EXTENDED WORKING HOURS IN THE

SOUTHEASTERN LOGGING INDUSTRY

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EXTENDED WORKING HOURS IN THE SOUTHEASTERN LOGGING INDUSTRY

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A Dissertation

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Doctor of Philosophy

Auburn, Alabama
August 9, 2008

EXTENDED WORKING HOURS IN THE

SOUTHEASTERN LOGGING INDUSTRY

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DISSERTATION ABSTRACT

EXTENDED WORKING HOURS IN THE

SOUTHEASTERN LOGGING INDUSTRY

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Doctor of Philosophy, Auburn University, August 9, 2008
(M.F. Oregon State University)
(B.S. Washington State University)

176 Typed Pages

Directed by Tom Gallagher and Steve Taylor

Logging business owners are exploring the ways to reduce equipment costs. Although shift work is common in some other industries, it is not common in the logging industry in the southeastern United States. Implementation of shift work in logging may be generically referred to as "extended working hours" because some logging business owners are using longer than traditional working hours, while others are actually using two shifts in a 24-hour period. The human factor impacts and financial considerations for implementing extended working hours were investigated by interviewing logging business owners in the southeastern states. Logging business owners interviewed include those who are currently using extended working hours, and those that have tried extended working hour schedules and quit using them. Several different types of schedules were found. Some logging business owners offered rotating shifts, some offered permanent shift assignments, and others offered long day-only schedules. Most scheduled fewer than 24 hours/day, but a few implemented 24-hour schedules. Past studies have shown that extended working hours can have physiological and psychological impacts on workers. Logging business owners reported high employee turnover rates when first implementing extended working hours. For safety purposes, most logging business owners either ordered equipment with manufacturer's lighting packages, or added lights to existing equipment for working after dark. None of the logging business owners reported having any accidents in the woods by late shift crews. Nearly all of those interviewed reported slower production on the late shift as compared to the day shift. Slower skidder speeds, poor visibility, glare, and circadian misalignments could be responsible for the reduced production from the late shift. Financially, the choice of schedule and the equipment used on the late shift may impact the cost/ton produced. Most logging business owners did not schedule felling or hauling at night, resulting in 49% fewer workers on the late shift as compared to the day shift. The average production increase was 56% for those who tried and continued to implement extended work hour schedules. Cost differences were explored using two alternative shift schedules. Analysis indicates costs are sensitive to production. There is a potential for a 9.3% reduction in logging costs, but this is dependent upon the operating characteristics and shift hours employed. Extended working hours may be a viable option for increasing production in the southeastern states. Outside support from wood suppliers and markets are important for successful implementation of extended working hour schedules.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the Wood Supply Research Institute and the USDA Forest Service Southern Research Station for funding the majority of this Ph.D. research. She would also like to acknowledge her co-major professor, Dr. Tom Gallagher, for his support as well as the support and patience of her committee members: Dr. Steve Taylor (co-major professor), Dr. Robert Tufts, Dr. Greg Somers, and Dr. Bob Rummer. She would like to extend her appreciation to her supervisor, Dr. Bob Rummer, for his support while she was pursuing her degree requirements. She would also like to thank Dr. Conner Bailey for representing the Graduate School as the outside reader.

The author appreciates the logging business owners, their crews, and the forest industry professionals who assisted in the data collection effort. She is grateful for their time, kindness, and honesty.

Special thanks are offered to her husband, family, co-workers and friends for their support throughout the research and writing of this dissertation.

Style manual or journals used: Journal of Agricultural Safety and Health, and Southern Journal of Applied Forestry

Computer software used: Microsoft Word 2002, Microsoft Excel 2002, Microsoft PowerPoint 2002, and SAS System for Windows 9.1

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CHAPTER 1.

GENERAL INTRODUCTION

1.0 Background

Profitability is a key component of any logging business. The use of extended working hours or multiple working shifts per day may increase production, reduce the impact of equipment costs on a per-unit basis and increase overall profit of the company. These are all very positive reasons for implementing extended working hours or operating multiple daily shifts. However, these are not the only items to be considered when increasing the daily working hours of a machine. There are other, less direct but equally important, impacts from increased working hours. For example, night production may be less than daytime production, so the costs for night work may be higher than the traditional working hour costs. Implementing extended working hours or shift work without considering all of the potential impacts may result in early failure of the endeavor.

Logging operations in Canada have used extended working hours to increase their production for many years. Extended working hours are so common in Canada, that at forestry training centers in New Brunswick and Quebec, students are required to operate equipment on various shifts within a 24 hours/day, 7 days/week (Turtle, 1997) schedule for real life experience. In New Zealand, 32% of forestry workers report working 12 hours or more per day (including travel time) during summer months (Thomas et al, 2001). However, extended work schedules are not commonly used in the southeastern United States (Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina). Logging business owners in the southeastern states are wary of extended working hours because they do not fully understand the costs and benefits associated with the increased hours of operation. Therefore, the common method of increasing logging production for a logging business owner in the southeastern states is to add a second crew with a complete second set of logging equipment.

Articles addressing extended working hours have begun to appear in trade magazines within the past few years (Fullerton, 2003; Lammers, 2003; Mims, 2005; and Rottgering, 2004). While some of these publications have profiled experiences of logging businesses using extended work hours, none have provided adequate detail to aid in making informed business decisions regarding implementing extended working hours in the southeastern states. Some published articles portray Canadian businesses, but it is difficult to compare these businesses to the southeastern states because of the differences in tax laws, accounting procedures, governmental regulations, and fragmented land ownership patterns.

A specific definition of extended working hours does not exist because there are so many options available. Extended hours can be two overlapping day shifts where overlap hours are used for maintenance. Three shifts per day, or longer shifts for more days per week are other options for extending working hours. In addition, some business owners employ a rotating shift schedule while others assign workers to permanent shift assignments. For this dissertation, the use of the term "extended working hours" will imply all of the schedules described.

1.1 Project Description

Some logging business owners in the southeastern United States have begun to implement extended working hours. The practice is not widespread, and work schedules are individually created and implemented with the expectation of increased production. Although other logging business owners are interested in extended working hours as a way of increasing production, many are waiting to see how it works for others before committing to the new type of work schedule.

Two areas of concern are suggested that need to be addressed in order for business owners to make sound business decisions. The first is to determine the impacts associated with implementing extended working hours. Safety, night production, and employee turnover are a few of the tangible and intangible costs that need to be evaluated.

The second area of concern to be analyzed is the impact of this new type of working schedule on the finances of a logging business. Machine depreciation and the costs associated with various working schedules should be examined to aid in making informed work schedule decisions.

The objectives for this study are:

1. To characterize the human factors impacts of extended work hour schedules on forestry workers,
2. To identify and quantify the financial considerations of implementing extended working hours, and
3. To develop a tool to aid logging business owners in their decision to implement extended working hours.

1.2 General Outline

This dissertation explores the impacts of human factors and financial considerations of implementing extended working hours in logging businesses in the southeastern United States. Chapter 2 serves as a literature review of human factors and logging business finances to provide a basis for Chapters 3 through 5.

One area of concern is the effect of extended working hours on employees. Many journals highlight the physiological and psychological (human factors) impacts on shift workers. However, few of these address the use of extended working hours in forestry. Many of these studies address workers in an industrial setting, frequently indoors. However, how workers respond to some of the work schedules may be applicable to forestry workers, regardless of the work environment. Researchers in New Zealand have been documenting impacts of long working days in forestry terms of fatigue, response times, and physical workload (Cummins, 1998; Kirk, 1998; Lilley, et al 2002; and

Sullman and Kirk, 1998) since the late 1990's. The application of this existing research to the logging industry in the southeastern United States is presented in Chapter 3.

Chapter 4 addressed financial considerations associated with extended working hours. Of concern is the financial impact of additional hours on a machine. This is addressed through discussion of equipment salvage values, depreciation impacts, production differences between shifts, and a cash flow analysis for comparison between traditional and extended working hours.

Chapter 5 provides a decision tree to aid logging business owners in determining whether or not to implement extended working hours. Challenges to implementation are identified based on responses to questions posed regarding variables such as scheduled hours, equipment use, labor availability, and tract selection.

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CHAPTER 2.

LITERATURE REVIEW

2.0 Introduction

We live in a 24-hour society in the United States. 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 southeastern United States 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: mill procurement foresters and logging company owners. The mill procurement foresters are interested in having logging companies work extended hours because they assume the additional working 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.

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 manufacturers 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 may lower 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.

Often, the decision to work extended work hours or work shifts is based on potential increased profits. But, two topics should be understood before implementing shift work: (1) How does shift work impact employees? and (2) How can additional scheduled working hours impact business finances? This chapter begins with a synthesis of available literature that documents the physiological, psychological and performance impacts of shift work on employees. Then, a background on equipment-related costs is examined to aid in developing a methodology for investigating costs associated with shift work in logging. Finally, due to the lack of available literature on shift work in forest harvesting operations, a brief review of highway construction operations is offered to identify concerns associated with working outside at night.

2.0.1 Definition

Terminology is important when communicating between loggers, industry and researchers. Generally, shift work hours are defined as those hours outside the normal daylight hours, 7 a.m. to 6 p.m. (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 paper, "shift work" will include hours outside of typical daylight hours (7 a.m. to 6 .pm.) and signify that more than one shift is used in a scheduling period. The "late shift" will signify a shift that begins in the afternoon or evening.

There is no single perfect work schedule for shift operations. A myriad of work shift systems 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). Unfortunately, in some cases, work scheduling is a collateral duty given to those that do not have a background in ergonomics.

2.1 Impact of Shift Work on Employees

Shift work is commonly thought of as working odd or non-daylight hours. If you grew up with a parent working shift work, as a child, you may remember those days when you were told to play quietly so that your parent could sleep. Therefore, many of us relate shift work to sleep deprivation and the social impacts that it has on the immediate family. However, a large body of work is available that documents the impacts of shift work on sleep, social activities, safety, and a number of other non-work hour activities.

Webster's Ninth New Collegiate Dictionary (Mish, 1983) defines physiology as a branch of biology that deals with the functions and activities of life or of living matter and of the physical and chemical phenomena involved. This same dictionary defines psychology as the science of mind and behavior. Based on these definitions, physiology and psychology are important topics that are necessary for developing a basic understanding of shift work and its impacts on workers.

Little literature exists on the physiological, psychological, and performance impacts of shift work in forest operations. Many existing studies are tested in environments that are more controlled than the forest operations environment, or are simulated laboratory trials. Some of the information provided in this review will not be easily translated to forestry applications due to the differences in work environments. However, the existing data was reviewed to provide a basic understanding of how various factors of shift work can impact workers. This section explores some of the ways that shift work impacts workers and how some of these impacts can be minimized.

2.1.1 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 24-25 hours. Our circadian pacemaker is located in the suprachiasmatic nuclei (SCN) of the hypothalamus and modulates regions of the central nervous system involved in arousal state control (Edgar, 2005).

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 (zeitgebers) 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 may disrupt these circadian cues.

A typical circadian rhythm includes one major low and one high point each day. The low point typically 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 naturally 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.

2.1.1.1 Age

Costa (2005) reports that many studies deem the critical age for reduced tolerance to shift work is between 40 and 50 years. Aging decreases the ability of circadian adjustment to night work due to the weakening of the circadian system. In general, people go to bed earlier and rise earlier as they age. To further exacerbate the impact of shift work on older workers, their health in terms of sleep disturbances, gastrointestinal and cardiovascular diseases increase as their age rises above 40. Alternatively, older shift workers may have developed coping strategies to deal with shift work stresses and related social impacts. Older workers may also have a more stable home environment, better living conditions and fewer domestic constraints as compared to younger workers.

2.1.1.2 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. Exposure to chemical compounds, noise and vibration are some of the work-related risk factors for cardiovascular disease. Shift work does not appear to have an adverse effect on longevity (mortality) or on risk of cancer.

Relationships between pregnancy and work conditions have been reported in several studies (Knutsson, 2003). Increased risk of miscarriages, low birth weights, and premature birth are frequently cited as being strongly related to shift work.

Logging machine operators work in a seated position inside the machine’s cab. The lack of physical body 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).

2.1.1.3 Melatonin and Light Therapy

Melatonin is a hormone that is produced and released from the pineal gland with a circadian rhythm (Burgess et al, 2002). It can be described as a sleep-promoting hormone in humans (Scheer and Czeisler, 2005). In research, melatonin levels are often used as an indicator of circadian phases in humans (Burgess et al, 2002). Melatonin regulation in humans results in high levels of melatonin plasma during darkness (at night) and low levels during the day. Even in an environment free of clocks and other time cues and in constant dim light, research subjects continue to express a 24-hour rhythm in melatonin levels. However, light exposure during the night can aid in suppressing melatonin production. Light therapy has been found to reduce the production of melatonin to phase delay sleep for shift workers (Burgess et al, 2002; Bougrine et al, 1998).

Another method of trying to adjust the circadian rhythms to night shift work is to administer exogenous melatonin. This is a readily available substance in health food stores and has been proven to modestly enhance circadian rhythm shifts (Burgess et al, 2002). In a study where melatonin was administered before an afternoon/evening sleep schedule, subjects were better able to adapt to the shifted sleep schedule.

2.1.1.4 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 1 hour after the night shift and lasted for 8 hours. These workers were then awake for 7 hours prior to the night shift (also known as "extended prior waking"). This typical sleep schedule was compared to one where 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.

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). Two recovery days are usually sufficient for office workers working a typical office week. Shift workers working in 12-hour shifts in 2-3 day sequences felt 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, is needed to feel alert and fresh.

Shift workers in an industrial plant were authorized to take a nap during the night shift (Bonnefond et al, 2001). Individual sleeping areas were provided near the work stations. Data was collected over the course of one year. Results found that vigilance level was higher during the hours following the nap. There was no apparent impact on the length of sleep time after work shifts. Employees found that taking a nap at work (up to one hour) made it easier for them to stay awake and they felt less fatigued in the later shift hours.

2.1.2 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 working 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.

Personality traits seem to play a major role in worker's ability to adapt to shift work. Furnham and Hughes (1999) found that night shift television crew workers reported lower levels of job satisfaction than day workers. However, the workers with an introvert-type personality seem to fare better on night shifts than those with an extrovert-type of personality. Social networks may be important to some extrovert-type workers. Extroverts may fare better working as a team at night where they can rally support from others, rather than working alone on a particular task.

Tamagawa et al (2006) was able to distinguish some 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).

2.1.2.1 Social Factors

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). In the Dutch Military Police force, day-only workers had a lower level of work-home conflict (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.

Job satisfaction was rated lowest by rotating shift workers, and those whose shifts included weekends reported the lowest job satisfaction rates.

2.1.2.2 Safety and Accidents

In a study involving 10 years of data on lost time injuries in the mining industry, Monk and Wagner (1989) compared the night shift accidents to the day of the week. Although the night shift cycle began on Thursdays, most accidents occurred on the fourth night shift, Sunday. The researchers suggest that weekend sleep disruptions due to heavy schedules of weekend activities (including church and church-related activities) could explain the higher Sunday night/Monday morning accident rate.

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 night workers 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 accidents occurred in the first half of the shift, while on the night shift, 57% of the accidents occurred during the second half of the shift. Accumulated fatigue and circadian effects may be the reason for the timing of the majority of the night shift accidents (Nag and Patel, 1998; and Levin et al, 1985).

In a highway construction-related survey Hancher and Taylor (2001) found that common perceptions regarding safety and nighttime work were not upheld. Engineers and contractors cited safety as being one of the primary disadvantages of working at night, but the survey found that safety was not affected by night work.

Another type of accident risk posed by sleepiness from shift work is driving to and from work. Many studies report that driving while sleepy reduces vigilance and increases the risk of a motor vehicle collision (MacLean et al, 2003; George, 2003; and 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.

Nicholls et al (2004) found that logging machine operators that 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. Lilley et al (2002) found that near-misses by forest workers were associated with actual accidents and lost-time injuries.

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. Fatigue levels of machine operators could be reduced by incorporating two or more tea breaks per shift.

State workman's compensation rates are often lower for mechanized operations as compared to operations using manual chainsaw felling. 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 woods use. 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. It is unknown if shift work implementation will change workman's compensation premiums in the future. One way to reduce the insurance expense is to work safely (Reisinger et al, 1994).

2.1.2.3 Fatigue

Fatigue may be associated with compromised safety for forest workers (Lilley et al, 2002). Sleep patterns, number of breaks taken during the workday, and lack of job task variability can be associated with feelings of fatigue at work. 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.

Extended working hours are commonly used in New Zealand (Thomas et al, 2001; Lilley et al, 2002). In a national survey, 32% of forestry workers reported working for 12 hours or more each day during the summer. Machine operators averaged 10 hours of work/day with 25% working over 10 hours/day. Some machine operators worked 15.5 hours/day, excluding travel time to the job site. Although a third of these forestry workers felt that fatigue affected their safety, few of the machine operators reported a high level of fatigue. In Lilley et al (2002), workers in more physically demanding tasks, such as chainsaw operation reported high levels of fatigue. Forest workers who slept less than 8 hours were also more likely to report high levels of fatigue.

The U.S. Federal Motor Carrier Safety Administration regulates the hours of service for commercial truck drivers. The purpose of the regulation is to improve highway safety by reducing driver fatigue (Jarvis, 2000). One example of how the regulations limit fatigue is by requiring an off-duty period of 34 or more consecutive hours following a 70 hour duty over 8 consecutive days (USDOT, 2008).

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 and 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 lack of physical body exercise on sitting working places. By getting off the machine during breaks, operators benefit by introducing movement back into muscle groups. Kirk (1998) recommends 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 for operators to physically get off a machine.

2.1.2.4 Performance

Time on shift affected the work performance of workers in a simulated power plant study (Gillberg et al, 2003). The effect of day versus night shift on work performance was not significant. Reaction time did not differ between subjects based on shift, but reaction time increased across shift during both day and night shifts. Night shift workers self-reported increased sleepiness across the night shift, although this was not accompanied by negative effects on performance. Even though they felt sleepy, their performance was not reduced. Scheduled breaks in each shift resulted in a decrease in subjective sleepiness for about 20 minutes following each break.

Multiple tasks can reduce the monotony and prove to be more stimulating for shift workers (Persson et al, 2001; and 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, 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.

In an assessment of work load (Gellerstedt et al, 2005), researchers found that an 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 where 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 means 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 production.

2.1.3 Shift Scheduling/Rotation

Due in part to circadian rhythms, most people find that it is easier to go to bed later and wake up later than to go to bed earlier and wake up earlier. While this phenomenon could be impacted by external factors such as daylight and family noise, most people find it easier to go to bed later rather than earlier. If rotating shifts are being considered, a schedule that rotates from day to evening to night shifts (forward rotating) fits better with natural circadian rhythms than one that rotates in the opposite direction from day to night to evening shifts.

