Investigation of Compliance with the Ansi Z133.1 - 2006 Safety Standard in the New England Tree Care Industry

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INVESTIGATION OF COMPLIANCE WITH THE ANSI Z133.1 – 2006 SAFETY STANDARD IN THE NEW ENGLAND TREE CARE INDUSTRY

A Thesis Presented

by

ALEXANDRA KRISTIN JULIUS

Submitted to the Graduate School of the University of Massachusetts Amherst in partial fulfillment of the requirements for the degree of

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Environmental Conservation
INVESTIGATION OF COMPLIANCE WITH THE ANSI Z133.1 – 2006 SAFETY STANDARD IN THE NEW ENGLAND TREE CARE INDUSTRY

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ABSTRACT

INVESTIGATION OF COMPLIANCE WITH THE ANSI Z133.1 – 2006 SAFETY STANDARD IN THE NEW ENGLAND TREE CARE INDUSTRY

SEPTEMBER 2012

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Arborists are exposed to many occupational hazards and experience more than three times the overall fatality rate of all U.S. workers. Investigations into fatal incidents lead to a better understanding of industry dangers. However, this knowledge does not extend to how tree workers operate when an injury or fatality does not occur. Current research regarding fatal and nonfatal injuries does not include the accreditation status of the company at which the worker was employed, nor whether certified arborists were on staff. Given the highly skilled nature of the work involved, certification and accreditation might ensure a minimum level of demonstrated safety practices. This study aimed to 1. Determine whether certification and accreditation in the tree care industry are associated with safer workplace behavior, and 2. Identify safety practices that tree workers commonly violate. Tree care companies in southern New England were divided into three categories: accredited, non-accredited with certified arborists on staff, and non-accredited with no certified arborists on staff. A stratified random sample of 63 companies was evaluated in the field by direct observation, assessing workers’ adherence to the industry’s safety standard, the American National Standards for Arboricultural
Operations (ANSI Z133.1-2006). Analysis indicated that, overall, accredited companies and those with certified arborists on staff complied with the Z133.1 Standard more than those without. Although these companies were more compliant, few significant differences emerged, and low overall compliance was found for personal protective equipment and chainsaw and chipper safety. There were low levels of compliance across all types of companies with the basic aspects of safety, including feeding the chipper from the curbside, not drop-starting a chainsaw, and using head, eye, and hearing protection. Implications of findings include possible considerations for improvements on accreditation and certification processes. Further findings address aspects of the Z133.1 Safety Standard that are currently unclear.
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CHAPTER 1
BACKGROUND AND LITERATURE REVIEW

Introduction

Arborists are exposed to many occupational dangers, and, thus, require a honed skill-set to avoid daily hazards and potential injuries. The Bureau of Labor Statistics reported 14.1 fatalities per 100,000 U.S. tree workers in 2003, which is more than three times the overall fatality rate of 4.0 for all U.S. workers that year (Wiatrowski 2005). According to data from the Census of Fatal Occupational Injuries (CFOI) from 1992 to 2007, 1,285 workers in the United States died as a direct result of tree care operations, 42% of which were from fatal contact with an object such as a tree or branch (Castillo 2009). Castillo further analyzed 45 fatality investigations conducted as part of the National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) program. In 31% of these incidents, death resulted from falls, either from a limb or an aerial bucket, and 29% of deaths resulted from either direct or indirect contact with a power line. Mobile wood chippers remain one of the most dangerous arboricultural tools, responsible for 31 deaths in the United States from 1992 to 2002 and approximately 155 amputations from 1992 to 1996 (Struttmann 2004).

Efforts to reduce these numbers come from in-house safety training, as well as from educational programs through the International Society of Arboriculture (ISA) and the Tree Care Industry Association (TCIA). These organizations offer their own certifications, which aid in expanding workers’ knowledge and company credibility. TCIA and ISA also frequently distribute literature that reveals common causes of injuries and fatalities. These publications contain information for companies on how to train their
new employees. A recent study on safety training programs for tree care companies showed that 37.9% of companies do not provide any formal training (Ball and Vosberg 2010). Companies that did provide training focused on aerial lifts and sprayers. Given the high fatality rates for chipper and chainsaw operators, greater emphasis on safety training must be placed in these areas.

Common among recent studies is an emphasis on the importance of using personal protective equipment (PPE) during all tree care operations. A study on landscaping fatalities showed that 26.3% of decedents sustained head injuries, almost all of which included brain injuries (Buckley et al. 2008). These numbers could presumably be reduced by consistent use of head protection that conforms to the American National Standard Institute’s (ANSI) standard for industrial head protection (ANSI Z89.1).

