts (including weekends) will experience more job dissatisfaction than even those with fixed non-day schedules (Demerouti et al., 2004). Those on fixed schedules report higher job satisfaction, higher professional efficacy, lower cynicism, and lower turnover rates than those on rotating shifts. However, non-day fixed schedule (including weekends) workers may exhibit a high level of home conflict.

One logging company owner found that to compete for labor in a market with a powerful regional oil industry, he had to provide a similar work schedule with long work hours for several days in a row followed by several days off (schedule A, table 1). He offered the advantage of mini-vacations, as offered by the oil industry, coupled with the additional advantage of workers being able to return home at the end of each daily shift. The owner has only been implementing this schedule for a short time, so the impacts on the employees have not yet been fully realized. This type of work schedule can have complications (Rosa and Colligan, 1997). People who work long shift hours, such as 12-hours per day, only have 12 hours left in each day to sleep, commute to and from work, eat, and perform other household and family responsibilities. People working a traditional 8-hour day have 16 hours to accomplish these daily tasks. To accomplish all of the daily household needs in a reduced timeframe, a worker may reduce sleeping hours. Over the length of the shift rotation, this sleep loss can accumulate to the point where the worker may feel overly tired during the last few days of the work schedule. For these reasons, the longer rotation can cause extra stress and fatigue and possibly a higher risk of injury or accidents near the end of the work schedule.

One logging company owner operating with permanent day and night shifts offered some flexibility for their employees to alleviate some of the complications that can arise with permanent night shifts. Workers were able to switch hours with workers on the opposite shift so that they could participate in social and family events and take care of personal business when companies are open. A disadvantage of this flexibility is that sleep cycles can be disrupted and cause workers to feel overly tired.

Workers with permanent night shifts, such as schedules B and D (table 1) may experience more work-home conflicts (WHC) than workers assigned to permanent day shifts. Demerouti et al. (2004) examined the social and psychological impacts of four shift schedules (fixed-day work, fixed non-day work including weekends, rotating without weekends, and rotating including weekends). For the Dutch military police, he found that day-only workers had a lower level of WHC than those from other shifts. Workers with fixed non-day shifts including weekends experienced the highest level of WHC, followed by those with rotating shifts with and without weekends included. Rotating shift workers whose shifts included weekends reported the lowest job satisfaction rates.

Shift Hours

Shift lengths in use by logging company owners were not always equal, with the night shift frequently being shorter due to mill delivery hours for products other than pulpwood. Many of the operations use an overlap period for communication between the crews and for machine maintenance. Owners reported that having both operators perform

the maintenance on each piece of equipment together during the overlap period provided a higher level of maintenance than when the work was performed by only one worker.

Logging operations that changed from traditional day-only, single-shift logging to multiple-shift logging frequently had the most senior employees working the day shift and newer employees working the night shift. Penkala (1994) also found that workers with the most seniority were often assigned to day shifts. However, discussions with logging company owners suggested that the reason for the more experienced workers on the day shift was due to personal preference of the workers themselves when the crew changed from single-shift operation to more than one shift per 24-hour period. One logger proved the opposite in terms of which shift his best operators worked. This logger put his best men on night shift so they could make good decisions on their own and keep production at acceptable levels.

In implementing work shifts in the southeastern U.S., some of the same social factors may come into consideration, as they did in a study of mining accidents (Monk and Wagner, 1989). Church and church-related activities are important social functions on Sundays in the southeastern region of the U.S. Logging company owners should seriously consider whether Sunday should be scheduled as a work day due to the impacts on social lives and potentially higher accident rates. Two of the logging company owners scheduled work on Sundays.

While a logging operation works together on one tract, individual workers on a logging crew typically work alone. The feller-buncher operator fells trees ahead of the skidder operation, so interaction between operators is typically limited, but they are aware of each other's location. Because the workers are each in an enclosed equipment cab, interactions are further limited. With this limited interaction between co-workers, night workers may feel even more isolated due to the absence of sunlight. As Furnham and Hughes (1999) suggest, perhaps workers with an internal locus of control would fare better during the night shift than a worker with an external locus of control. Many of the logging company owners interviewed reported that some of their workers prefer the night shift because there were fewer people on the job site at night, as contract administrators, foresters, and others work daytime hours. When fewer workers are on site, operators experience lower mental stress levels because man and machine interferences are lessened (Kirk, 1998).