How quickly a work schedule progresses through the shifts is referred to as the speed of rotation, or rotation rate. A fast rotation may be one where three shifts are rotated through in a week. At the Uniroyal plant in Opelika, AL, some shift workers cycle through the three shifts in 28 days – a slow rotation. Overall, studies find more positive influences on psychological factors (job satisfaction, health and well-being) with faster rotations (Popkin et al, 2006).

2.1.4 Summary

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

2.2 Impact of Shift Work on Financial Considerations

2.2.1 Introduction

According to a recent Wood Supply Research Institute (WSRI) report (Stuart et al, 2007), logging costs have increased 40% from 1995 to 2005. Prices paid for logging services during this same time frame have decreased 10%. Logging businesses are looking for ways to reduce their costs or increase the value of their products to stay in business. Working additional hours may help address the issue of reducing costs.

The major cost components for a logging business are: administrative overhead, contract services, insurance, labor, consumables (including fuel), and equipment. Equipment may account for just 15% of these costs (Stuart et al, 2007), but it is one of the few categories that can be controlled through business decisions (Figure 2.1). The current trend is that small and mid-size firms are not increasing their equipment outlays.

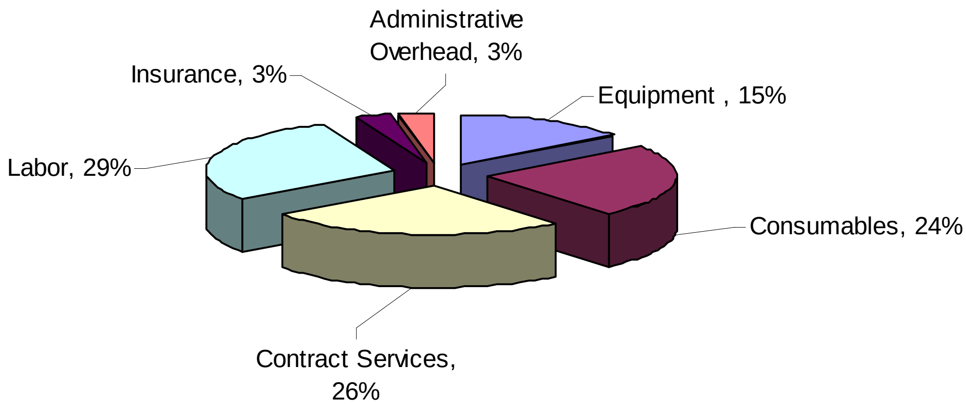

Figure 2.1. Major cost components for a logging business (data from Stuart et al, 2007).

New logging equipment is an expensive capital investment. The manufacturers suggested retail price of a new 215 hp, rubber-tired grapple skidder is approximately $185,000 (USD) depending on the options included. Most logging businesses include several additional pieces of heavy equipment. The preliminary findings from the Logging Capacity Survey (Taylor et al, 2006) indicate that less than 20% of logging and trucking businesses plan to expand in the next three years. In this survey, difficulty in raising necessary capital was identified as one of the expansion barriers in the southern states. Increasing the working hours on the machines may be a way to increase production without increasing capital investments.

2.2.2 Salvage Values

The price that a piece of equipment could sell for at the end of its economic life is known as the salvage value. Equipment salvage values are important in making financial decisions because they can influence maintenance and repair, depreciation, and replacement schedules.

One source for salvage values is a current listing of sales information from auction houses. The Green Guide (2007) offers equipment auction sales information that includes types of machine with standard configurations, serial numbers, and sales prices. Value adjustments are made based on equipment options and extras, condition, age, and region. A recent investigation of Green Guide auction data (Thompson, 2008) revealed that machine hours were not included on all individual sales histories. Due to the recent implementation of extended working hours in the southeastern region, no sales or auction histories are available for equipment that has been used in extended hours.

Of concern is the impact on salvage values when equipment has higher machine hours than another of the same age. Cubbage et al (1991) examined logging equipment resale values and found that equipment age was the most significant variable affecting resale values for equipment that was up to 5 years old. Equipment condition did not affect the resale value of newer equipment, but it did significantly contribute to predicting the resale value of older equipment.

Lucko et al (2007) found that the typical guidance for determining residual value of construction equipment is to use a particular percentage coinciding with the age of the equipment. However, their analysis indicates that the impact of the residual value on hourly costs is significant based on different annual hours of usage.

2.2.3 Depreciation

Taxes and depreciation are of concern when working a machine for more hours in a year than under traditional work schedules. Equipment replacement can impact taxes, depreciation based on book values, and potential capital gains or losses from equipment sales which can be added to the equipment's basis. Business owners must consider their equipment replacement schedules and the impact that they can have on their finances. If owners replace equipment based on a certain number of machine hours, they will be replacing equipment much more frequently under extended working hours. Owners that replace their equipment based on the number of years of ownership may find that the higher machine hours may impact the price they receive when the machine is sold (salvage value).

In general, the United States Department of the Treasury Internal Revenue Service (IRS) does not allow taxpayers to deduct the entire cost of property purchased for use in a business in one year if the use of equipment has a useful life substantially beyond the tax year (IRS, 2006). Some general tax regulations that may apply to logging businesses include the Section 179 deduction and depreciation of repair and maintenance. Section 179 allows for deducting all or part of the cost of machinery and equipment in the year it is placed in service. If a Section 179 deduction is taken in the first year, the basis for depreciating the equipment is reduced by the Section 179 deduction. Depreciation deductions may be taken for repair and maintenance costs that improve depreciable property if the improvement work makes the property more useful or lengthens its life. IRS publication 946 (2006) contains more extensive details on the rules and regulations that affect taxes and equipment and machinery. Because the cost of expensive machinery cannot be expensed in one year, depreciation becomes an important variable in determining owning and operating costs.

The Modified Accelerated Cost Recovery System (MACRS) is used to apply depreciation deductions to business equipment (IRS, 2006). MACRS allows for two methods of depreciating property placed in service after 1987: the General Depreciation System (GDS) and the Alternative Depreciation System (ADS). Generally, the GDS method is used unless tax laws specifically require the use of the ADS method.

GDS allows for a class life of 6 years with a recovery period of 5 years for logging and road building machinery and equipment. There are 2 depreciation methods available under GDS for forest machines: the 200% declining balance method, and the straight line method over the GDS recovery period. The declining balance method provides a greater deduction during the earlier recovery years and changes to a straight-line method of depreciation when it provides an equal or greater deduction. An averaging convention is used to determine how many months the equipment was used in the first year and in the year the equipment was disposed. The half-year convention allows for all property placed in service or disposed of during a tax year as happening in the midpoint of that tax year. The percentages of depreciation for each depreciation method for equipment with a 5-year recovery period under GDS are excerpted from Publication 946 (IRS, 2006) and displayed in Table 2.1.

Table 2.1. Depreciation rates for forestry equipment by depreciation method.

	Method of Depreciation (half-year convention)	
Year	200% Declining Balance	Straight-Line
1	20%	10%
2	32%	20%
3	19.2%	20%
4	11.52%	20%
5	11.52%	20%
6	5.76%	10%
Totals	100%	100%

Source: IRS, 2006

2.2.4 Machine Rate Method Overview

Machine rates have been around since the 1940's and are often used for financial analyses when comparing equipment costs. The machine rate method by Brinker et al (2002) is often cited in literature when comparing equipment costs. The machine rate provides an average hourly cost over the life of a machine and only accounts for straight line depreciation.

There are limitations in using a machine rate for comparisons. For example, the use of a machine rate does not take into account impacts of after-tax cash flow. In addition, the cost of insurance, interest, and taxes are estimated by calculating them as a fixed percentage of average fixed value. Repair and maintenance is calculated as a percentage of the depreciation. Many applications of machine rates ignore overhead, profit and risk.

The machine rate analysis includes two types of costs, fixed and variable. Fixed costs include the original purchase price, salvage value, and insurance. Fixed costs are spread over the life of the machine as determined by the business owner. Variable costs include those costs that vary due to production, such as fuel consumption, lubrication costs, repair and maintenance, and those items that are regularly replaced such as tires, tracks, or cutting teeth.

One of the questions associated with extended working hours is whether it is appropriate to compare the costs using the standard machine rate methods. The assumptions for the machine rate analysis may not be applicable when machine hours are increased more rapidly than under a traditional working schedule. The machine rate method uses an average production per hour for each of the scheduled machine hours. However, workers may not be as productive during extended hours as compared to the traditional work hours.

Some of the common assumptions used when determining machine rates may not apply to machines that have been operated for extended hours. Repair and maintenance is calculated as a percentage of depreciation in a machine rate analysis (Brinker et al, 2002). If the same maintenance costs were incurred on a machine under the extended working hours schedule as under a traditional schedule, they will occur in a condensed time frame. Repair rates may also change under an extended working hours schedule. There isn't any documented evidence of changes in the level of wear and tear attributable to working forest machines after dark. However, forest harvesting equipment repairs can vary a great deal. Some of the variability in equipment repairs have been associated with operators, working environments, and maintenance practices (Tufts and Hitt, 1983).

2.2.5 Cash Flow Method Overview

A cash flow analysis is another method available to determine the financial burden of equipment. Instead of comparing the cost per hour for different pieces of equipment as in the machine rate method, the cash flow analysis method can be used to display the annual costs associated with owning and operating equipment. An advantage of a cash flow analysis is that depreciation does not have to be limited to the straight-line calculation method. Depreciation can be calculated using any of the IRS approved depreciation schedules and the cash flow analysis method can be adjusted to incorporate any IRS Section 179 deduction amounts. Machine rates assume that the maintenance and repair will basically replace the entire machine over the course of the machine life. With a cash flow analysis, costs can be adjusted to reflect actual or anticipated costs and they can be assigned to the actual year of the expense rather than averaged over the life of the machine.

After-tax cash flow analysis may be made using equivalent annual worth (EAW), present worth (PW), or internal rate-of-return (IRR) methods (Riggs and West, 1986). The EAW method produces results compatible with PW and IRR comparisons. The EAW method may be easier to apply because cost-accounting procedures, depreciation expenses, and tax calculations are annual in nature (Riggs and West, 1986).

Several spreadsheet models are available for determining logging costs for an annual discounted cash flow analysis (Bilek, 2007; and Tufts and Mills, 1982). The spreadsheet-based models are automated and flexible allowing for adjustments in several cost items. These type of spreadsheet tools may be applicable for analyzing and comparing annual costs associated with various work schedules.

2.2.6 Production Rate Differences Between Shifts

The production from the late shift may not be the same as the production found on the day shift. Nicholls et al (2004) found the late shift production to be 78% of the day shift production with an average shift length of 10.5 hours for each shift. They suggest 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.

From the few forest operations studies available, Murphy and Vanderberg (2007) estimate the night production to be 12.5% less than the day shift production. For shifts longer than 9 hours, production can also be reduced by an additional 6% per extra hour over 9 hours.

A method of collecting performance data from forest machine operations in Canada was developed by Lepage and LeBel (2007). A performance dashboard that incorporates operational, tactical and strategic levels was used to provide timely feedback to logging business owners. The data collected was used to identify factors that impact production, such as weather, month, operational delays, and work shift. In their study, both operator and month of the year were significant to production. This type of detailed data collection and analysis could be useful for identifying factors that could impact production rates of extended working hours in the southeastern United States.

2.2.7 Work Environment

Lighting requirements for highway work zones have been documented by the National Institute for Occupational Safety and Health (NIOSH) for road work zones (Pratt et al, 2001), but none are available for forest operations in the United States.

Lighting of a work environment is important because low levels can impact quality and safety of work. Excessive levels of lighting can result in unnecessary waste in lighting cost and light trespass to adjacent property. A framework for identifying the lighting requirements for nighttime highway construction was developed by Hyari and

El-Rayes (2006). The framework considers the tasks to be performed by a nighttime highway construction crew, and considers four visibility factors that can affect performance: (1) the size of the target and distance between the worker's eye and the target; (2) the contrast between the target and its immediate background; (3) the visual capacity of the worker; and (4) the illuminance level in the work area. When considering the visual capacity of the worker, age of the worker can require an adjustment in the lighting level. In addition, lighting should be at a level where workers can work comfortably and not at the top of their limits.

Poon et al (2007) performed a study to compare xenon and halogen lamps. Test subjects were able to identify green and orange displays under a range of lighting conditions. Test subjects were able to identify the green displays significantly better than the orange displays when xenon lamps were used. However, no such difference between lamp types was found with the orange displays. The illumination (lux) level from a single xenon lap was the same as three halogen lamps, and requires less energy. However, xenon lamps can cause glare and reflections more easily than halogen lamps. This can be a disadvantage during harvesting operations, especially if two or more machines are working in the same area.

Forest machine operators will likely find work more demanding when operating in artificial lighting than in daylight (Frumerie, 1999). Lighting on a forest machine should be of high enough intensity and directed in such a way that there is no dazzle from contrasts or reflections. Uneven lighting can cause headaches and eye fatigue. Frumerie (1999) recommends lighting guidelines (60 lux) within the working area of a harvester or forwarder boom, and also for the area in the periphery (15 lux) of the operating equipment. Color of light should be toward the white (high color temperature) end of the spectrum.

2.2.7.1 Night Work in Highway Construction

Some positive benefits for contractors performing highway construction during the night hours include lower temperatures for more comfortable working conditions, reduced traffic levels, contract incentives, schedule limits and safety (Hancher and Taylor, 2001). Their report documented that one contractor mentioned worker availability would be better if nighttime work could be constant and uniform. One explanation for safe night work was because workers were more aware of the dangers at night and were more conscious of safety practices. Schedule limits could be met more easily with working day and night shifts. Financial incentives include performing night work to meet schedule limitations and early contract completion. Few of these drivers for performing night highway construction work are expected to apply to logging business owners.

The amount of highway construction by state can vary greatly. However, a study involving data from 18 states indicates that nighttime shifts and dual day/night shift operations only account for a small number of highway construction projects (Al-Kaisy and Nassar, 2005). California and Michigan extensively use dual shifts in highway construction to speed up the construction work and minimize the interruption to traffic.

Al-Kaisy and Nassar (2005) report construction cost increases of 0-25% and administrative costs increases within that same range for night construction work. The higher contract costs reflect not only the shift differential in pay, but also the additional traffic control features required for night work. Police presence is an additional expense that is often required during night highway construction work.

Some of the indirect costs, known as road user costs, of performing highway construction only on the day shift include increased fuel consumption by vehicles idled in traffic (reduced air quality) and significant delays. Traffic levels are typically at their lowest level during night hours, thereby reducing the road user costs. State Departments of Transportation ranked the top seven considerations for implementing night time highway construction as: high daytime traffic, traffic safety, worker's safety, traffic control, road user costs, disruptions to surrounding businesses, and noise (Al-Kaisy and Nassar, 2005). Day and night work have similar work quality because both shifts have to meet the same quality specifications.

Comparison of day and night work savings can be reflected in an economic analysis. Holguin-Veras et al (2003) relate traffic speed and travel time through construction zones to project costs. They suggest that the economic savings of avoiding traffic congestion be transferred to construction work in the form of a pay differential.

2.2.8 Summary

Prices paid for logging services have decreased, while logging costs have increased. One possible way that logging business owners may be able to control logging costs is by increasing the working hours of machines. Increasing the smh may increase total annual production without requiring increased capital investments.

However, the impacts of increasing the smh may result in some additional financial considerations. While equipment age has been identified as the most significant variable affecting resale values for equipment that was up to 5 years old, no literature describes the impact of high hours on machines that are only -2 or 3-years old. In addition, total shift production on late shift is often less than that found on the day shift. It follows that the cost of wood produced during the late shift may be higher than the wood produced during the day shift, but this hasn't been addressed in existing literature.

A comparative analysis is needed to determine the potential cost differences between implementing various extended hour schedules. The cash flow method of analysis may be appropriate for comparing the annual costs of various working schedules in forest harvesting operations. The cash flow method allows for a variety of depreciation calculation methods and it can account for repair and maintenance during the year of the expense. Difficulties in estimating costs arise given the lack of data for determining the actual salvage values. Similarities to the nighttime highway construction industry appear to be minimal. Incentives for nighttime highway construction incorporate specific societal values (such as travelers delay time) that are not considered in the forest industry.

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CHAPTER 3.

THE HUMAN FACTORS OF IMPLEMENTING SHIFT WORK IN LOGGING OPERATIONS

3.0 Introduction

We live in a 24-hour society in the United States. 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 day time 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 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.

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 manufacturers 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 paper attempts to address this issue by:

1. Providing a basic understanding of the physiological and psychological impacts of shift work on workers,
2. Reviewing shift work implementation schedules used in the southeastern United States, and
3. Providing recommendations for implementing shift work in the logging industry.

3.1 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, 7 a.m. to 6 p.m. (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 paper, "shift work" will include hours outside of typical daylight hours (7 a.m. to 6 p.m.) and signify that more than one shift is used in a scheduling period. The "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 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.

3.1.1 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 24-25 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.

3.1.1.1 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 body 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).

3.1.1.2 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 1 hour after the night shift and lasted for 8 hours. These workers were then awake for 7 hours prior to the night shift (also known as "extended prior waking"). This typical sleep schedule was compared to one where 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.

3.1.2 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 working 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).

3.1.3 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; and 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; and 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.

3.1.4 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 where 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 production.

Multiple tasks can reduce the monotony and prove to be more stimulating for shift workers (Persson et al, 2001; and 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, 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. 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.

3.2 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. A face-to-face interview method was selected because more in-depth information can usually be attained in person, as opposed to telephone calls or through mail surveys. The interview process began in the spring of 2006. Twenty-two interviews were completed with logging company owners who have made efforts to implement shift work (Figure 3.1). 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. Therefore, this was a 100% sampling of those logging business owners that could be identified. Because some loggers were found through contacts with other loggers implementing extended working schedules, the snowball method (Ritchie et al, 2003), there was limited variety in the types of logging business owners interviewed. The bulk of the logging business owners interviewed were preferred suppliers for large timber industries.

The interview questions were used as a guide, and some of the discussions led away from the topics and provided some additional insightful information. Generally, interviews lasted for one hour. Interviews were held in the woods, at restaurants, and at business offices over the course of 18 months. Data collected during the interviews included employee turnover, shift hours, shift scheduling, safety considerations and production of each shift (Appendix A). Most of the owners operated their ground-based systems in fairly flat terrain, consisting mostly of various types of southern pine trees.