To improve tree worker safety, the tree care industry and affiliates developed certifications and accreditation to educate arborists about safety in the workplace. These educational steps are voluntary, but potentially aid in expanding knowledge about arboriculture and maintaining a safe workplace. Companies that are members of TCIA receive monthly trade magazines that highlight emerging issues in the industry, as well as detail recent occupational injuries or deaths. In this magazine, particular situations that are most commonly reported and dangerous in the workplace are described, such as electrical hazards and operating machinery. However, these scenarios are compiled from press reports and may not reflect actual rates of occurrence of particular injuries or accidents. Given these common dangerous scenarios, certain aspects of the ANSI Z133.1 appear to be especially important, such as those specifications pertaining to safe chainsaw and chipper operation, as well as the proper use of PPE.
Research has exposed the most common causes of death in the tree care industry, as well as different demographics for these decedents, including gender, age, nationality, and size of company by which they were employed. The majority of decedents worked for small companies and died from electrocution and fallen trees, or from being struck by an object, usually a branch (Buckley et al. 2008; Castillo 2009). Many of these incidents could have been avoided with the proper use of PPE and the proper training on heavy machinery (Castillo 2009).

Looking for possible ways to improve work behavior, researchers have studied surveillance methods used by employers, exploring which ones make for more efficient and creative work without resulting in a negative reaction from workers. A 2010 article outlining an overview of workplace surveillance looked at varying methods of surveillance with the intent of assessing worker productivity, behavior, and personal attributes. The article showed that employee response to supervisory monitoring was “unsavory” and reduced “productivity, creativity, and motivation” (Ball, K. 2010). Employees react negatively to excessive monitoring, often resisting and exacerbating the behaviors the monitoring was designed to prevent. Regan (1998) wrote that such surveillance techniques, as indicated in Figure 1.1, concentrate more on the person than on the work. For the purpose of this study, the section indicating behaviors is the most relevant. Asplundh Tree Expert Company employed the use of GPS technology to manage their vehicles, including routes taken, if the engine is on or off, maintenance needed, miles driven, etc. According to Orr and Kempter (2009), the system was met with some uncertainty, but ultimately was accepted by the employees. Although this system works to assess productivity and efficiency, it cannot look at work behavior
beyond time spent operating the vehicles. Based on Figure 1.1, the best surveillance method applicable to on-site tree care work is covert surveillance. Behaviors of interest include proper operation and application of chainsaws, bucket trucks or aerial lifts, and wood chippers. This method is often met with much hesitancy. However, it is currently the only method that can produce a realistic view of how people work day-to-day without skewed interference from changed work behavior. This surveillance does not evaluate the quality of work. Rather, it assesses the level of safe work behavior practiced by the workers.

A study of retailers’ safety knowledge of nail guns – the most common source of injury in the construction industry – covertly investigated salesmen by posing as potential customers and inquiring about possible dangers of the tool and its safety features (Lipscomb et al. 2011). Members of a trained research team individually entered specific retail outlets and asked salespersons scripted questions, initially giving them time to volunteer safety information or warnings of danger, but if no such information was offered, they inquired further with leading questions about specific safety features. The researcher assessed salespersons’ familiarity with the tool based on information offered and if they proved to be knowledgeable about the safety information requested. Further, they inquired about Spanish speaking sales staff to see if there were appropriate safety precautions available to the high number of Hispanic construction workers. This study found that salespeople had limited knowledge of nail gun trigger systems and risks associated with the tool, relaying 74.2% misinformation. Those who offered information regarding specific trigger systems, however, were more likely to do so for male investigators. Finally, the study found that safety culture was influenced by a general
acceptance of dangerous scenarios in the workplace as an unavoidable occupational hazard. Limitations of this study included only visiting businesses once, potentially not discussing nail guns with the most knowledgeable employee, and not controlling for the gender of the different investigators. As it relates to the current study, Lipscomb’s study emphasizes the importance of dissemination of proper safety information to reduce occupational injuries. For the tree care industry, the committee for the Standard, as well as ISA and TCIA, develop that primary source of knowledge.