Fatigue can be of concern when working longer shifts. Studies have reported the potential for increased fatigue associated with long periods of mentally demanding and repetitive, but sedentary, machine operation work (Cummins, 1998; Sullman and Kirk, 1998). Breaks are recommended to stimulate the mind and reduce the cumulative effect of mental fatigue. Breaks can also help reduce some of the illnesses associated with the lack of physical exercise in sedentary work. By getting off the machine during breaks, operators benefit by introducing movement back into muscle groups. Kirk (1998) recommends that the working day be broken up every 3 to 4 hours for rest, meal, or maintenance breaks. He also recommends a 5-minute break for every hour of machine operation to allow operators to get off their machines. Since each machine operator in this study operated the same machine for the duration of the shift, logging company owners should consider how breaks are incorporated into workers' schedules.

The majority (86%) of the work schedules discovered during the interviews required the day shift to begin work at or before 0630. One schedule started work at 0500. Nicholls et al. (2004) found that logging machine operators who rose early exhibited their circadian low with slower reaction times in mid-morning. Workers had slower responses and were less predictable in the mid-morning. This was identified as a safety concern because this time of day is consistent with accident statistics in New Zealand. Although the potential for increased worker fatigue and compromised safety may exist, none of the

logging business owners experienced increased accidents after converting to a shift work schedule. Several mentioned that they had never had an accident or injury on the late shift. They proposed that the limited number of people on the site during the late shift hours and the operational restriction of only using machines during this shift were responsible for the increased safety. However, the early start times for the daytime crew could be a safety concern.

Safety

Some safety-related changes were made when implementing shift work on logging operations. Some logging company owners purchased new equipment with the manufacturer's additional lighting package. Others added extra lights to existing equipment. Most felt that the additional lighting package was needed for employees to accomplish their tasks after dark. One logging company's crew used a generator with a light pole at the ramp. Others purchased headlamps to fit on hardhats and required crew members to wear high-visibility vests. Several instituted new policies to protect workers when they exited their machine cabs at night. Some required all other moving equipment to be stilled while an operator was out of a machine's cab. Others purchased two-way radios and required machine operators to contact other crew members before exiting their machine after dark.

State workman's compensation rates are often lower for mechanized operations as compared to operations using manual chainsaw felling. Insurance rates are often increased for logging companies when their employees are working in timber salvage operations, because this type of work has an increased worker safety risk due to the use of chain saws. The interviews did not find an increase in accidents or injuries upon implementation of shift work. This may be due to the night activities being limited to machine operations only. However, the small sample size cannot be extrapolated to a larger population. It is unknown if shift work implementation will change workman's compensation premiums in the future.

In the spring of 2007, two loggers reported that their annual questionnaire from their insurance company specifically asked if they were working at night. When the loggers responded with affirmative answers, their policies were cancelled. Insurance companies use accident and injury records to aid in determining insurance rates. Because the use of shift work in the southern states logging industry is a recent development, insurance companies do not have a history of accidents and injuries to determine the insurance risk of the practice. None of the remaining logging business owners reported any changes in their workman's compensation insurance policies due to shift work implementation.

Reductions in accident rates can be partially attributable to increased mechanization of felling (LeFort et al., 2003). However, many fall-related injuries can be attributed to mounting or dismounting equipment. LeFort et al. (2003) noted that the steps on logging equipment are often damaged during normal use in the woods. Therefore, proper techniques for mounting and dismounting equipment should be incorporated into safety programs.

Lilley et al. (2002) found that how employees are paid can impact safety. Workers paid by the piece rate were less likely to take breaks due to production targets. By skipping breaks, the workers were increasing their safety risk due to accumulated fatigue. Although breaks were not part of our survey, we found that three of the logging company owners were paying their crews by the ton. Although none of these three owners reported increased accidents, injuries, or near-misses, the opportunity for increased fatigue exists. The majority of the logging crews were paid a daily shift rate or an hourly rate that was not related to production. Weekly production bonuses were common, and payment was shared across all shifts.