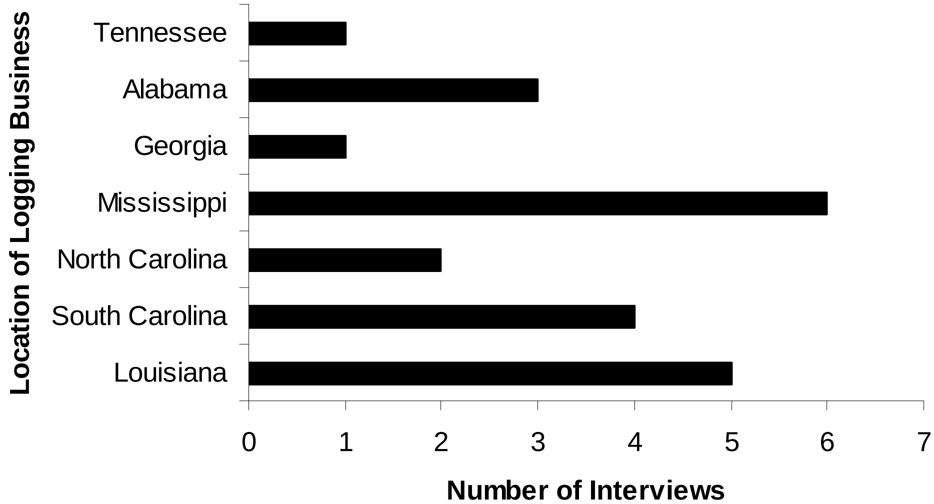

Figure 3.1. Number of interviews by state.

3.3 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 (Figure 3.2), inclusive of their extended working hour experience years.

Figure 3.2. Years of logging experience of logging business owners interviewed.

3.3.1 Shift Rotation

Of the twenty-two 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 3.1. One logger uses one long shift per day (Schedule A), but the workers 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 3.1 were each used by one or two logging company owners.

Table 3.1. Work schedules[a].

Schedule A: 12-hour work days with weekly rotation (n=1)
Shift 1 DDDDDDD●●●●●●●
Shift 2 ●●●●●●●DDDDDDD
Schedule B: Permanent shifts with weekends off (n=16)
Shift 1 DDDDD●●DDDDD●●
Shift 2 NNNNN●●NNNNN●●
Schedule C: Bi-weekly rotation with weekends off (n=1)
Shift 1 DDDDD●● DDDDD●● NNNN●●● NNNN●●●
Shift 2 NNNN●●● NNNN●●● DDDDD●● DDDDD●●
Schedule D: Permanent shifts with weekends off (n=2)
Shift 1 DDDDD●● DDDDD●●
Shift 2 NNNN●●● NNNN●●●
Schedule E: Rotating weeks with weekends off (n=1)
Shift 1 DDDDD●● NNNNN●●
Shift 2 NNNNN●● DDDDD●●
Schedule F: Rotating intermittently for extra second shift (n=1)
Shift 1 DDDDDD● DDDDDD●
Shift 2 NNNNN●●NNNNN●●

[a]D = Day Shift; N = Night Shift; ● = Day Off

3.3.2 Shift Hours

A variety 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/day rotates shifts every two weeks (Schedule C) (Table 3.1). The remaining logging company owner uses a permanent shift schedule (Schedule B) (Table 3.1) for 12-

hour shifts. Schedule F has two day workers stay to work the late shift 5 nights/week, but the workers rotate so that they don't work extended shift hours on two consecutive days.

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) 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 3.1). 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 3.2. 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 previously ended their night shift between midnight and 0200. Shift hours were considered to determine if work was scheduled during the hours of the typical circadian low (0300 - 0500), but only those logging business owners implementing a 24-hour schedule scheduled work during these hours.

Table 3.2. Ending clock hours for schedules using two shifts and less than 24 working hours per day.

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

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 of the logging company owners interviewed 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.

3.3.3 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 for added visibility at night when workers need to be out of the machine cabs at night. 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 the daylight hours.

3.3.4 Production and Performance

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 total 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 don't "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.

3.4 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. Most operate on flat terrain while very few 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 are employed.

3.4.1 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 3.1), are considered a fast, but acceptable rotation speed in the United States (Popkin et al, 2006). In Europe, a fast rotation schedule is one where 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 3.1). 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 2-3 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 3.1). 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 (Santhi et al (2005).

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 late shift schedules (Demerouti et al, 2004). Those on fixed schedules report higher job satisfaction, professional efficacy and lower cynicism and lower turnover rates than those on rotating shifts. However, late shift fixed schedule (including weekends) workers may exhibit a high level of home-work conflict. The use of late shift fixed schedules or rotating shifts in the southern logging industry could create some of these same negative impacts.

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 3.1). He offered the advantage of mini-vacations 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 3.1) 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). On the Dutch Military Police, he found 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. Job satisfaction was rated lowest by rotating shift workers, and those whose shifts included weekends reported the lowest job satisfaction rates.

3.4.2 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 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 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 a single shift operation to one with 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 United States, some of the same social factors may come into consideration as did in a study of mining accidents (Monk and Wagner, 1989). In a data set covering a period of 10 years, they found that the Sunday night/Monday morning shift had higher accident rates than the other late shift nights. They surmised that Sunday church and church-related activities impacted worker's post-shift sleep and could be responsible for the higher accident rates on Sunday nights. Logging company owners should consider the potential impact of social activities on accident rates when scheduling work. 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 introvert-type of personality would fare better in this situation than those with an extrovert-type of personality. 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 and 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 lack of physical body exercise on sitting working places. By getting off the machine during breaks, operators benefit by introducing movement back into muscle groups. Kirk (1998) recommends 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 for operators to physically get off a machine. Since the machine operators in this study operated the same machine for the duration of the shift, logging company owners should consider how breaks are incorporated into worker's schedules.

The majority (86%) of the work schedules reported 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 that 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.

3.4.3 Safety

State workman's compensation insurance (WCI) 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. Respondents did not report 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 WCI 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. The National Council on Compensation Insurance, Inc. (NCCI) uses national accident and injury records to aid in determining insurance rates through use of experience modifiers. 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 woods use. Therefore, proper techniques for mounting and dismounting equipment should be incorporated into safety programs as this could be an even greater hazard at night. Logging company owners reported that workers were encouraged to stay in the machine cab at night to help reduce the risk of skips, trips and falls that could occur due to poor lighting conditions.

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 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 is not substantiated by the interviews.

Implementation of a near-miss accident reporting system could be used as a tool to aid in identifying and addressing any new safety concerns.

3.4.4 Production and Performance

Most of the logging company owners interviewed had difficulty determining production levels from 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 discern 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 total production increase (54%) reported during the interviews was less than that found by Nicholls et al (2004). Nicholls et al (2004) found the late shift production to be 78% of the day shift production with an average shift length of 10.5 hours for each shift. In this study, the average day shift length was 10.4 hours and 9.5 hours for the late shift. This larger average difference between the daily shift lengths may explain the lower production 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 United States, 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, 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.

3.5 Conclusions

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 were found. Overall, loggers in the southeastern states reported an increase in total production from shift work as compared to traditional hours.

Those logging business owners that quit implementing extended working hours were unhappy with their production from the late shift. Some of the interview responses indicated that skidding at night was slower, and the additional production stacked on the landing from the late shift slowed morning activities for the day shift. Poor visibility, glare and circadian misalignments could also be responsible for the reduced production from the late shift.

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. Safety plans should 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. In addition, future interviews that include forestry shift workers may provide additional insights and identify concerns that were not expressed by the business owners.

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CHAPTER 4.

FINANCIAL CONSIDERATIONS

4.0 Introduction

According to a recent WSRI report (Stuart et al, 2007), logging costs have increased 40% from 1995 to 2005. Prices paid for logging services during this same time frame have decreased 10%. Logging businesses are looking for ways to reduce their costs or increase the value of their products to stay in business. Working extended hours may help address the issue of reducing costs.

The major cost components for a logging business are: administrative overhead, contract services, insurance, labor, consumables (including fuel), and equipment. Equipment may account for just 15% of these costs (Stuart et al, 2007), but it is one of the few categories that can be controlled through business decisions (Figure 4.1). The current trend is that small and mid-size firms are not increasing their equipment outlays (Stuart et al, 2007).

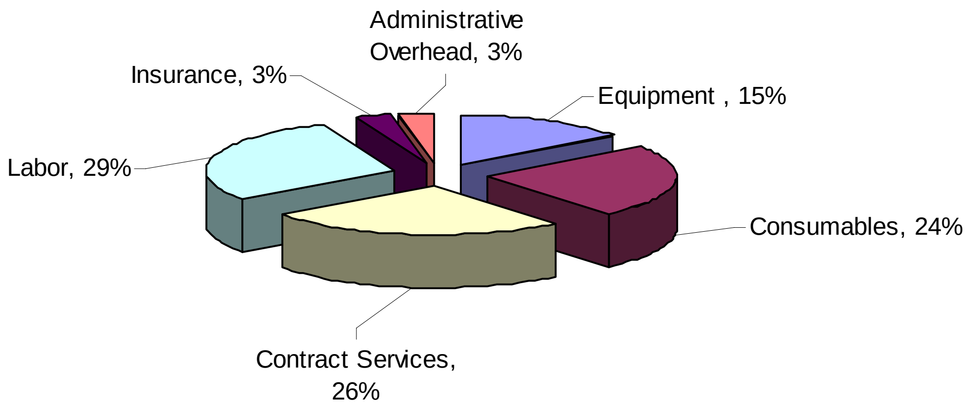

Figure 4.1. Major cost components for a logging business (data from Stuart et al, 2007).

New logging equipment is an expensive capital investment. The manufacturer's suggested retail price of a new 215 hp, rubber-tired grapple skidder can be more than $175,000 (USD) depending on the options included. Most logging businesses include several additional pieces of heavy equipment. The preliminary findings from the Logging Capacity Survey (Taylor, 2006) indicate that less than 20% of logging and trucking businesses plan to expand in the next three years. In this survey, difficulty in raising necessary capital was identified as one of the expansion barriers in the southern states. Increasing the working hours on the machines may be a way to increase production without increasing capital investments.

There could be some initial costs to starting extended work hours if they involve working at night. Task lighting, such as additional lights mounted on equipment, pole lights in areas of concentrated activity, and flashing log load lights are just a few of the initial costs that could be incurred.

This paper addresses several questions pertaining to implementation of extended working schedules:

1. What is the potential impact of extended working hour schedules on equipment salvage values?
2. Are repair and maintenance costs higher with extended work hours as compared to traditional work schedules?
3. What is the impact of paying a higher labor rate for the late shift workers?
4. Are insurance rates different after implementing extended working hours?
5. What are some of the factors to consider for tract selection under extended working hour schedules?
6. How is production impacted under an extended working hours schedule as compared to the traditional work hours?
7. What are some of the cost differences between working hour schedules?

4.0.1 Machine Cost Overview

In order to answer some of the financial questions relating to implementation of extended working hour schedules, it is important to understand the after-tax cash flow method of estimating costs. A cash flow method is an analysis tool used to determine the financial burden of equipment. Instead of comparing the cost per hour for different pieces of equipment as in the machine rate method (Brinker et al, 2002), the cash flow analysis method can be used to display the annual costs associated with owning and operating equipment. An advantage of a cash flow analysis is that depreciation does not have to be limited to the straight-line calculation method. Depreciation can be calculated using any of the IRS approved depreciation schedules (IRS, 2006) and the cash flow analysis method can be adjusted to incorporate any special depreciation expense allowances. With a cash flow analysis, costs can be adjusted to reflect actual or anticipated costs and they can be assigned to the actual year of the expense. The equivalent annual worth (EAW) method of after-tax cash flow analysis is fairly simple to apply because cost-accounting procedures, depreciation expenses, and tax calculations are annual in nature (Riggs and West, 1986).

4.0.1.1 Salvage Values

The price that a piece of equipment could sell for at the end of its economic life is known as the salvage value. Equipment salvage values are important in making financial decisions because they can influence maintenance and repair, depreciation charges, and replacement schedules. The impact of extended working hours on equipment salvage values is unknown.

One source for salvage values is a current listing of sales information from auction houses. The Green Guide (2007) offers equipment auction sales information that includes types of machine with standard configurations, serial numbers, and sales prices. Value adjustments are made based on equipment options and extras, condition, age, and region. However, due to the recent implementation of extended working hours in the southeastern region, no sales or auction histories are available for equipment that has been used in extended hours.

Of concern is the impact on salvage values when equipment has higher machine hours than another of the same age. Cubbage et al (1991) examined logging equipment resale values and found that equipment age was the most significant variable affecting resale values for equipment that was up to 5 years old. Equipment condition did not affect the resale value of newer equipment, but it did significantly contribute to predicting the resale value of older equipment.

4.0.1.2 Depreciation and Taxes

Taxes and depreciation are another concern when working a machine for more hours in a year than under traditional work schedules. Equipment replacement can impact taxes, depreciation based on book values, and potential capital gains or losses from equipment sales which can be added to the equipment's basis for tax purposes. Business owners must consider their equipment replacement schedules and the impact that they can have on their finances. If owners replace equipment based on a certain number of machine hours, they will be replacing equipment much more frequently under extended working hours. Owners that replace their equipment based on the number of years of ownership may find that the higher machine hours may impact the price they receive when the machine is sold (salvage value).

The Modified Accelerated Cost Recovery System (MACRS) is used to apply depreciation deductions to business equipment (IRS, 2006). MACRS allows for two methods of depreciating property placed in service after 1987: the General Depreciation System (GDS) and the Alternative Depreciation System (ADS). Generally, the GDS method is used unless tax laws specifically require the use of the ADS method.

The General Depreciation System (GDS) method allows for a class life of 6 years with a recovery period of 5 years for logging and road building machinery and equipment. There are 2 depreciation methods available under GDS for forest machines: the 200% declining balance method, and the straight line method over the GDS recovery period. The declining balance method provides a greater deduction during the earlier recovery years and changes to a straight-line method of depreciation when it provides an equal or greater deduction. The percentages for each depreciation method are displayed in Table 4.1.

Table 4.1. Depreciation rates for forestry equipment by depreciation method.

Year	Method of Depreciation (half-year convention): 200% Declining Balance	Straight-Line
1	20%	10%
2	32%	20%
3	19.2%	20%
4	11.52%	20%
5	11.52%	20%
6	5.76%	10%
Totals	100%	100%

Source: IRS, 2006

4.0.2 Production Rates

Because of the high level of capital investments required, these machines need to be kept productive. By increasing working hours, machine usage also increases. Extended work schedules increase the annual scheduled machine hours which is one of the basic variables used in calculating machine costs. Increased scheduled machine hours may be able to reduce the cost of producing each ton of wood.

Nicholls et al (2004) studied the impacts of extended working hours on a first-thinning operation that used cut-to-length equipment. The 2-shift schedule spanned 21 hours/day, with each shift typically 10.5 hours in length. They compared the production levels between the two shifts and found that the afternoon shift averaged 78% of the day shift production. They suggest 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.

From the few forest operations studies available, Murphy and Vanderberg (2007) estimate the night production to be 12.5% less than the day shift production. For shifts longer than 9 hours, production can also be reduced by an additional 6% per extra hour over 9 hours.

From existing literature, we know that there are several ways to calculate equipment costs. The after-tax cash flow (ATCF) method is better than a machine rate method because the ATCF method can consider atypical salvage values and account for them when equipment is used and then sold. The ATCF method also allows for assigning costs in the year of occurrence, rather than averaging them over the life of the equipment. Existing literature also provides some guidance on production changes between day and late shift production rates, but information is lacking on the costs associated with implementing extended working hour schedules.

4.1 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. A face-to-face interview method was selected because more in-depth information can usually be attained in person, as opposed to telephone calls or through mail surveys. 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. 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. This was a 100% sampling of those logging business owners that could be identified. All leads to finding logging business owners to had tried implementing extended working hour schedules in the southern states were exhausted. Therefore, the sample of 22 should provide a representative depiction of extended working hour schedule implementation in the southern states. Because some loggers were found through contacts with other loggers implementing extended working schedules, the snowball method (Ritchie et al, 2003), there was limited variety in the types of logging business owners interviewed. The bulk of the logging business owners interviewed were preferred suppliers for large timber industries, so the survey was biased toward this type of logging business owner.

The interview questions were used as a guide, and some of the discussions led away from the topics and provided some additional insightful information. After the first few interviews, the survey was expanded to include more detailed financial-related questions. Generally, interviews lasted for one hour. Interviews were held in the woods, at restaurants, and at business offices over the course of 18 months. Data collected during the interviews included shift hours, repair and maintenance considerations, safety considerations, operational differences between the day and late shifts, tract selection criteria, and production increases attributed to extended working schedule implementation (Appendix A). In addition to contacting logging business owners, three of the well-known insurance providers were contacted to determine if implementing extended working hours would impact insurance costs.

Two schedules were compared in an after-tax cash flow analysis. One represents a popular schedule used by many of the logging business owners interviewed. The other schedule selected for the analysis represents the logging business owners on the high end of the scheduled machine hour spectrum.

An updated version of the spreadsheet model developed by Tufts and Mills (1982) was used for the after-tax cash flow analysis. The spreadsheet-based model is both automated and flexible allowing for adjustments in some of the costs associated with implementing extended working hours.

4.2 Results and Discussion

4.2.1. Shift Hours

A variety of extended working schedules were observed. Only twelve of the twenty-two logging business owners who tried implementing extended working schedules continue to use them, ten logging business owners returned to traditional working schedules. Of the twelve that continue to implement extended working schedules, eleven schedules include two shifts per day. The shifts encompass 15 – 24 hours/day. One unique schedule rotates 7 days on and 7 days off with 12-hour work days.

4.2.2. Repair and Maintenance

The regular scheduled maintenance that is normally performed after a certain number of machine hours will not change, but those maintenance costs will be borne in a shorter timeframe under an extended hour schedule. For example, the oil change schedule for a 24 hours/day schedule, triple the scheduled machine hours as compared to an 8-hours/day working schedule, could require three oil changes in a timeframe as opposed to one oil change during the same timeframe for a traditional shift machine.

A larger inventory of common repair parts (hoses, oil and filters) may be needed because supply vendors will probably not be open during the extended work hours. When machines are used for extended hours, down time for repairs may impact production more than they would under a traditional working schedule. This is because extended working hour schedules have fewer unscheduled working hours available for making repairs. In contrast, under a traditional schedule, some repairs can be performed during the evening or early morning hours, without impacting production time. In some areas, vendors have been very helpful by opening day or night for emergency repairs. One crew that was interviewed had a supply trailer filled with spare parts supplied by the vendor. The vendor inventories the trailer contents and invoices the logging business for the products that had been removed. This is advantageous in reducing equipment down time, but many companies may not be able to have this in-woods inventory. Most of those interviewed said that they didn't increase their parts inventory when they switched to extended working hours. They just replenished typical replacement parts in their inventory as they were used.

Many of the logging business owners implementing extended working schedules often use smaller crews on the late shift as compared to the day shift, leaving some equipment parked during the late shift. Down time for the late shift can be reduced when equipment malfunctions because the operator can switch to the parked piece of equipment and keep working. The repair would be corrected during daylight hours.