**Limitations of Existing Data on Injuries in Tree Care**

Cullen (2002) noted that NIOSH admitted to limited surveillance data for analyzing nonfatal injuries. Although they have improved their methods by including occupational fatality surveillance data, these data cannot aid in assessing habitual work behavior. Such data provide only a cause of death, but are of limited use in studying the specific behaviors of fatally injured workers. OSHA depends on the self-reported record keeping of employers to assess safety, excluding those who are exempt – self-employed and government workers – thereby only representing one-fifth of the work force. These files are only reported to OSHA during an audit or survey, and may otherwise be overlooked. Prior research on tree worker safety has been based on census data from BLS and the Centers for Disease Control and Prevention (CDC). Cullen (2002) further critiqued surveys conducted by the Bureau of Labor Statistics (BLS), as it only sampled 2.8 percent of work establishments as of 2002. Moreover, BLS relies upon self-reported occupational injuries and illnesses. Wolfe et al. (2010) reported that current workplace surveillance misses approximately 80% of illnesses and injuries, largely due to fear of disciplinary and perhaps financial repercussions. According to Azaroff et al. (2002), the
use of workers’ compensation and physician reports by BLS results in underreporting of injury cases, while census reports from NIOSH and other safety bureaus attribute the high fatality statistics to the inability to differentiate among loggers, landscapers, horticulturists, homeowners, and arborists in national data systems. Under the old Standard Industrial Classification (SIC) system, made available by CFOI, the ornamental shrubs and trees services industry included “arborist services; ornamental tree and bush planting, pruning, bracing, spraying, removal, and surgery; and utility line tree trimming services.” As of 2003, a new system was used, the North American Industry Classification System (NAICS), which includes all landscape services, including landscape construction (Wiatrowski 2005). This new blanket term makes it more difficult to obtain a clear idea of the more specific dangers posed to arborists.

A recent article in the Morbidity and Mortality Weekly Report (MMWR) compiled statistics from census data regarding fatalities in the tree care industry (Castillo 2009). Gathered between 1992 and 2007, the data came from CFOI, which obtains its data from coroner records, death certificates, police reports, etc. This research only assessed fatalities and their most common causes including chippers, felling, falls, and struck-bys.

Ball and Vosberg (2010) conducted a mail-in survey asking companies about accidents and safety training. This nationwide survey sought to assess types of training programs, including their locations, the instructors, and the topics of concern. The authors recognized survey bias that resulted from missing two populations of companies: smaller companies that do not advertise in the Yellow Pages and those that perform utility line clearance. Companies that conducted formal training emphasized the safe use of sprayers,
aerial lifts, chainsaws, and chippers, in that order of occurrence. Surveys also revealed that 13% of the companies were members of TCIA, which administers an accreditation program and publishes a trade magazine, *Tree Care Industry Magazine*. Without membership, there are few other resources for safety education in tree care. Ball and Vosberg plan to publish more data regarding severity and frequency of nonfatal accidents and their correlation with safety training. The reliability of Ball and Vosberg’s (2010) data depends on the accuracy and honesty of employers self-reporting their work ethic. This dependency may cause an underestimation of the frequency of incidents and overestimation of the frequency of safety training.

Data from the BLS provide the basis for many studies on occupational injuries and fatalities. These data include, but are not limited to, injury and illness, lost workdays, workers’ compensation, fatality rates, and worker demographics. According to Azaroff et al. (2002), occupational injury surveillance is unreliable and produces underestimates of the number of nonfatal injuries. Based on a filter model from Webb et al. (1989), documentation of injuries is limited by a series of decisions, all of which need to be taken in order to be reported in the BLS survey. Although a worker may get injured at work, the BLS survey will not reflect this if the worker and the employer do not both report the injury. The BLS survey does not include any unreported worker injuries.

**Occupational Safety & Health Regulation**

The Occupational Safety and Health Act of 1970 (OSH Act) came as a response to thousands of work-related fatalities and millions of other debilitating injuries. Standards and enforcement that resulted shifted from state to federal agencies (Mendeloff 1979). Since OSHA’s inception, its fines have been deemed expensive and unnecessary
by businesses (Nash 2004). Companies were inspected and fined if found not to be
providing a safe workplace. More recently, however, OSHA inspectors see themselves as
educators, rather than enforcers (Nash 2004). This shift toward education allows OSHA
safety compliance specialists to help employers improve their company’s safety, instead
of threatening small companies that often cannot recover from large fines. Information
distributed by TCIA also helps companies work with OSHA inspectors to improve the
process and relations between the tree care industry and OSHA. Current research on this
new relationship does not yet indicate an increase or decrease in compliance. It does,
however, show an increase in opportunities for education (Nash 2004).

A 2010 study on the impact of OSHA inspections (Haviland et al. 2010), linked
federal OSHA inspection records with Workers’ Compensation records and the
Pennsylvania Unemployment Insurance system. This study showed that violations of
PPE-related standards have the greatest effect on injury rates. Contrary to a prior study
that showed a weak connection between injury types and OSHA standards (Mendeloff
and Gray 2005), Haviland et al. (2010) showed a stronger correlation between citations
for specific standards and injuries strongly associated with that standard. They reasoned
that the injury abatement in cases related to PPE standards showed such an impact due to
the spectrum of injury types that proper PPE usage could reduce or prevent. Similarly,
more specific standards have a smaller scope of impact, and as such, prevent fewer types
and numbers of injuries. Citations for PPE standards showed the greatest injury reduction
for “caught-ins, bodily reaction and exertions, and eye injury” (Haviland et al. 2010).
Given this study’s conclusion on the importance of PPE standards to further reduce injury
rates, it is important to note the relevance to the tree care industry and how continual
enforcement by OSHA inspectors and the consistent use of PPE could positively impact tree worker safety.