Use of shift work in the southern forest industry may change the risks associated with working in the forest, but the additional risk was not substantiated by the interviews. Logging company owners reported that workers were not encouraged to get out of the machine cab at night to help reduce the risk of skips, trips, and falls that could occur due to poor lighting conditions. Implementation of a near-miss accident reporting system could be used as a tool to aid in identifying and addressing any new safety concerns.

Production

Most of the logging company owners interviewed had difficulty determining productivity of the night crews. Many of the chip-and-saw and sawtimber mills did not accept deliveries 24 hours per day. Those products could be piled on a ramp or loaded on trailers, but the delivery would not occur until the next day shift, making it complicated to distinguish the night production from the day production. Trucking availability and differences in operational characteristics between shifts also impact the ability to estimate production differences. Most logging company owners used the total weekly production as their way of determining production increases from shift work implementation. Several logging company owners quit shift work because they did not perceive enough increase in their total weekly production. The average production increase (63%) reported during the interviews was less than that found by Nicholls et al. (2004). Nicholls et al. (2004) found the late shift productivity to be 78% of the day shift productivity, with an average shift length of 10.5 hours for each shift. In this study, the average day shift length was 10.4 hours, with 9.5 hours for the late shift. This larger average difference between the daily shift lengths may explain the lower productivity reported in this study. Nicholls et al. (2004) suggests that supervisory and management factors may contribute to lower production in the late shift due to transfer of information at shift change and lack of dedicated supervisors. Poor visibility, glare, and circadian misalignments could also be responsible for the reduced production from the late shift.

In the southeastern U.S., crew members are not typically cross-trained on equipment. Most are hired to perform a single operation or operate a single machine. Therefore, the opportunity to increase the variability of tasks, as suggested by Gellerstedt et al. (2005), is limited. Adding maintenance duties in the middle of a shift may serve as an additional task that can help provide some of the variety needed to relieve monotonous, sedentary tasks. However, some of the interview data suggested that maintenance at night is slower due to lighting conditions. If a tool or bolt is dropped, it takes longer to find it after dark as compared to during daylight hours. If additional tasks cannot be added to logging workers duties, then scheduled breaks may help reduce the monotony of some tasks and help performance. Time on shift affected work performance of workers in a simulated power plant study (Gillberg et al., 2003). As the hours into a day or night shift progressed, worker's reaction time increased. Scheduled breaks in each shift resulted in a decrease in subjective sleepiness for about 20 minutes following each break for power plant workers. Kirk (1998) found that harvester processor operators appeared to recover from mental burnout when schedules included two or more substantial rest breaks evenly spread throughout the working day. Longer breaks allow the mind to relax from the mental pressures of machine operation.

Conclusion

Twenty-two logging company owners were interviewed. Ten of these owners have abandoned using shift work, while six feel shift work is promoting an acceptable increase in their weekly production. A variety of work schedules was found. Overall, loggers in

the southeastern states reported an increase in total production from shift work as compared to traditional hours.

The results of this study may be of value to those logging business owners that are considering changing from a traditional schedule or may be helpful to those that already implement shift work. Scheduling work breaks and cross-training employees on equipment has the potential to create a positive impact on shift work employees. While no safety concerns were raised during the interviews, safety was actively considered by owners when they increased machine lighting, required workers to wear high-visibility vests after dark, and implemented a radio communication plan for machine operators. It is recommended that safety plans include a near-miss reporting policy to identify and address any new safety concerns that arise due to shift work implementation.

Logging after dark involves working outdoors in various weather conditions, navigating equipment through darkened stands of timber, distractions due to headlight glare, and a host of other variables that are not common in non-forestry shift work. Additional research is needed to determine the physiological, psychological, and performance impacts of shift work on forest workers. For example, additional research may help to identify preferred lighting options for a variety of equipment types to aid in reducing worker fatigue.

The logging equipment employed by those included in these interviews was highly mechanized ground-based machines. Implementation of shift work in other areas may find additional impacts due to differences in topographic relief, stand type and conditions, equipment, and weather conditions.

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