One interview topic concerned the changes in repairs upon implementing extended working hours. The predominant interview response was that there wasn't a noticeable change in the wear and tear of the equipment. Only one logger noticed an increase in equipment damage, but he attributes this to his equipment choice. He was using a harvester to fell at night and the operator hit the boom on branches more at night.

The Forest Resources Association, Appalachian Region, reported their findings of commonly neglected maintenance items from the equipment dealer's perspective and from the logger's perspective (FRA, 2006a; FRA, 2006b). These maintenance items are listed here because they may become more important when a machine is worked under an extended working hour schedule. The equipment dealers identified these commonly neglected maintenance items that loggers were not performing:

- Failure to grease machines often enough or properly,
- Failure to check and change oil and filter often enough,
- Not keeping air filter clean or not changing it often enough
- Inadequate tire pressure in wheeled machines.

Equipment dealers can provide a variety of services beyond parts and labor. Some dealers can assist with oil sampling analysis, others provide service outside of traditional hours on logging sites, and still others provide service contracts (FRA, 2006a).

In the logger study (FRA, 2006b), many of the same items listed by the dealers were repeated, especially those relating to greasing machines and checking and changing various oils and filters. In addition, the loggers recommended daily walk around inspections and power washing machines. Problems can be identified easier and sooner on a clean machine. Keeping tire pressures to manufacturer's recommendations reduces the risk of getting debris between the tires and rims. Taking time to do maintenance and impact a few loads is better than missing a lot of loads due to a major repair that could have been prevented.

In addition, the loggers in the Appalachian survey listed some areas for their own improvement. These areas included better record keeping and documentation; and devoting more time to maintenance and keeping maintenance on schedule.

All of these observations and suggestions from Appalachian loggers and equipment dealers should be applicable to the southern region of the United States. With the additional hours on machines working extended hours, some of these improvements may be a necessity. If communication between day and the late shift crews is poor, a maintenance record log could help to make sure that scheduled maintenance is completed on time. One of the southern logging business owners mentioned that he keeps such a log at his shop and machine operators have plenty of warning of upcoming scheduled maintenance.

Some logging business owners interviewed said that they plan repair and maintenance in accordance with the schedule recommended by the manufacturer. Most have their crews perform the daily maintenance and simple repairs. More involved maintenance and repairs are usually performed at a separate maintenance shop or the at the equipment dealer's shop. Some maintenance may be delayed until a weekend so the down time does not impact a regular scheduled work day.

One business owner stated that his new machines have 5,000 hours on them after just 18 months. Daily maintenance, like lubricating the machine, is performed by crew members. However, the equipment dealer performs monthly maintenance and testing, such as checking for metal in the machine oil. This arrangement works without causing production delays because the dealer provides temporary loaner equipment while the company's machines are in for maintenance. The owner strictly adheres to the manufacturer's maintenance schedule to avoid losing production due to equipment failure.

None of the logging business owners interviewed reported higher repair and maintenance costs upon implementing extended working hours. Working in unfamiliar terrain would be one reason why machines could potentially exhibit more repair and maintenance costs. A machine operator could run into a ditch or get stuck in a wet area in unfamiliar terrain. One way logging business owners addressed this was to have the late afternoon shift begin their work during daylight hours when operators could see any potential terrain problems. One crew used glow sticks to identify hazardous areas during the later portion of the day shift. These sticks glowed into the evening hours to alert the late afternoon shift operators to the locations of holes and protected areas.

Additional lighting is often added to equipment for working after daylight hours. Several logging business owners stated that their manufacturer's add-on lighting package cost $3,000. This additional cost is often included in the initial purchase price. Others have added a variety of types of lights to equipment, with costs soaring as high as $500 each for aviation lights added to a skidder. Accountants or bookkeepers should be consulted because receipts for these added lights may be used to reduce the basis, or book value, of the equipment when it is sold.

4.2.3. Salvage Values

The logging equipment used in extended working hours in the southeastern states was fairly new. Feller-bunchers were 1 to 2 years old. Skidders ranged from 3 years old to brand new. The oldest loader age recorded was just 3 years. In logging businesses where there was more than one logging operation (side), equipment was transferred from the extended working hours side to one of the traditional working hours sides. Moving equipment between sides allowed the extended working hours side to use new equipment with minimal down time for repairs. Transferring the machines to the traditional sides kept new equipment with newer technology in the equipment fleet.

One concern about impacts on equipment salvage values was identified in a conversation with an insurance company representative. If a loss occurs due to fire or theft, insurance adjusters may decrease the insured loss value of the machine. Depending on how the machine was financed, this reduced value may be below the amount still owed on it at the time of the loss. In this case, the insurance company insured equipment based on some other value, and not on the replacement cost. Although insurance accounts for just 3% of logging costs (Stuart et al, 2007), the impact of the value loss, if realized, could be substantial. The cost of insurance premiums could change if machines used in extended hour working schedules were insured for full replacement value instead of an adjusted fair market value.

Thompson and Rummer (2006) developed salvage value curves based on real equipment auction data for the southern region of the United States. Because the extended working hours schedule is new in this region, it is assumed that the machines in the auction data were used under a traditional schedule of 2,000 scheduled machine hours per year. Age is related to a percentage of the original equipment purchase price for grapple skidders as shown in Figure 4.2. Data from Thompson and Rummer (2006) are displayed as the traditional 8 hrs/day line in Figure 4.2.

The extended working hour schedule curves in Figure 4.2 were generated by converting the years of the traditional hours to scheduled machine hours (smh) using 2000 smh/year. The percent of original purchase price value was then estimated by linear interpolation of 4625 hours/year for the 18.5 hours/day schedule and 6000 hours/year for the 24 hours/day schedule.

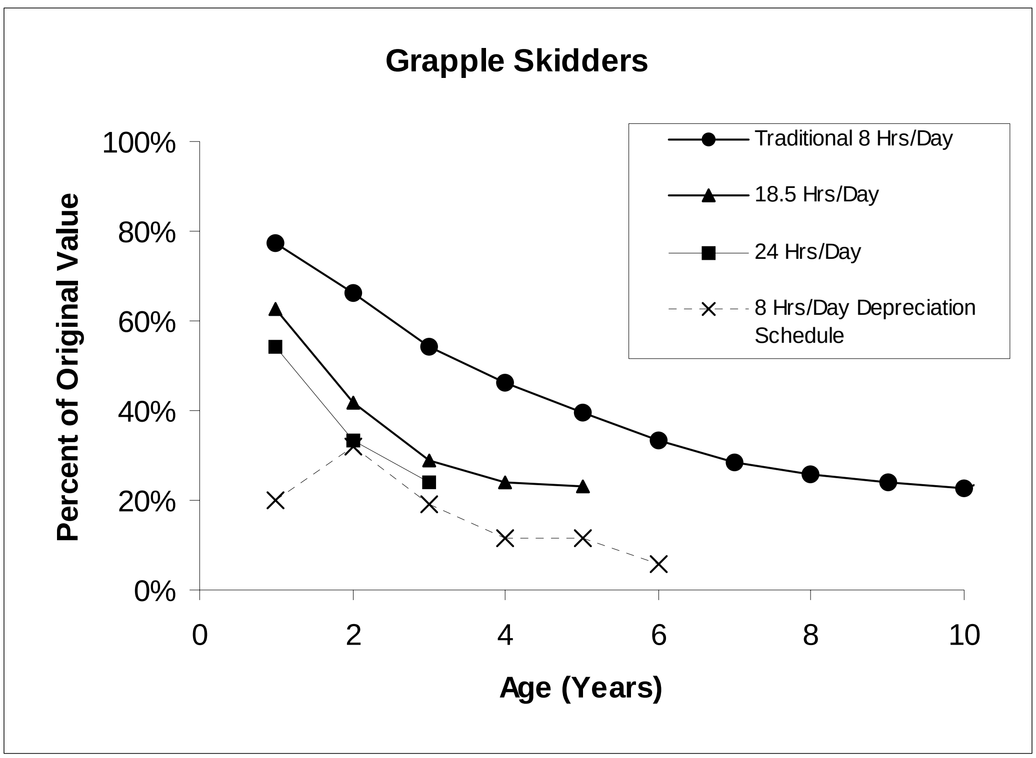

Figure 4.2. Salvage value curve for traditional schedule grapple skidders (Thompson and Rummer, 2006) adjusted to reflect potential salvage values for grapple skidders used in two extended working hour schedules with depreciation curve to indicate potential capital gains if equipment is sold.

The salvage value curve for grapple skidders under the traditional schedule shows that salvage values are relatively level between years 8 through 10. However, when operating a schedule of 18.5 hours/day or 24 hours/day, the salvage values of grapple skidders reach the 9-year salvage value in just 4 years. Under a traditional schedule, the average grapple skidder salvage value is 46% of the original purchase price at age 4. After 4 years of implementing a 18.5 hrs/day or 24 hrs/day schedule, the salvage value drops to 23-24% of the original purchase price.

Wheeled feller bunchers indicate a similar salvage value impact from the implementation of extended working hours. Machines reach a fairly level salvage value of approximately 20% after 10 years of traditional schedule use (2000 SMH/year). Machines used under extended working schedules of 18.5 or 24 hrs/day reach 21% of their original purchase price after only 4-5 years. Traditional schedule machine use maintains approximately 38% of the original purchase price in year 5.

Knuckleboom loaders appear to reach a salvage value of 26% of the original purchase price after 5 years of implementing an 18.5 hrs/day schedule. Under a 24 hour/day schedule, knuckleboom loaders reach 26% of the original purchase price after just 4 years. The traditional schedule machine does not reach a salvage value of 26% of the original purchase price until year 10.

Analysis of Figure 4.2 provides evidence of potential financial concerns from implementing extended working hours. However, the impact of high machine hours on a newer machine may not follow the salvage value curve for a traditional working schedule. There isn't any published literature on the impact of extended working hours on salvage values of forestry equipment. Attempts to include salvage values in a cost analysis should include a sensitivity analysis until further auction or resale data is available. Figure 4.2 should reflect a worst case example of the impact of salvage values because the linear interpolation method of generating the curves only accounted for the scheduled machine hours, and did not include consideration for the machine's year of manufacture or the values that may be associated with newer machine improvements. These salvage values are important because they can impact the adjusted basis of a piece of equipment for tax purposes. The depreciation curve shown in Figure 4.2 is based on the values shown in Table 4.1. For each year shown, the difference between the salvage value and the depreciated value indicate potential taxable capital gains that could be realized if the equipment was sold. The salvage value curves for the extended working hour schedules follow the depreciation curve more closely than the salvage curve for the traditional schedule.

4.2.4. Insurance and Safety

The topic of safety has been incorporated into the financial considerations because increases in workman's compensation and liability insurances could negatively impact insurance costs. Four representatives from three popular logger's insurance providers were contacted by phone. They were asked about their concerns with implementing extended working hours in southern forests. Their responses varied widely. Two representatives said that if the field representatives did not raise a concern, there would not be a change in insurance coverage or rates. The other two representatives reported that they did not have any concerns as long as the crews did not fell or haul at night. Both stated that there would not be a rate surcharge if night operations were limited to skidding and loading.

Insurance company representatives stated that night hauling could be a higher risk for underwriting liability insurance because truck visibility was a problem. Their greatest concern was hauling at dawn and dusk because log trailers have a low profile and are difficult to see when they are empty. They stated that reflective tape on the trailers is not usually adequate and lights cannot be mounted on the bolsters (standards) because they get broken off during loading and unloading. Insurance representatives reported that even with back lights and meeting other state requirements (for example, strobe lights on longest log), their worst reported accidents occur at dawn and dusk with vehicles running into the side of the trailer.

Two loggers reported having vehicular accidents 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 lowboy trailer and snagged some power lines that were hanging low over the road. Neither of these accidents would have happened during the day, as other drivers would be able to see the equipment during the daylight and the crew members would have been able to see the low hanging power lines during daylight hours.

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 (NCCI, 2008). Because the use of extended working hours in the southern states is a recent development, insurance companies do not have a history of accidents and injuries to determine the insurance risk of the practice. Rate differences will only be expressed as loss history accumulates. However, even if specific data regarding increased felling accident rates after dusk cannot be cited, a company can determine that night felling and hauling are an unacceptable risk for the company's shareholders. None of the logging business owners reported an increase in their insurance premiums due to extended working hours, nor did any report having any accidents in the woods on the late shift.

Loggers indicated that many operations choose to use only mechanized equipment after dusk. Workers can operate most mechanized equipment from the safety of the machine's cab, which reduces the risk of slips, trips and falls in uneven terrain and downed timber after dark. State workman's compensation rates are often lower for mechanized operations as compared to operations using manual labor chainsaw felling. Reductions in accident rates can be partially attributable to increased mechanization of felling (LeFort et al, 2003). Insurance rates are often increased for logging companies while they are working in timber salvage operations, which has an increased worker safety risk. While the data collected didn't indicate an increase in accidents or injuries during this study, the small sample size cannot be extrapolated to a larger population. It is unknown if working extended shifts will change workman's compensation premiums in the future. Still, the best way to reduce the insurance expense is to work safely (Reisinger et al, 1994).

4.2.5. Operational Characteristics

In addition to actual work schedule differences, logging business owners also differ on how work is implemented during extended work hours. One of the more notable differences is whether a crew fells at night or not. Five crews tried night felling. Four of those crews have quit using extended working hours. Only one crew has continued felling at night. In order to keep enough wood ahead of the skidders, two other crews fell from daylight to dark. Another option to keep felling from being a bottleneck is to add a second cutting machine to the daytime operations and concentrate on skidding, and processing during the late shift.

Three of the crews currently using extended working hours haul at night. Some end trucking at 10 pm because of mill delivery hours. Most that tried hauling during the late shift had problems getting truck drivers to haul at night, so trucking was typically limited to daylight hours. Three logging businesses used setout trailers, either for products that couldn't be hauled at night due to mill delivery hours, or because night trucking availability was a problem.

On average, the late crew was half the number of people as on the day crew. The size of the late crew ranged from 29-100% of the day shift crew size.

Generally, most crews operated one grapple skidder and one loader during the late shift. Two crews did not skid during the late shift, they only operated log processors and loaders. Using a processing head allowed the operator to safely buck the logs at night while obtaining the increased value for each log. Most businesses that use nonmechanized operations, such as chainsaw felling or cable skidders, must usually limit these activities to daylight hours due to visibility and worker safety concerns.

Two different logging business owners tried to use cut-to-length equipment for extended working hours. Both operated the harvester and forwarder during the day shift. However, one logging business owner parked the forwarder and operated the processor during the late shift. The other worked the machines in an opposite manner, by parking the harvester during the late shift and operating the forwarder. Both have quit implementing extended working hour schedules.

One 24-hour logging business owner had his thinning crew fell the “take down” rows during the daylight hours because the operators can’t keep a row straight after dark. Night felling was limited to thinning between the rows. Other logging business owners only scheduled felling from daylight to dark.

Some efficiencies reported during the interviews may help in keeping production within range of a set goal. Many reported that felling at night was slow. Those that tried night felling recommend cutting trees near sensitive areas (power lines, streams, etc) during the day, leaving easier areas for the late shift. One logging business owner related operating a feller-buncher at night to “riding a bike at night in unfamiliar territory, you can’t tell you’ve hit a rock until you see the sparks”. One logging business owner recommended using traditional ground-based equipment, not harvesters, for extended working hours. He said that the harvester was a more complicated piece of equipment and finding trained operators was a challenge. Some only skid the removal (“take-down”) rows at night, so the day crew could skid the in-between row thinned areas. Others skidded the longer distances during the day, leaving shorter skids for the late shift.

One logging business owner reported that although skidding at night was slower than during the day, processing and loading after dark was faster because there were fewer visitors and distractions at night.

4.2.6 Tract Selection

Because all of the logging business owners found for this study were preferred suppliers for timber industries, most relied on company land or company stumpage for their extended shift operations. Larger tracts were preferred by logging business owners to limit the number of moves. When operating extended working hours, the production increases necessitate frequent moves if the tracts are small. Most logging business owners specified tract sizes of 65 to 80 acres for their extended working hour crews. Limited undergrowth, flat terrain, and all-weather access roads were cited as the best tract conditions for extended working hour implementation.

Having available tracts is very important to keeping crews on an extended working hour schedule busy. But, having tracts is just one part of successful implementation of extended working hour schedules. Available markets are also important. If mills are full and limiting deliveries, logging business owners that are implementing extended work hours will not be able to deliver their products. If deliveries for one product are limited, a variety of products to deliver to other mills can help alleviate the problem if it is short-term. However, it is important to have support from the mills for implementing extended working hours to avoid or reduce the impact of delivery quotas.

4.2.6.1 Noise

The ownership pattern of timberlands can play a part in the decision to select a tract for extended work hours. Logging equipment noise from working extended hours will not usually impact adjacent landowners if the tract is in a large, undeveloped parcel of land. In the southeastern states, the timberlands may be near the wildland urban interface or near rural homes. However, noise was not a common problem for loggers implementing extended working hours. In some areas, the logging business owner contacted residents adjacent to a tract and explained what they were doing and why. Some parishes of Louisiana have already implemented noise-restriction ordinances.

4.2.6.2 Harvest Type

Type of harvest operation was considered as a possible deterrent to implementing extended working schedules. All of the logging business owners operated in tracts of fairly flat terrain, consisting mostly of various types of southern pine trees, and with mechanized ground-based harvesting systems. Of the twenty-two loggers implementing extended working hours, nine returned to traditional hours. Of those nine, six were clearcut operations and three were thinning operations. Alternatively, of those that continued implementing extended working hours, eight were clearcutting operations, and five were thinning operations. Therefore, type of harvest operation did not explain why some logging business owners quit using extended working hours schedules.

4.2.6.3 Night Hauling

In the southeastern states loaded log trucks haul a large percentage of their loads over county roads. Safety issues surrounding log transport at night become even more important when there are mixed types of traffic on a road. Many states have laws regulating the amount of overhang that is allowed from the rear of the trailer after dark. Others require a strobe light to be mounted on the longest log. If hauling after dark becomes more common, states may further restrict their transportation regulations.

4.2.6.4 Terrain

Not all logging sites are applicable to logging in the dark. When working in steep terrain, equipment operators may need to pick the safest travel route between trees, and this may be more difficult in the dark. Uneven terrain or small ravines may not be as visible if it is in the shadows of the night working lights. This provides additional incentives for some operations to limit felling to daylight hours.

4.2.6.5 Sensitive Areas

Extra precautions are often needed when working near sensitive areas, such as streams or protected sites. Cutting timber in these areas may require a technique known as directional felling. This is a method of felling the timber away from the sensitive area. In the dark, the sensitive area may be beyond the lighted working area, but within the tree's length, increasing the chance of having a tree top enter the protected area. The logging crew must take special protective measures to either log adjacent areas during the daylight hours, or adequately mark the areas for avoidance after sunset.

4.2.7 Production Rates

One of the main drivers for implementing extended working hours was increased overall production with an anticipated reduction in the cost per unit produced. So, the interviews included a question relating the logger's production under the traditional working hours versus the extended working hours.

A wide range of production was found. Different harvest systems, equipment use, crew size and hours per shift are responsible for some of the variety of production rates found. Overall, loggers in the southeastern states reported an increase in total production from implementing extended working hours as compared to traditional hours. However, lack of adequate production increases was often cited as a reason for quitting use of extended working hours. A statistical analysis was performed to determine if there was a difference in the production changes between the group of logging business owners who quit implementing extended working hours and those that continued to implement extended working hours. The average production increase cited by those that quit implementing extended hours was 51%. The average production increase cited by those that continued implementing extended working hours was 56%. The data did not provide evidence of a difference in the production increases between the two groups (Appendix B). So, the analysis indicates that the loggers who quit implementing extended working hours due to lack of adequate production increases may have required more production increase than those continuing to implement extended hours. But, upon further review of the interview responses, the production increases were calculated in response to the questions about production before and after implementing extended working hours. Further review of the data indicates that tract availability may have been more to blame. Without continued tracts to cut, the available wood supply would not support two shifts.

When the production increases of those continuing to implement extended working hour schedules are further separated into groups by cut type (clearcut or thin), no evidence of a difference in production increases was detected (Appendix B). However, when shift schedules are also considered, production changes become more apparent. Those two logging business owners implementing a 24-hour schedule indicate that the two shifts have the same production rate. One of these owners is implementing a 24-hour schedule in thinnings, while the other implements the schedule in clearcuts. For those crews working less than 24 hours per day, logging business owners of thinning crews reported average production rate increases of 40% after shift work implementation. The average production increase for clearcutting crews was 47%. Again, the statistical analysis was not able to detect a statistically significant difference in the production increases between the two groups (Appendix B). But, the analysis did provide evidence of a statistical difference (p-value<0.0001) in the production increase for logging business owners implementing a 24 hours/day schedule and those using a shorter daily schedule (Appendix B.).

To further complicate these comparisons, the late shifts were frequently working not only shorter hours/shift (on average 1.2 fewer hours), but also with smaller crews. For those operations scheduling 2 shifts/day, the late shift consisted of 49% fewer people on a crew. The average day shift crew size was 6 people, while the night crew averaged 3 people.

These overall production findings are somewhat consistent with Nicholls et al (2004), who found late shift production to be 78% of the day shift given the same number of working hours per shift. The production rate similarities in the studies imply that adding a second shift to a logging operation can increase production, but does not typically result in a doubling of production.

These numbers do not reveal the production rate change per shift. Most loggers in the study were not able to determine the amount of production for each shift. The most common way loggers use to determine the production, or loads, per shift would be to examine a loader book. A detailed loader book is often used to record information such as the load number, truck driver and resulting mill delivery ticket. However, because only 6 loggers hauled at night, loads of those loggers who did not haul at night were not recorded until trucks arrived in the morning. At that time, it was difficult to determine which shift produced which logs.

Even if truck drivers were available to haul at night, mill delivery hours created another obstacle to overcome to make implementing extended working hours successful. Many of the logging business owners had support from pulp mills in their area for night deliveries, but mills for other products had limited delivery hours. Most loggers reported that they could haul pine pulpwood 24 hours/day. However, all of the logging business owners interviewed, except one, reported hauling multiple products from a tract. Only one logger had the luxury of only harvesting and hauling pine pulpwood. Chip-and-saw mills typically closed their gates to deliveries between 8 or 9 p.m. Sawtimber mills usually closed their gates by 5 or 6 p.m. Only one mill in the delivery area accepted evening deliveries for pine sawtimber. Even if night trucking was not a problem, some loggers chose not to haul at anything night because their primary products were chip-and-saw and sawtimber, and mill delivery hours could not support night deliveries of these products.

Many loggers cited reduced night shift production as compared to the day crew. Without night hauling, the loading area of a logging operation can get congested during the late shift. The log inventory in a loading area may hold logs from the later hours of the day shift plus the production from the late shift. The size of the loading area may delay day shift production until trucks can be loaded and the loading area cleared.

If the crews were paid on a ton/shift basis, additional complications arose. In two cases, the day crew concentrated on the short skids to get more wood to the ramp during the day resulting in a high production rate for that shift. However, this left the longer pulls for the night crew which further reduced their late shift production. Logging business owners who tried this payment type changed to other methods such as hourly pay or shift basis payments.

4.2.7.1 Logging Business Owner Demographics

Most of the logging business owners in this study had been working in logging for as few as 4 years to over 25 years. The average years of logging experience of the business owners was 19 years (median = 18.5 years). Only five of the twenty-two interviewed had less than 15 years of experience. The average years of experience of those that quit using extended hours was 20.3 years. A t-test statistical analysis was used to determine if there was a difference in the years of logging experience between the group of logging business owners who quit using extended working hours and those that continued using extended working hours. Analysis of the sample data resulted in little evidence (p-value = 0.4506) to suggest that there was a difference in the logging experience levels between the two groups (Appendix B). However, this finding could be confounded with the fact that all of those interviewed were either preferred suppliers for timber industry firms or were specifically asked to participate in a program to test implementing extended working hours.

4.2.8 Machine Cost Analysis

A machine cost analysis was performed to display some of the costs that could differ between extended work schedules and traditional work schedules. Costs were examined using owning and operating costs because several of the logging business owners said that they would not be interested in leasing equipment. They preferred to earn equity in their equipment. A few said they were interested in leasing equipment, but none of the manufacturers were offering lease options when they began implementing extended working hours. The cost of leased equipment is not included in this analysis because none of the logging business owners were leasing equipment for use in extended working hour schedules.

Two separate comparative analyses were performed. In the first analysis, the costs of a grapple skidder are examined using three work schedules. The purpose of examining just one piece of equipment is to display a simple analysis and discuss the impacts production, salvage values, and labor rates can have on costs. In the second analysis, the costs of for an entire harvesting system are compared using the same three work schedules.

4.2.8.1 Equivalent Annual Cost Analysis for a Grapple Skidder

An equivalent annual cost (EAC) analysis was performed to calculate the cost differences for a single grapple skidder using extended working schedules. The analysis included two extended working schedules to compare the range of the work schedules reported during the interviews. The traditional schedule was included as a source of comparison to determine if working extended hours schedules can actually reduce the cost of producing a ton of wood. The traditional schedule is defined as 8 hours/day with weekends off, or 2000 scheduled machine hours (smh) per year. For this analysis, the average production rate under the traditional shift operation is 26 tons/smh, which is roughly the equivalent of a load per clock hour.

The first alternative is the true 24 hours/day schedule. This 2-12 hour shifts/day schedule was found in 5 different businesses. Although only 2 logging business owners elected to continue implementing this schedule and 3 quit using extended working schedules, it was selected as the alternative representing the maximum scheduled hours in a day. For this maximum use alternative, the skidder is scheduled to work for two 12-hour shifts/day, 5 days/week (6000 smh/year). Day shift production is estimated to be the same as the traditional shift (26 tons/smh), but the late shift production rate is reduced. Late shift production was 22% less than the day shift production in one study (Nicholls et al, 2004) and 12.5% in another (Murphy and Vanderberg, 2004). In this analysis, an average between the two published late shift production reductions was used (17.25%, rounded to 17%). The day shift production rate was reduced by 17% to represent the production rate on the late shift, or 21.58 tons/smh. A daily weighted average production rate was calculated for the 24-hour work day, resulting in a rate of 23.79 tons/smh (Appendix C).

The second alternative is representative of the two scheduled shifts per day, 5 days/week, but only working 18.5 hours/day (4625 smh/year). Under this alternative, a single skidder is scheduled to work 9.5 hours on the day shift (26 tons/smh) and 9 hours on the late shift. Hourly production during the 9-hour late shift is estimated to be 17% less than the day shift rate, or 21.58 tons/smh. For the 18.5 hour shift, the weighted average production rate is 23.85 tons/smh (Appendix C).

Several assumptions were made for the purpose of the comparison cost analysis displayed in Table 4.2. The use of these assumptions may create an unusually low costs, but the purpose of the cost analysis is to provide a comparison between working schedules rather than provide exact costs. The assumptions are:

- Fuel cost is estimated given the published rate for off-road diesel (EIA, 2008) and fuel consumption for a 180-hp skidder (Plummer and Stokes, 1983);
- Lubrication is estimated at 40% of fuel costs (Plummer and Stokes, 1983);
- A major repair of $15,000 is included in the analysis at 6,000 machine hours;
- A fixed maintenance and repair cost is calculated as a percentage of the purchase price (Brinker, 2002) less the major repair;
- Inflation is included in the analysis for fuel and lubrication, repair and maintenance, and labor;
- Salvage values were determined using Thompson and Rummer (2006);
- Labor rates do not include a shift differential for the late shift;
- Original purchase price is $175,000 without any equipment traded in at purchase;
- The machine is purchased without financing,
- Analysis does not include profits;

- Productive machine hours remain constant throughout the analysis timeframe and do not lessen with machine age; and
- Expected machine life is 10,000 hours, rounded up to the whole year.

Another assumption was made regarding administrative overhead. It can be considered as a fixed cost and would be paid regardless of the number of hours worked. Alternatively, a percentage of the administrative overhead expenses could be assigned to each ton of wood produced. If administrative overhead expenses are tied to production, extended working hours could reduce the percentage assignment charged per ton because the costs could be spread over the additional production. Administrative overhead costs were not included in the analysis because they only account for 3% of logging business cost components (Stuart et al, 2007) and because they can vary widely between logging businesses.

The annual costs for each of the schedules are displayed in Table 4.2. The average cost of producing each ton of wood under the traditional schedule is $1.96/ton in the first year of ownership. The cost of owning and operating the skidder for a two year period lowers to $1.81/ton. If the skidder is operated for a third year and then sold, the cost is $1.76/ton. As a result of the analysis, the skidder should be owned and operated for four years and sold at the end of the fourth year to produce wood at the lowest cost ($1.71/ton).

Table 4.2. Comparison of equivalent annual costs (EAC) by working schedule.

	Equipment Ownership Period (Years)				
	1	2	3	4	5
Traditional Schedule (8 hours/day)					
EAC	$101,966	$94,239	$91,298	$88,903	$100,244
$/ton	$1.96	$1.81	$1.76	**$1.71**	$1.93
24-Hour Schedule					
EAC	$229,772	$219,901	$210,089	Na	Na
$/ton	$1.61	$1.54	**$1.47**	Na	Na
18.5-Hour Schedule					
EAC	$183,952	$174,032	$171,987	$167,464	Na
$/ton	$1.67	$1.58	$1.56	**$1.52**	Na

For the 24-hour schedule, the lowest cost of owning and operating the skidder occurs in the third year of ownership ($1.47/ton). If the skidder is owned and operated under the 18.5-hour schedule, the lowest cost occurs in the fourth year of ownership ($1.52/ton).

Both of the extended working hour schedules have lower costs/ton to own and operate the skidder than the traditional schedule, given the optimum years of ownership for each schedule. If the skidder is operated for 3 years under the 24-hour schedule, the cost/ton is 14.0% less than the lowest cost/ton under the traditional schedule. If the skidder is operated for 18.5 hours/day, the cost is 11.1% lower than the cost/ton associated with owning and operating the skidder under a traditional schedule. Even with the reduced production rates during the late shift, both of the extended hour working schedules resulted in lower costs/ton than the traditional schedule.

Of course, the annual cost for the optimum ownership period of the traditional shift is lower than the optimum ownership periods of either of the extended working schedules analyzed (Table 4.2). This annual cost difference can be explained by the difference in the total variable costs associated with traditional working schedules as opposed to the total variable costs associated with longer (18.5 or 24) scheduled working hours per day (Appendix C). But, when the incremental cost of producing a ton of wood ($/ton) is used in the comparison, the total annual costs are spread over the additional production created during the extended working hours.

The salvage values are expected to decline more rapidly for the extended working schedules as compared to the salvage values from traditional schedule implementation (Figure 4.2). The difference between the salvage value and the book value (adjusted basis less accumulated depreciation) of equipment is used in the EAC analysis for estimating the potential taxable gains (or losses) from the sale of equipment. Salvage values are also used in the analysis to calculate insurance expenses. Both of the extended working hour schedules analyzed have lower insurance costs as compared to the traditional schedule due to the decreased salvage values.

An EAC analysis allows for assigning large maintenance expenses in the year of the planned expenditure. In this analysis, the 6,000-hour major repair occurs in different years, based on hours of use. Under the 24-hour schedule, the major repair occurs in year 2, whereas under the traditional schedule, the major repair does not occur until year 5. Under the 18.5-hour schedule, the major repair occurs in year 3. The impact of this large repair expense on the cost/ton is lessened under the extended working hour schedules because it is spread across more annual tons produced as compared to the traditional schedule. The annual production for each schedule is displayed in Table 4.3.

Table 4.3. Comparison of annual production of a grapple skidder by working schedule.

Schedule	Tons/Scheduled Machine Hour	Total Annual Tons
Traditional (8 hours)	26	52,000
24 Hours	23.79	142,740
18.5 Hours	23.85	110,306

4.2.8.1.1 Sensitivity Analysis for Various Production Rates

Since a variety of production increases were found during the logging business interview process, a sensitivity analysis was performed for the three skidder schedules to determine the impact of a variety of production rates on costs. Previously, the analysis was based on a production rate of 26 tons/smh for the day shift. Production for extended working hour schedules incorporated a late shift production rate of 83% of the day shift, based on an average of previously published data. In this section, the annual equivalent cost/ton is adjusted by reducing the late shift production rate until the resulting cost/ton matches the annual cost/ton of the traditional shift, resulting in a breakeven point. In Figure 4.3, the traditional schedule production was held constant at 26 tons/smh at a production cost of $1.71/ton. For the extended working hour schedules, a daily weighted average was calculated using 26 tons/smh for the day shift and a reduced production rate for the late shift. For example, if the late shift production rate of the 24-hour schedule was 75% of the day shift, the night shift production rate was 26 * 75%, or 19.5 tons/smh. Using two 12-hour shifts resulted in an average daily production of ((26*12) + (19.5*12))/24 = 22.75 tons/smh.

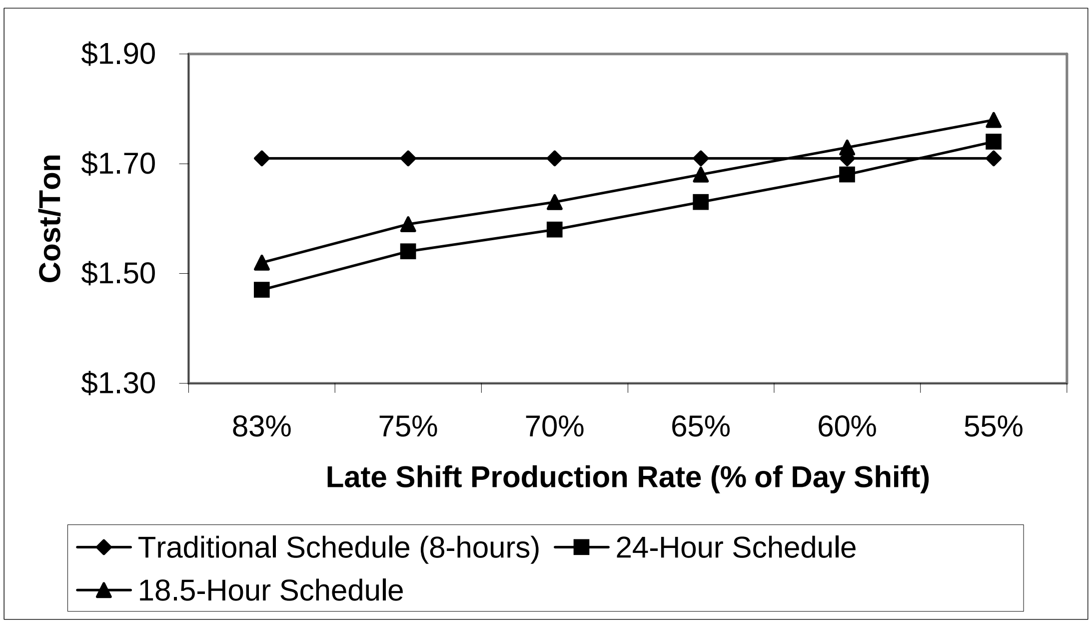

Figure 4.3. Sensitivity of costs for extended working hour schedules when the late shift production rate is lower than the day shift production rate.

The cost of the 24-hour schedule increases from $1.47 to $1.71/ton when the late shift production rate reduces from 83% to 57.5% of the day shift production rate. Since $1.71 is the cost/ton of owning and operating the grapple skidder under the traditional schedule, the cost advantage of the 24-hour schedule disappears when the late shift production rate is 57.5% of the day shift.

When the late shift production rate of the 18.5-hour schedule is 83% of the day shift, the cost/ton is $1.52. The breakeven cost of $1.71/ton is reached when the late shift production rate is reduced to 62% of the day shift production rate.

Changes in the production rate of the late shift can impact the cost of extended working hour implementation. By comparing the owning and operating costs, then analyzing various production rates through a sensitivity analysis, a logging business owner may be able to set reasonable production goals for determining success in implementing extended working hour schedules. During implementation, production rates can be monitored to determine success or failure. If production goals are not met, changes to schedules, late shift operations (equipment mix) or other variables can be made. These changes can be monitored for the effect of the changes.

4.2.8.1.2 Sensitivity Analysis for Salvage Values

Because the salvage values for fairly new equipment sold with high machine hours are unknown, a sensitivity analysis was performed to see what the impact would be if the salvage values were adjusted. As stated earlier, the salvage values used in the analysis did not include consideration for the machine's year of manufacture or the values that may be associated with newer machine improvements. Because the initial analysis considered only the worst case salvage values based on smh, these values were increased to see what impact higher salvage values may have on the costs associated with implementing extended working hours. Figure 4.4 displays the sensitivity analysis for salvage values (also see Appendix C) for the 24-hour and 18.5-hour schedules. Salvage values are used to calculate insurance rates in the EAC analysis, so insurance expenses also change when salvage values are adjusted in the sensitivity analysis. The taxes associated with the gain or loss from the sale of the skidder at the end of the ownership period also change the cost analysis because the gain/loss is determined by the difference between the book value and the salvage value.

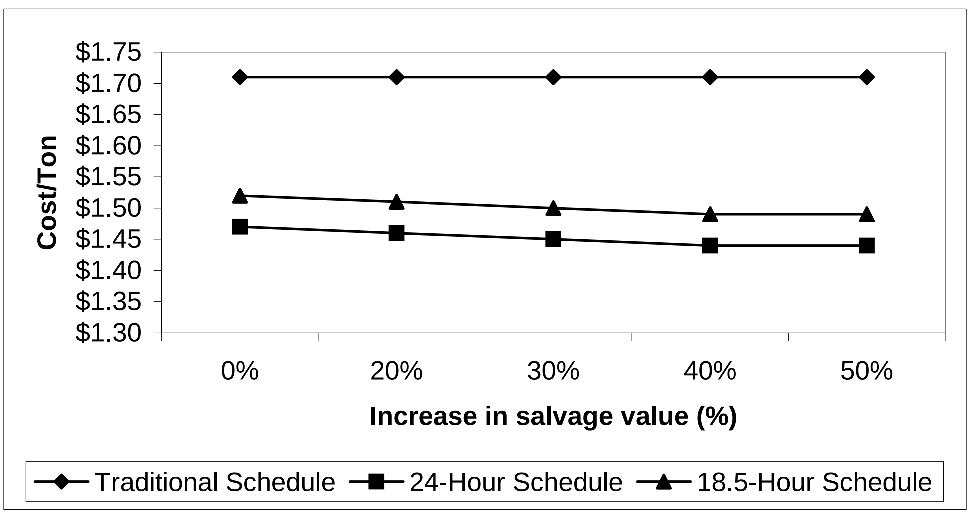

Figure 4.4. Impact of varying salvage values on the equivalent annual costs (in $/ton).

If the salvage values are 20%, 30%, or even 50% higher than the adjusted salvage rates reported by Thompson and Rummer (2006), the cost/ton for either of the extended working hour schedules change only slightly. Under the 24-hour schedule, a 50% increase in the salvage value only lowers the cost/ton by $0.03. A 50% increase in the salvage value at the end of the ownership period of the skidder under the 18.5-hour schedule also results in only a $0.03/ton cost difference.

Several logging business owners indicated that transferring equipment from an extended working hours schedule to another of a company's traditional schedule logging sides may aid in relieving residual value losses. By working equipment for extended hours where machine hours increase at a high rate for a year or two, then operating it on a traditional schedule for a few more years, the average yearly production hours over the life of the machine can be lowered as the equipment ages. By transferring equipment between crews, some of the impact of the high machine hours on salvage values may be avoided or minimized. However, based on this salvage value sensitivity analysis, these actions taken by some of the logging business owners would have had a minimal impact.

4.2.8.1.2 Sensitivity Analysis for Labor Rates

Many of the logging business owners reported paying a higher labor rate for the late shift than for the day shift. In this sensitivity analysis, late shift labor rates were increased in increments of 10% from 0% through 50% to determine the impact of paying a shift differential. Figure 4.4 is a graphical display of the impact.

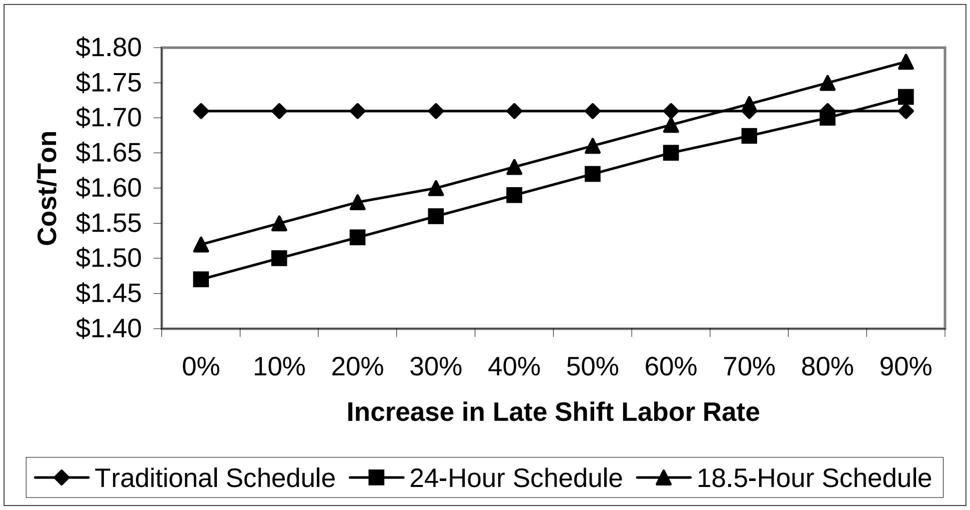

Figure 4.5. Impact on the equivalent annual costs (in $/ton) of varying late shift labor rates as a percentage of the day shift rate.

The impact of increasing the late shift labor rate was minimal in terms of the impact on the cost/ton produced. For each 10% increase in late shift labor rates, the cost/ton increase was only $0.03/ton, including the impact of the 40% fringe benefits cost. Late shift labor rates would have to increase 81% over the day shift rate to make the cost/ton of implementing a 24-hour schedule rise to the costs of the traditional schedule (1.71/ton). A 81% increase of the labor rate used in the analysis ($12.50/hour) would require paying the late shift equipment operators $22.63/hour.

The impact of raising late shift labor rates in 10% increments on the 18.5-hour schedule also resulted in a cost/ton impact of $0.03. Under this extended working hour schedule, the late shift labor rate would have to increase by 66% to bring the cost/ton to the $1.71/ton cost of the traditional schedule. A 66% increase over the $12.50/hour day rate would be $20.75/hour.

Increasing the late shift labor rate has the potential to increase the cost/ton by $0.03 for every 10% increase in the hourly labor rate. The financial impact of paying a night shift differential of 20% ($15/hour) is minimal, and may help in recruiting or retaining late shift employees.

4.2.8.2 Equivalent Annual Cost for a System

The previous section displayed the impacts of extended working hours on the costs of a single piece of equipment. However, the interviews proved that production increases may be attained with a smaller crew on the late shift, and often with fewer hours or fewer machines. In order to display the potential system cost differences between production and costs of various schedule alternatives, an additional EAC analysis is included that incorporates several pieces of equipment.

The traditional schedule is still 8 scheduled machine hours/day, 250 days/year. Equipment included in this operation includes one rubber-tired feller-buncher, two grapple skidders and two loaders. The skidders and loaders are operated for 8 hours/day, and the feller-buncher is operated for 10.18 hours/day. Production from the traditional schedule system is 52 tons/smh. Total annual production of this system is 104,000 tons/year.

The 24-hour schedule still consists of two 12-hour shifts per day. This alternative includes one skidder, one loader, and one feller-buncher. The skidder and loader are scheduled to work a day and a late shift 5 days/week (24 hours/day), 50 weeks/year. The single feller buncher is scheduled to work 14 hours/day, but some of the scheduled felling hours can occur on weekends, especially during the winter when daylight hours are shorter. The day shift production rate is 26 tons/smh. The late shift production rate is 83% of the day shift (21.58 tons/smh). Total annual production of this system is 142,740 tons/year.

The 18.5-hour schedule is 9.5 hours on the day shift, and 9 hours on the late shift, 250 days/year. The equipment mix includes two skidders, two loaders, and two feller-bunchers. One skidder and one loader are only used on the day shift (9.5 hours). The remaining skidder and loader are scheduled to work both shifts, 18.5 hours/day. The feller-bunchers do not fell at night and are scheduled to work 8.42 hours/day. The day shift production rate for the system is 52 tons/smh. The late shift system production rate, based on one skidder and one loader, is reduced to 21.58 tons/smh. Total annual production of this system is 172,000 tons/year.

No attempt is made to "balance" these example systems. They are representative of the equipment mixes and operational characteristics found during the interviews. Additional overhead, employees that are not equipment operators, profit and other expenses not part of the owning and operating costs of equipment are not included. The day shift production rate for the loader was assumed to be the same as the skidder in the previous example, 26 tons/smh. Because feller-bunchers typically have much higher production rates than skidders, the day shift feller-buncher production rate used in all alternatives was 40.86 tons/smh.

An EAC analysis was used to determine the ownership period for each of the systems as a whole, not as individual pieces of equipment, for ease of comparisons (Table 4.4). The late shift production rate used in this analysis is the same as in the previous example of the grapple skidder, 83% of the day shift production rate. In this analysis, the lowest cost of the traditional schedule occurs in the fourth year of ownership at a rate of $4.30/ton. The 24-hour schedule has the lowest cost of $3.90/ton when the ownership period is 3 years. For the 18.5-hour schedule, the lowest cost/ton ($4.16) occurs in the fourth year of ownership.

Table 4.4. System costs of implementing extended work hour schedules.

	Equipment Ownership Period (Years)				
	1	2	3	4	5
Traditional Schedule (8 hours/day) (104,000 tons/year)					
EAC ($)	487,177.19	467,699.68	455,008.34	477,498.66	508,733.28
$/ton ($)	4.68	4.50	4.38	**4.30**	4.89
24-Hour Schedule (142,740 tons/year)					
EAC ($)	599,766.93	574,639.37	556,480.46	Na	Na
$/ton ($)	4.20	4.03	**3.90**	Na	Na
18.5-Hour Schedule (172,000 tons/year)					
EAC ($)	775,235.52	748,351.44	727,665.81	714,944.72	Na
$/ton ($)	4.51	4.35	4.23	**4.16**	Na

One reason that the 24-hour schedule cost/ton is lower than the other two schedules is because the equipment mix is different. The traditional schedule and the 18.5-hour schedule include the cost of owning and operating two skidders and two loaders, but the 24-hour schedule only includes one of each. The schedules are compared using varying equipment mixes because these equipment mixes represent the operations reported by logging business owners during the interviews.

The 24-hour schedule, with the equipment mix of just three machines, can produce wood at a cost of $3.90/ton. This cost is 9.3% less than the cost of operating the five machine mix of the traditional schedule. However, even with the reduced cost/ton, reduced late shift production rate, and fewer pieces of equipment, the 24-hour schedule is capable of producing 37.25% more tons on an annual basis.

The 18.5-hour schedule can produce wood at an estimated cost of $4.16/ton. This cost is 3.26% less than the cost of the traditional schedule. The equipment mix differs between these schedules. The 18.5-hour schedule includes an additional feller-buncher because additional day time felling capacity was needed to meet the production of two day shift loaders and skidders, plus one late shift loader and skidder. The annual production of this schedule is 172,000 tons/year, a 65.38% increase in annual production as compared to the traditional schedule.

4.2.8.2.1 Sensitivity Analysis for Various Production Rates

The sensitivity analyses of the grapple skidder documented in the previous section indicate that salvage values and shift differentials for labor rates do not significantly impact the costs of implementing extended working hour schedules. But, a sensitivity analysis on the system was performed because the results of the survey indicated that production increases from implementing extended working hours varied.

System costs were calculated using a reduced production rate for the night shift (83% of the day shift production rate). Using these system costs as a base value, the annual production was adjusted in increments of 5% to test for the sensitivity of the impact of production levels on costs. Figure 4.6 displays the results of the analysis in graphical form.

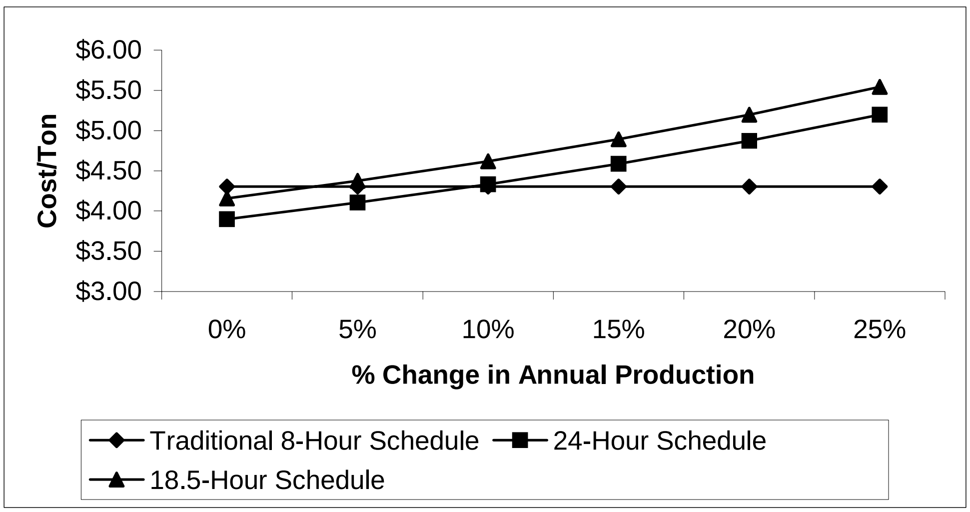

Figure 4.6. Sensitivity of system costs for extended working hour schedules when the annual production is reduced.

Logging costs are very sensitive to annual production. A 5% reduction in annual production for the 18.5-hour schedule results in a 5.26% increase in the cost/ton. This increase causes the 18.5-hour schedule have a higher cost/ton than the traditional schedule. When the annual production of the 18.5-hour schedule drops just 3.3%, the cost/ton equals that of the traditional schedule.

The slopes of the lines for the extended working hour schedules in Figure 4.6 are the same. As in the 18.5-hour schedule, a 5% reduction in the annual production under the 24-hour schedule results in a 5.26% increase in the cost/ton. Under the 24-hour schedule, the breakeven point in cost/ton as compared to the traditional schedule occurs when the annual production is reduced by 9.3%.

One of the explanations for the 6% difference in the breakeven points of the extended working schedules lies in the equipment mix. The 18.5-hour schedule includes six machines in the costs, but also produces more tons on an annual basis. The 24-hour schedule has just three machines and produces 17.03% fewer tons than the 18.5-hour schedule on an annual basis.

Across the range of production rates analyzed, the cost/ton difference between the 24-hour schedule and the 18.5-hour schedule is 6.6%. Both of the extended working hour schedules respond in the same way to production rate changes, with a 5.26% cost/ton increase for every 5% decrease in annual production. This analysis indicates that annual production can impact the cost/ton, but also that the equipment mix is very important to successful extended working hour schedule implementation.

The traditional method of increasing production is to add a second logging side with a complete set of equipment. This production expansion could entail two more loaders, two more skidders, and another feller-buncher added to the equipment fleet of the logging business. Since this equipment mix is the same as the traditional schedule examined, the cost/ton for this second set of equipment is $4.30. Now, the annual production for the logging business is doubled, but the cost is still $4.30/ton.

If the traditional 8-hour schedule (with two skidders, two loaders, and one feller-buncher) produces 26 tons/smh, the total annual production would be 104,000 tons at $4.30/ton. Analysis of two extended working hour schedules indicates that production can be increased at a lower cost/ton as compared to the traditional schedule. However, the production is not doubled, even if scheduled hours are increased by more than double. If the late shift production rate is 83% of the day shift, the total annual production for the 24-hour schedule is 142,740 tons, (37.3% increase over the traditional schedule's annual production) at $3.90/ton. The value of the extended working hour schedule lies in the ability to produce the annual tons at a lower cost/ton. At $3.90/ton, the 24-hour schedule produces wood at 9.3% less than cost/ton of the traditional schedule. For the 18.5-hour schedule, the total annual production is 172,000 tons at $4.16/ton, resulting in an annual production increase of 65.4%. But, the cost/ton of producing the additional tons is 3.26% less than the cost/ton produced under the traditional schedule.

4.3 Conclusions

The majority of the logging business owners used traditional ground-based equipment consisting of feller bunchers, grapple skidders, and tracked or trailer-mounted loaders. Most of the logging business owners in this study did not schedule felling or hauling at night. Operationally, the logging business owners in the southern states used a variety of schedules and varied on the equipment mix that was operated on the late shift. Generally, even if the logging operation used more than one skidder and loader during the day shift, the late shift operation typically consisted of only one skidder and one loader. In general, the late shift crews were about half the size of the day shift.

Larger tracts, 65-80 acres, were preferred by logging business owners to limit the number of moves. Limited undergrowth, flat terrain, and all-weather access roads were cited as the best tract conditions for extended working hour implementation. Noise was not a cited as a problem for tract selection, although most of the logging business owners did not operate in or near urban areas.

An equivalent annual cost method is a readily available analysis tool that has some advantages over using a machine rate. When evaluating or comparing extended working hour schedules and their impacts on the financial burden of the operation, an equivalent cost analysis can take into account the costs for a machine rebuild, or major repair, in a particular year rather than incorporating it across all the years of the machine's expected life. In addition, this analysis tool allows for different types of machine depreciation, as well as the ability to vary salvage values.

Three variables were analyzed for their impacts on extended working hours: production rates, labor costs, and equipment salvage values. Production rates were generally lower for the late shift as compared to the day shift, especially if combined shifts are less than 24 hours/day. However, even with the lower late shift production rates, the extended working hours can be used to produce wood at a lower cost/ton than the traditional 8-hour schedule. A rate differential is often added to the night shift labor rates to recruit and retain forest workers, and the cost of producing wood under the extended working hour schedules is not very sensitive to the higher labor rates associated with a shift differential.

The impact of high equipment use (high machine hours) on salvage values is unknown. Although the equipment may be fairly new (1-3 years old), the hours on a machine used during extended working hours may be double those expected from use under a traditional schedule. Auction data regarding the sale of this type of "high use" of logging equipment does not exist because the implementation of extended working hours in the southern region is fairly recent. A sensitivity analysis indicated that costs of implementing extended working hours were not sensitive to salvage value changes.

In the comparative analysis presented in this chapter, both the 18.5 hours/day and the 24 hours/day schedules increase the annual production, as compared to the traditional schedule production by 65.4% and 37.3%, respectively. However, the 24-hour extended working hour schedule produced wood at a cost that was 9.3% less than the cost of producing wood under the traditional 8-hour schedule. The cost/ton for the 18.5-hour schedule was 3.26% less than the cost/ton of the traditional schedule. The result of implementing extended working hours is that production will be increased, but not doubled, even if the scheduled working hours are more than doubled. However, the ability to spread the ownership and operating costs over the additional production from extended working hour schedules can reduce the cost/ton as compared to the traditional schedule examined in this chapter.

Future sales and auction data that includes equipment used in extended working schedules is needed for better estimates of salvage values. This additional research and future information can lead to better financial decisions regarding equipment management and the impact of salvage values on a company's assets.

Additional research is also needed to determine the production of the late shift. When wood is not hauled at night, it is difficult to discern how much each shift produced. In addition, if a business added hours to the day schedule, production from the longer shift could also be impacted. These production rates are needed to calculate more accurate financial impacts of implementing extended working hours.

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4.5 Appendices

Appendix A. Extended Shift Questionnaire

Background

Date

Logging Company

Contact Name(s)

Address

Supplier for ? Preferred Supplier?

Shift Hours/Operations

How long have you been in the logging business?

When did you start using extended shifts?

Why did you decide to work extended shifts?

How many and what are the shift hours and days/shift? Number of crewmen on each shift?

Do the shifts overlap? Rotate? How often? Direction?

Do you have a crew supervisor for each shift?

How often are you contacted from the crew during the extended shifts?

How are crews paid? (day/by the ton/ hour) Is there a shift differential?

What other equipment was bought for extended shifts? (generator, light pole, etc..)

What support equipment do you own?

What changes have you made in your operations since switching to extended shifts?

When is maintenance performed?

Is there a service mechanic on each shift? At shop or on service truck?

Which shifts?

Has the contents of your service truck/shop changed since increasing shifts? Do you keep more/different parts in stock?

Have you experienced more employee turnover with extended shifts?

Production

Has your production rate per shift increased?

How many loads did you get with a single shift? (day/week)

How many loads with extended shifts? (day/week)

How long did it take to see an advantage in production with extended shifts?

Do you perceive a difference in production rates between the shifts?

If so, how would you characterize this difference?

What equipment is used on each shift? (year/make/model)

Characterize the operations for each shift

Tracts

Do you buy your own wood?

What % of your wood comes from company land or stumpage?

How do you decide which tracts are suitable for extended shifts?

What criteria do you use for determining tract suitability?

Is noise considered a factor in tract selection?

Have you ever had noise complaints?

Are your tracts near urban environments or rural housing?

Do you operate differently if noise is an issue?

Machine Repair, Maintenance & Costs

Have you made any equipment modifications to extended shifts?

Are manufacturer's suggested maintenance schedules adhered to?

How long do you keep your equipment? Has this changed from single/traditional to extended shifts?

How do extended hours/shifts affect your warranty?

Are you seeing any change in the wear and tear of equipment?

How do you handle breakdowns when they occur after normal business hours?

Have you seen a change in your insurance premiums since using extended shifts? Workman's compensation? Liability? Other?

Hauling

Do you haul at night?

Is noise an issue for night hauling?

Do you use your own trucks? How many?

Do you use contract trucks? How many?

Safety

How does your accident rate compare between single & extended shifts?

What changes have you made to your operation for working after sunset?

Mills

Are mills open for late or night deliveries?

What products can be hauled late or at night?

Where do you deliver your wood?

Does delivery change between own stumpage and company stumpage?

Incentives

Do you receive an incentive from a mill for extended shifts?

What type of incentive (extra pay per ton, extra pay, guaranteed wood order, other)?

Other Operations

Do you have other crews?

Are people or equipment shared between the crews?

Changes in Business Operations Due to Extended Shifts

Have you changed any of your financial-related practices for extended shifts?

Have you noticed a difference in your depreciation and salvage values for your equipment? If so, what are some of these differences?

Do you expect to have a capital loss when you trade in your extended use equipment?

Have you asked your accountant for input on extended shift impacts on your financial statements? What does your accountant think of extended shifts and what guidance has he/she given you?

What are some of the accounting-related cautions that you would share with people considering extended shifts? Depreciation considerations?

Have you considered leasing equipment to avoid depreciation and salvage problems? What is the use criteria for the lease? Machine hours? Other?

Barriers/Problems

What are your biggest problems?

Do you ever switch back-and-forth between single and extended shifts? Why?

Do you see extended shifts as a way to increase production without additional capital investments, but readily available to downsize crews if needed?

Do you use extended shifts year round, or just during some seasons? Why?

What are some of the cost differences that you've experienced between traditional work shifts and extended hour shifts?

Appendix B. Statistical Analyses

Appendix B.1. Statistical Analysis for the Difference in Production between Groups

Test to determine if there is a difference between the percentage production increase between those logging business owners who quit (q) and those who continued (w) implementing extended working hour schedules.

Statistics											
Variable	Sch	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Min	Max
PctIncr	q	8	33.989	51.183	68.376	13.597	20.566	41.857	7.2711	20.25	77.78
PctIncr	w	10	38.645	56.047	73.449	16.733	24.327	44.411	7.6928	31.39	100
PctIncr	Diff (1-2)		-27.75	-4.864	18.02	16.949	22.758	34.636	10.795		

T-Tests					
Variable	Method	Variances	DF	t Value	Pr>|t|
PctIncr	Pooled	Equal	16	-0.45	0.6583*
PctIncr	Satterthwaite	Unequal	15.9	-0.46	0.6520

* Fail to reject Ho: $\mu_{Quit}=\mu_{Work}$ at significance level $\alpha=0.05$ because the p-value> 0.05.

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr>F
PctIncr	Folded F	9	7	1.40	0.6727*

* variances are equal ($\alpha=0.05$)

The difference between the mean increases of the groups who continued implementing extended working hours (w) and those who did not (q) is -4.864%. The 95% confidence interval includes zero (-27.75, 18.02) and indicates that there is not a significant difference in the production increases between the two groups.

Appendix B.2. Statistical Analysis for the Difference between Thinning (th) and Clearcut (cc) Production of those Logging Business Owners that Continued Implementing Extended Working Hours

Statistics											
Variable	CutType	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Min	Max
PctIncr	cc	7	34.78	54.419	74.057	13.683	21.234	46.759	8.0258	33.33	100
PctIncr	th	3	-29.01	59.847	148.7	18.624	35.769	224.8	20.651	31.39	100
PctIncr	Diff (1-2)		-46.25	-5.428	35.392	17.327	25.652	49.143	17.702		

T-Tests					
Variable	Method	Variances	DF	t Value	Pr>|t|
PctIncr	Pooled	Equal	8	-0.31	0.7669*
PctIncr	Satterthwaite	Unequal	2.63	-0.24	0.8243

* Fail to reject Ho: $\mu_{th}=\mu_{cc}$ at significance level $\alpha=0.05$ because the p-value > 0.05.

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr > F
PctIncr	Folded F	2	6	2.84	0.2715*

* variances are equal ($\alpha=0.05$)

The difference between the means of the groups who implementing extended working hours in thinning operations (th) and those implemented extended working hours in clearcut operations (cc) is -5.428%. The 95% confidence interval (-46.25%, 35.392%) includes zero and indicates that there is not a significant difference in the production changes between the two groups.

Appendix B.3. Statistical Analysis for the Difference between Thinning (th) and Clearcut (cc) Production of those Logging Business Owners that Continued Implementing Extended Working Hours Using Shifts of Less than 24-Hours/day.

Statistics											
Variable	Cut Type	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Min.	Max.
Change	cc	6	138.95	146.82	154.69	4.6828	7.502	18.4	3.0627	133.33	156
Change	th	2	33.292	139.77	246.25	5.2874	11.851	378.17	8.38	131.39	148.15
Change	Diff (1-2)		-9.701	7.0517	23.804	5.4033	8.385	18.464	6.8463		

T-Tests					
Variable	Method	Variances	DF	T Value	Pr >|t|
Change	Pooled	Equal	6	1.03	0.3427*
Change	Satterthwaite	Unequal	1.28	0.79	0.5492

* Fail to reject Ho: $\mu_{CC}=\mu_{TH}$ at significance level $\alpha=0.05$ because the p-value > 0.05. The 95% confidence interval includes 0.

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr>F
Change	Folded F	1	5	2.50	0.3500*

* variances are equal ($\alpha=0.05$)

The difference between the means of the groups who implementing extended working hours on thinning operations (th) and those who implemented extended working hours on clearcut operations (cc) is 7.05%. The 95% confidence interval (-9.701%, 23.804%) includes zero and indicates that there is not a significant difference in the production changes between the two groups.

Appendix B.4. Statistical Analysis for the Difference in the Percent Increase in Production (PctIncr) between Logging Business Owners that Continued Implementing Extended Working Hours Using Shifts of 24-Hours/Day (n) and Those Using Less than 24-Hours/Day (y).

Statistics											
Variable	Hr24	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Min	Max
PctIncr	n	8	38.018	45.059	52.099	5.568	8.4214	17.14	2.9774	31.39	56
PctIncr	y	2	100	100	100	.	0	.	0	100	100
PctIncr	Diff (1-2)		-69.3	-54.94	-40.58	5.3209	7.8775	15.091	6.2277		

T-Tests					
Variable	Method	Variances	DF	t Value	Pr > |t|
PctIncr	Pooled	Equal	8	-8.82	<.0001*
PctIncr	Satterthwaite	Unequal	7	-18.45	<.0001

* Reject Ho: $\mu_n=\mu_y$ at significance level $\alpha=0.05$ because the p-value < 0.05.

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr > F
PctIncr	Folded F	7	1	Infty	<.0001

*Variances are not equal. The logging business owners using a 24 hours/day schedule is based on a small sample size.

The difference between the means of the groups with different working schedules is a 54.94% production increase. The 95% confidence interval (-69.3%, -40.58%) does not include zero. There is a significant difference ($\alpha = 0.05$) between the production increases between the logging business owners using a 24 hours/day schedule and those using less than 24 hours/day.

Appendix B.5. Statistical Analysis for the Difference in Years of Experience

Test to determine if there is a difference in the years of experience between the group of logging business owners that returned to traditional working schedules (Q) and those that continued implementing extended hours (W).

Statistics

Variable	Schedule	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Min	Max
YrsExp	Q	10	15.75	20.3	24.85	4.375	6.3605	11.612	2.0114	10	30
YrsExp	W	12	12.278	17.5	22.722	5.822	8.2186	13.954	2.3725	4	35
YrsExp	Diff (1-2)		-3.845	2.8	9.4452	5.6921	7.4401	10.744	3.1857		

T-Tests

Variable	Method	Variances	DF	t Value	Pr > |t|
YrsExp	Pooled	Equal	20	0.88	0.3899*
YrsExp	Satterthwaite	Unequal	19.9	0.90	0.3788

* Fail to reject Ho: $\mu_{Quit}=\mu_{Work}$ at significance level $\alpha=0.05$ because the p-value=0.3899 > 0.05. The 95% confidence interval (-3.845, 9.4452) includes 0.

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
YrsExp	Folded F	11	9	1.67	0.4506*

* Variances are equal ($\alpha=0.05$)

The difference between the mean years of experience for the two groups is 2.8 years. The 95% confidence interval (-3.845, 9.4452) includes zero and indicates that there is not a significant difference in the years of experience between the two groups.

Appendix C. Discounted After-Tax Cash Flow Cost Analyses

Appendix C.1. Discounted After-Tax Cash Flow Cost Analysis for a Skidder Using the Traditional Schedule (8 hours/day)

DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
Skidder					
Purchase price	$175,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$175,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$175,000
Hours per day	8.00		Expected life, years		5
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$28.74		Inflate F&L		5.00%
Maint & Repair	$14.25		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		60.00%
Insurance & taxes	5.00%		Production (tons/PMH)		43.33
AEC	($101,966)	($94,239)	($91,298)	($88,903)	(100,244)
Cost per ton	($1.96)	($1.81)	($1.76)	($1.71)	($1.93)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	133,000	110,250	89,250	75,250	63,000
ACRS Dep	35,000	56,000	33,600	20,160	20160.00
Book value	140,000	84,000	50,400	30,240	10,080
Fuel & Lub	20,694	21,729	22,815	23,956	25,154
Maint.	10,260	11,799	13,569	15,604	**32,945**
Labor	35,000	36,750	38,588	40,517	42,543
Insurance	8,750	6,650	5,513	4,463	3,763
Total Expenses	74,704	76,928	80,484	84,540	104,404

Appendix C.2. Discounted After-Tax Cash Flow Cost Analysis for a Skidder Using the 24-Hour Schedule

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
	Skidder 24 hrs/day					
Purchase price		$175,000		Discount rate		8.25%
Trade-in		$0		Finance APR		9.25%
BV of trade-in		$0		Marginal tax rate		25.00%
Down payment		$175,000		Amount financed		$0
Number of payment		48		Monthly payment		$0
Expense Option		$0		Adjusted basis		$175,000
Hours per day		24.00		Expected life, years		5
Days per year		250		Residual value end of life		20.00%
Fuel & Lube		$28.74		Inflate F&L		5.00%
Maint & Repair		$14.25		Inflate M&R		15.00%
Labor rate		$12.50		Inflate labor		5.00%
Fringe benefit %		40.00%		Utilization		60.00%
Insurance & taxes		5.00%		Production (tons/PMH)		39.65
AEC		($229,772)	($219,901)	($210,089)	($204,917)	(210,455)
Cost per ton		($1.61)	($1.54)	($1.47)	($1.44)	($1.47)
		Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value		94,500	57,750	42,000	40,250	40,250
ACRS Dep		35,000	56,000	33,600	20,160	20160.00
Book value		140,000	84,000	50,400	30,240	10,080
Fuel & Lub		62,082	65,186	68,446	71,868	75,461
Maint.		30,780	**50,397**	40,707	46,813	53,834
Labor		105,000	110,250	115,763	121,551	127,628
Insurance		8,750	4,725	2,888	2,100	2,013
Total Expenses		206,612	230,558	227,802	242,331	258,936

Appendix C.3. Discounted After-Tax Cash Flow Cost Analysis for a Skidder Using the 18.5-Hour Schedule

DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
Skidder					
Purchase price	$175,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$175,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$175,000
Hours per day	18.50		Expected life, years		5
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$28.74		Inflate F&L		5.00%
Maint & Repair	$14.25		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		60.00%
Insurance & taxes	5.00%		Production (tons/PMH)		39.75
AEC	($183,952)	($174,032)	($171,987)	($167,464)	(172,116)
Cost per ton	($1.67)	($1.58)	($1.56)	($1.52)	($1.56)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	110,250	73,500	50,750	42,000	40,250
ACRS Dep	35,000	56,000	33,600	20,160	20160.00
Book value	140,000	84,000	50,400	30,240	10,080
Fuel & Lub	47,855	50,248	52,760	55,398	58,168
Maint.	23,726	27,285	**46,378**	36,085	41,497
Labor	80,938	84,984	89,234	93,695	98,380
Insurance	8,750	5,513	3,675	2,538	2,100
Total Expenses	161,269	168,030	192,047	187,716	200,146

Appendix C.4. Discounted After-Tax Cash Flow System Cost Analysis for Three Work Schedules

Traditional Schedule, 8 Hours/Day (104,000 tons/year)

	Equipment Ownership Period (Years)				
	1	2	3	4	5
Skidder 1 (8 Hours/Day)					
EAC	$101,965.56	$94,239.11	$91,297.83	$88,902.99	$100,244.26
Skidder 2 (8 Hours/Day)					
EAC	$101,965.56	$94,239.11	$91,297.83	$88,902.99	$100,244.26
Loader 1 (8 Hours/Day)					
EAC	$76,321.19	$75,015.46	$73,477.83	$72,159.29	$85,194.78
Loader 2 (8 Hours/Day)					
EAC	$76,321.19	$75,015.46	$73,477.83	$72,159.29	$85,194.78
Feller-Buncher (10.18 Hours/Day)					
EAC	$130,603.69	$129,190.55	$125,457.02	$125,374.11	$137,855.21
System Costs					
EAC	$487,177.19	$467,699.68	$455,008.34	$447,498.66	$508,733.28
$/ton	$4.68	$4.50	$4.38	**$4.30**	$4.89

Appendix C.4. (Continued)

24-Hour Schedule (142,740 tons/year)

	Equipment Ownership Period (Years) 1	2	3	4	5
			Skidder (24 Hours/Day)		
EAC	$229,771.69	$219,900.99	$210,089.06	NA	NA
			Loader (24 Hours/Day)		
EAC	$190,901.07	$186,680.91	$181,184.51	NA	NA
			Feller-Buncher (14 Hours/Day)		
EAC	$179,094.18	$168,057.47	$165,206.89	NA	NA
			System Costs		
EAC	$599,766.93	$574,639.37	$556,480.46	NA	NA
$/ton	$4.20	$4.03	**$3.90**	NA	NA

Appendix C.4. (Continued)

18.5-Hour Schedule, (172,000 tons/year)

	Equipment Ownership Period (Years)				
	1	2	3	4	5
			Skidder 1 (9.5Hours/Day)		
EAC	$112,552.86	$104,404.61	$101,525.85	$99,611.12	$110,526.22
			Skidder 2 (18.5 Hours/Day)		
EAC	$183,951.62	$174,032.06	$171,987.33	$167,463.92	$172,116.32
			Loader 1 (9,5 Hours/Day)		
EAC	$86,791.18	$85,126.47	$83,287.11	$85,171.49	$94,465.66
			Loader 2 (18.5 Hours/Day)		
EAC	$152,873.61	$151,171.21	$146,202.83	$144,403.28	$150,090.90
			Feller-Buncher (8.2 Hours/Day)		
EAC	$119,533.13	$116,808.54	$112,331.35	$109,147.45	$122,931.08
			Feller-Buncher (8.2 Hours/Day)		
EAC	$119,533.13	$116,808.54	$112,331.35	$109,147.45	$122,931.08
			System Costs		
EAC	$775,235.52	$748,351.44	$727,665.81	$714,944.72	$773,061.25
$/ton	$4.51	$4.35	$4.23	**$4.16**	$4.49

Appendix C.5. Discounted After-Tax Cash Flow Cost Analysis for a Skidder Scheduled to Work 9.5 Hours/Day

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
	Skidder					
Purchase price		$175,000		Discount rate		8.25%
Trade-in		$0		Finance APR		9.25%
BV of trade-in		$0		Marginal tax rate		25.00%
Down payment		$175,000		Amount financed		$0
Number of payment		48		Monthly payment		$0
Expense Option		$0		Adjusted basis		$175,000
Hours per day		9.50		Expected life, years		5
Days per year		250		Residual value end of life		20.00%
Fuel & Lube		$28.74		Inflate F&L		5.00%
Maint & Repair		$14.25		Inflate M&R		15.00%
Labor rate		$12.50		Inflate labor		5.00%
Fringe benefit %		40.00%		Utilization		60.00%
Insurance & taxes		5.00%		Production (tons/PMH)		43.33
AEC		($112,553)	($104,405)	($101,526)	($99,611)	(110,526)
Cost per ton		($1.82)	($1.69)	($1.64)	($1.61)	($1.79)
		Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value		131,250	108,500	87,500	71,750	59,500
ACRS Dep		35,000	56,000	33,600	20,160	20160.00
Book value		140,000	84,000	50,400	30,240	10,080
Fuel & Lub		24,574	25,803	27,093	28,448	29,870
Maint.		12,184	14,011	16,113	18,530	36,309
Labor		41,563	43,641	45,823	48,114	50,519
Insurance		8,750	6,563	5,425	4,375	3,588
Total Expenses		87,070	90,017	94,454	99,466	120,287

Appendix C.6. Discounted After-Tax Cash Flow Cost Analysis for a Feller-Buncher Scheduled to Work 10.18 Hours/Day (or 50.9 Hours/Week).

DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
Feller-Buncher					
Purchase price	$215,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$215,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$215,000
Hours per day	10.18		Expected life, years		4
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$29.55		Inflate F&L		5.00%
Maint & Repair	$20.00		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		65.00%
Insurance & taxes	4.50%		Production (tons/PMH)		62.86
AEC	($130,604)	($129,191)	($125,457)	($125,374)	(137,855)
Cost per ton	($1.26)	($1.24)	($1.21)	($1.21)	($1.33)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	172,000	133,300	109,650	94,600	81,700
ACRS Dep	43,000	68,800	41,280	24,768	24768.00
Book value	172,000	103,200	61,920	37,152	12,384
Fuel & Lub	31,770	33,359	35,027	36,778	38,617
Maint.	21,505	24,731	28,441	47,707	37,613
Labor	44,538	46,764	49,103	51,558	54,136
Insurance	9,675	7,740	5,999	4,934	4,257
Total Expenses	107,488	112,594	118,569	140,977	134,623

Appendix C.7. Discounted After-Tax Cash Flow Cost Analysis for a Feller-Buncher Scheduled to Work 8.42 Hours/Day

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
	Feller-Buncher					
Purchase price		$215,000		Discount rate		8.25%
Trade-in		$0		Finance APR		9.25%
BV of trade-in		$0		Marginal tax rate		25.00%
Down payment		$215,000		Amount financed		$0
Number of payment		48		Monthly payment		$0
Expense Option		$0		Adjusted basis		$215,000
Hours per day		8.42		Expected life, years		4
Days per year		250		Residual value end of life		20.00%
Fuel & Lube		$29.55		Inflate F&L		5.00%
Maint & Repair		$20.00		Inflate M&R		15.00%
Labor rate		$12.50		Inflate labor		5.00%
Fringe benefit %		40.00%		Utilization		65.00%
Insurance & taxes		4.50%		Production (tons/PMH)		62.86
AEC		($119,533)	($116,809)	($112,331)	($109,147)	(122,931)
Cost per ton		($1.39)	($1.36)	($1.31)	($1.27)	($1.43)
		Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value		169,850	131,150	107,500	92,450	77,400
ACRS Dep		43,000	68,800	41,280	24,768	24768.00
Book value		172,000	103,200	61,920	37,152	12,384
Fuel & Lub		26,278	27,592	28,971	30,420	31,941
Maint.		17,787	20,455	23,524	27,052	**46,110**
Labor		36,838	38,679	40,613	42,644	44,776
Insurance		9,675	7,643	5,902	4,838	4,160
Total Expenses		90,578	94,370	99,010	104,953	126,987

Appendix C.8. Discounted After-Tax Cash Flow Cost Analysis for a Feller-Buncher Scheduled to Work 14 Hours/Day

DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
Feller-Buncher					
Purchase price	$215,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$215,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$215,000
Hours per day	14.00		Expected life, years		4
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$29.55		Inflate F&L		5.00%
Maint & Repair	$20.00		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		65.00%
Insurance & taxes	4.50%		Production (tons/PMH)		62.86
AEC	($179,094)	($168,057)	($165,207)	($161,529)	(168,577)
Cost per ton	($1.25)	($1.18)	($1.16)	($1.13)	($1.18)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	144,050	103,200	79,550	62,350	51,600
ACRS Dep	43,000	68,800	41,280	24,768	24768.00
Book value	172,000	103,200	61,920	37,152	12,384
Fuel & Lub	43,692	45,877	48,171	50,579	53,108
Maint.	29,575	34,011	56,363	47,567	54,702
Labor	61,250	64,313	67,528	70,905	74,450
Insurance	9,675	6,482	4,644	3,580	2,806
Total Expenses	144,192	150,683	176,706	172,631	185,066

NOTE: The feller-buncher must be scheduled for 70 hours/week to balance production with a loader and skidder that operate 24 hours/day. Instead of operating the feller-buncher for 14 hours/day, it could be operated 12 hours/day for 5 days and 10 hours on Saturday.

Appendix C.9. Discounted After-Tax Cash Flow Cost Analysis for a Loader Scheduled to Work 8 Hours/Day

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
	Loader					
Purchase price		$145,000		Discount rate		8.25%
Trade-in		$0		Finance APR		9.25%
BV of trade-in		$0		Marginal tax rate		25.00%
Down payment		$145,000		Amount financed		$0
Number of payment		48		Monthly payment		$0
Expense Option		$0		Adjusted basis		$145,000
Hours per day		8.00		Expected life, years		5
Days per year		250		Residual value end of life		20.00%
Fuel & Lube		$16.84		Inflate F&L		5.00%
Maint & Repair		$11.55		Inflate M&R		15.00%
Labor rate		$12.50		Inflate labor		5.00%
Fringe benefit %		40.00%		Utilization		65.00%
Insurance & taxes		1.50%		Production (tons/PMH)		40.00
AEC		($76,321)	($75,015)	($73,478)	($72,159)	(85,195)
Cost per ton		($1.47)	($1.44)	($1.41)	($1.39)	($1.64)
		Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value		120,350	100,050	85,550	76,850	65,250
ACRS Dep		29,000	46,400	27,840	16,704	16704.00
Book value		116,000	69,600	41,760	25,056	8,352
Fuel & Lub		14,227	14,938	15,685	16,469	17,293
Maint.		9,760	11,224	12,907	14,843	32,070
Labor		35,000	36,750	38,588	40,517	42,543
Insurance		2,175	1,805	1,501	1,283	1,153
Total Expenses		61,162	64,717	68,681	73,113	93,058

Appendix C.10. Discounted After-Tax Cash Flow Cost Analysis for a Loader Scheduled to Work 9.5 Hours/Day

DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
Loader					
Purchase price	$145,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$145,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$145,000
Hours per day	9.50		Expected life, years		5
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$16.84		Inflate F&L		5.00%
Maint & Repair	$11.55		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		65.00%
Insurance & taxes	1.50%		Production (tons/PMH)		40.00
AEC	($86,791)	($85,126)	($83,287)	($85,171)	(94,466)
Cost per ton	($1.41)	($1.38)	($1.35)	($1.38)	($1.53)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	117,450	95,700	81,200	68,150	59,450
ACRS Dep	29,000	46,400	27,840	16,704	16704.00
Book value	116,000	69,600	41,760	25,056	8,352
Fuel & Lub	16,894	17,739	18,626	19,557	20,535
Maint.	11,590	13,328	15,327	32,626	20,270
Labor	41,563	43,641	45,823	48,114	50,519
Insurance	2,175	1,762	1,436	1,218	1,022
Total Expenses	72,222	76,470	81,212	101,516	92,347

Appendix C.11. Discounted After-Tax Cash Flow Cost Analysis for a Loader Scheduled to Work 18.5 Hours/Day

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS					
	Loader					
Purchase price		$145,000		Discount rate		8.25%
Trade-in		$0		Finance APR		9.25%
BV of trade-in		$0		Marginal tax rate		25.00%
Down payment		$145,000		Amount financed		$0
Number of payment		48		Monthly payment		$0
Expense Option		$0		Adjusted basis		$145,000
Hours per day		18.50		Expected life, years		5
Days per year		250		Residual value end of life		20.00%
Fuel & Lube		$16.84		Inflate F&L		5.00%
Maint & Repair		$11.55		Inflate M&R		15.00%
Labor rate		$12.50		Inflate labor		5.00%
Fringe benefit %		40.00%		Utilization		65.00%
Insurance & taxes		1.50%		Production (tons/PMH)		36.69
AEC		($152,874)	($151,171)	($146,203)	($144,403)	(150,091)
Cost per ton		($1.39)	($1.37)	($1.33)	($1.31)	($1.36)
		Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value		95,700	69,600	53,650	42,050	37,700
ACRS Dep		29,000	46,400	27,840	16,704	16704.00
Book value		116,000	69,600	41,760	25,056	8,352
Fuel & Lub		32,900	34,545	36,272	38,085	39,990
Maint.		22,569	40,955	29,848	34,325	39,474
Labor		80,938	84,984	89,234	93,695	98,380
Insurance		2,175	1,436	1,044	805	631
Total Expenses		138,581	161,919	156,397	166,911	178,474

Appendix C.12. Discounted After-Tax Cash Flow Cost Analysis for a Loader Scheduled to Work 24 Hours/Day

	DISCOUNTED AFTER-TAX CASH FLOW COST ANALYSIS				
Loader					
Purchase price	$145,000		Discount rate		8.25%
Trade-in	$0		Finance APR		9.25%
BV of trade-in	$0		Marginal tax rate		25.00%
Down payment	$145,000		Amount financed		$0
Number of payment	48		Monthly payment		$0
Expense Option	$0		Adjusted basis		$145,000
Hours per day	24.00		Expected life, years		5
Days per year	250		Residual value end of life		20.00%
Fuel & Lube	$16.84		Inflate F&L		5.00%
Maint & Repair	$11.55		Inflate M&R		15.00%
Labor rate	$12.50		Inflate labor		5.00%
Fringe benefit %	40.00%		Utilization		65.00%
Insurance & taxes	1.50%		Production (tons/PMH)		36.60
AEC	($190,901)	($186,681)	($181,185)	($184,701)	(182,811)
Cost per ton	($1.34)	($1.31)	($1.27)	($1.29)	($1.28)
	Year 1	Year 2	Year 3	Year 4	Year 5
Salvage value	85,550	58,000	42,050	0	0
ACRS Dep	29,000	46,400	27,840	16,704	16704.00
Book value	116,000	69,600	41,760	25,056	8,352
Fuel & Lub	42,681	44,815	47,055	49,408	51,878
Maint.	29,279	**48,671**	38,722	44,530	51,210
Labor	105,000	110,250	115,763	121,551	127,628
Insurance	2,175	1,283	870	631	0
Total Expenses	179,135	205,019	202,410	216,119	230,716

CHAPTER 5.

IMPLEMENTATION CONSIDERATIONS

5.0 Introduction

The variety of work schedules, shift rotations, hours per shift, operational characteristics, tract availability and location, type of equipment, and production rates make the decision to implement extended working hours very complex. In this chapter, a flowchart is offered to help guide the initial decision-making process in determining whether extended working hours may be a viable option. In the flowchart that follows (Figure 5.1), a series of questions are posed to guide users through some of the initial topics to be considered before implementing extended working hours. Section numbers listed in parentheses within the flowchart refer to areas of the dissertation that provide additional information on a topic. Implementation checklists are included in Tables 5.1, 5.2 and 5.3 to help guide logging business owners in their decisions related to selecting extended working hour schedules and to help in planning for implementation.

Figure 5.1 Flowchart of initial considerations for implementing extended working hours.

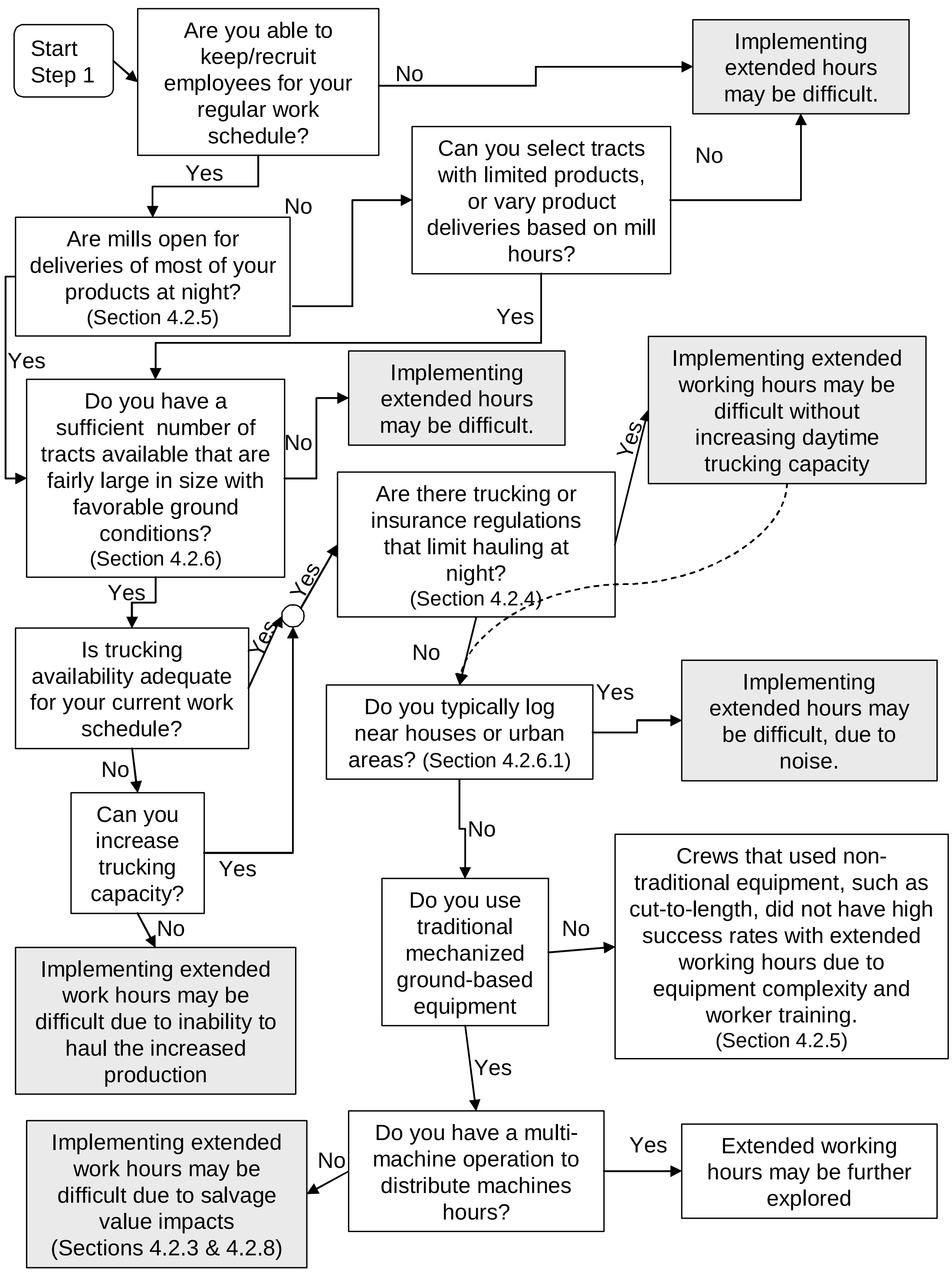

Table 5.1. Human factors checklist for implementing extended working hours.

Shift work can cause psychological, physiological and social impacts on employees. Some of these impacts may result in higher employee turnover, decreased safety, or decreased work performance. Increased turnover not only leads to understaffed operations, but it can lead to lower production because new employees may need a training period. Decreased safety and decreased work performance can also impact logging costs. The following points are suggestions of topics to consider before implementing extended work schedules.

- o Long shifts can lead to fatigue and mental burnout. They may be alleviated by two or more substantial rest breaks evenly spread throughout the shift. Performance levels may be maintained by scheduling rest breaks. (Section 3.4.4)
- o Long shifts can lead to illness (weakened immune systems, sore neck muscles from bracing, increased blood sugar) due to lack of physical body exercise. Frequent, short breaks where operators dismount equipment can introduce movement into muscle groups that aren't used when operating equipment. These short breaks may result in fewer work days missed due to illness. (Section 3.1.1.1)
- o Many find it difficult to adjust to shift schedules that include working the hours between 3 a.m. and 5 a.m. Workers who are "night owls" may be better suited for working the late shift. (Section 3.1.1)
- o Fatigue may be associated with compromised safety. Communication devices may be needed to allow equipment operators to communicate with each other after dark. (Section 3.1.3)
- o Safety meetings should be scheduled so they include workers from all shifts. (Section 3.1.3)
- o Some workers find it difficult to work on the late shift because fewer workers are on site and darkness further isolates them. People with an introvert type of personality fare better on the night shift than those with an extrovert personality type. (Section 3.4.2)
- o There may be social impacts of implementing extended work schedules. High levels of work-home conflict are reported by workers with permanent late shift assignments. Offering a rotating or flexible schedule can allow workers to participate in social activities. (Section 3.4.1)
- o A faster rotation, such as rotating shifts weekly, may have more positive influences on the psychological impacts (job satisfaction, health and well-being) of shift work. (Section 3.4.1)
- o Shift workers often have sleep complaints (length of time it takes to fall asleep, ordisrupted sleep). Fatigue, stress, daylight, health and age also impact the quality of sleep. Workers should be encouraged to try different sleep schedules including sleeping for 8 hours either immediately after, or immediately before the late shift. (Section 3.1.1.2)

Table 5.2. Financial considerations checklist for implementing extended working hours.

The financial impacts of implementing extended working hours are unique for every business. The following points are suggestions of topics to consider before implementing extended work schedules:

- o Select a working schedule.
  - o Determine if shifts are fixed or rotating.
  - o Determine a shift length for each shift.
  - o Determine which operations will be performed on each shift.
  - o Include current employees in the decision process.
- o Determine if a pay incentive is needed to recruit or retain late shift or rotating shift workers. (Section 4.2.8.1)
- o Contact your parts supplier and see if they are willing to provide you with after-hours support. (Section 4.2.2)
- o Use an equipment log to keep maintenance on schedule. (Section 4.2.2)
- o Speak with an insurance agent.
  - o Ask if they will insure a logging business that works extended hours. (Section 4.2.4)
  - o Find out how they would assess the value of your high-use (high hours) equipment if a loss occurs. (Section 4.2.3)
- o Make a plan for trucking the additional production. (Section 4.2.5)
  - o Determine if you need additional trucking capacity to help clear the ramp area in the morning if night hauling isn't implemented. (Section 4.2.7)
- o Speak with a financial manager or accountant. (Section 4.2.8)
  - o Ask for an analysis to help determine how long equipment used in extended working hour schedules should be kept to meet the minimum cost of producing wood over time. (Section 4.2.8.1)
  - o Using the analysis, determine the cost impacts of various production levels using a sensitivity analysis.
- o Prepare a plan to monitor the amount of production per shift after initial implementation. This knowledge is valuable in determining the production difference between shifts and the impact on costs. (Section 4.2.7)

Table 5.3. Operational considerations checklist for implementing extended working hours.

Some operational characteristics of implementing extended working hours may require outside support. Various items that are necessary for successful implementation of extended working hours may not be within the control of the logging business owner. These items include:

- Trucking support (Section 4.2.5)
    - Find out if there are trucking restrictions for hauling wood after dark. (Section 4.2.6.3)
    - If hauling at night using contract trucking, find truck drivers that are willing to commit to hauling at night.
  - Tract Selection (Section 4.2.6)
    - If working on timber industry land, try to obtain a tract package to aid in planning.
    - Limit moves between tracts by selecting large tracts.
    - Tract access roads should allow all-weather hauling.
    - Tracts with multiple products may permit hauling some products when other product deliveries are limited by mill inventories.
    - Select tracts in non-urban areas to avoid noise complaints.
    - Tracts with high volume/acre, or good wood, are more suitable for extended working hour schedules to meet production goals.
    - Tracts with flat or gently sloping terrain should be selected because they are easier to log after dark than those with steep slopes or ravines.
- Market Support
  - Meet with mill officials or woodyard managers to see if they would be willing to accept wood deliveries after normal business hours.
  - Obtain yearly production agreements with wood dealers so quotas will not be a concern after implementing extended working hours. (Section 4.2.6)