**Safety Culture & Research in Other Industries**

Safety culture, as defined by Fernández-Muñiz et al. (2007), is:

A set of values, perceptions, attitudes and patterns of behavior with regard to safety shared by members of the organization; as well as a set of policies, practices and procedures relating to the reduction of employees’ exposure to occupational risks, implemented at every level of the organization, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses.

According to Stricoff (2005), the latter half of that definition describes safety climate, the policies and implementations used to enforce safety. Fernández-Muñiz et al. (2007) suggest that commitment to safety from management can affect both the attitudes and behaviors of their workers. In forming a positive safety culture model, the authors determined that two other contributing factors are employees’ involvement and a safety management system. This system includes a safety policy, incentives for safe behavior, training for employees, communication between hierarchy, planning (for both prevention and in the case of emergency), and feedback on events and conditions. A study on telecommunications in Taiwan examined the causes of safety culture within a company dynamic (Wu et al. 2010). Information was self-reported through mail-in surveys distributed to electrical maintenance workers at risk of fatal injury. Findings included the importance of safety information disseminated by managers, employers’ concern for safety of the workers, safety enforcement, and safety coordination. The status of all four factors within a company can predict the safety culture of its workers.

Other studies (Olson et al. 2009; Alvero et al. 2008) looked at how observing others’ safety behavior, in effect, changed their own behavior. Alvero et al. (2008)
studied the effect behavioral observations have on observers’ own behavior. Subjects were given the task of stringing beads in a specific color sequence, which was used to assess productivity. These subjects also watched a video of people performing the same task and completed checklists to assess their sitting positions based on pre-determined criteria for ergonomic posture. After this evaluation period, subjects were later observed for their own posture while stringing beads. This study found that after the subjects had watched the video, they worked more safely and consistently through all subsequent sessions. Olson et al. (2009) looked at the use of personal protective equipment, focusing on collective norms and its effect on imitation. Subjects were placed in a room with white noise played slightly below the hearing protection standard (85 dBA) and were provided with hearing protection. They were shown an instructional video on how to carry out a certain task, but each video varied in one of four ways, altering the frequency of actors’ use of hearing protection. When later given the demonstrated task to complete, subjects were observed for the use of hearing protection. The findings suggest that proper modeling of PPE-use increases collective imitation.

Research conducted in labor-intensive industries shows considerable emphasis on personal protective equipment use. Similar to the tree care industry, many nonfatal injuries incurred by construction workers are caused by contact with an object, falls, and exertion injuries. Lipscomb et al. (2010) examined nonfatal construction injuries treated in 24-hour hospital emergency departments. Using data from the NEISS-Work surveillance system (available through NIOSH), injuries were stratified by body part, diagnosis, and treatment, and injury rates were estimated by use of the Current Population Survey (CPS). Their findings included greater injury rates among men (as was
expected by their higher representation in the industry), and workers aged 16-19. The single greatest source of injuries for construction workers was nail guns, followed by power saws and fixed saws. Given the wide range of tasks and their required tools, it is easy to see the similarities between construction and tree care.

In an attempt to make construction safety more proactive than reactive, Kines et al. (2010) conducted an observational study that used intervention groups altered by verbal safety culture. Construction site foremen were coached on verbal exchanges with their employees, altering the frequency of safety-oriented conversations. Both foremen and employees were interviewed throughout the process, as well as observed for safety behavior pre- and post-intervention. It was believed that foreman influence was greater than attitudes from fellow workers. This study found that verbal feedback from supervisors made for significantly increased safety behavior among employees. On-site reminders of work hazards prompt workers in their actual work environment (as opposed to in a classroom setting), allowing for a more hands-on approach to teaching, and increasing the ecological validity of the study.

In a report on safety in agriculture, forestry, and fishing (Chapman and Husberg 2008), the authors noted the high risk of hand injuries and the need for better tool designs for increased ergonomics and safety. By workers demanding safer equipment, manufacturers are forced to increase the quality of their products. The authors further suggested a means of behavioral primary prevention through “embedded” lessons, whereby a regular workday includes a short lesson in a pre-determined educational topic related to that day’s task. Wirth and Sigurdsson (2008) suggested that overstating behavioral changes of workers still neglects improving the unsafe conditions in which
they work. In essence, this “blames the worker” instead of solving the problem at hand. A different study took a technological approach to reducing the risk of hearing loss in the mining industry (Kovalchik et al. 2008). By Prevention through Design (PtD), the authors studied the source of hearing loss – continuous mining machines – and worked with NIOSH and machinery manufacturers to redesign the conveyors. A case study showed this as a successful means of noise control as it reduced noise exposure by 3 dB(A) and, although it increased cost by 20%, it also increased the life of the equipment threefold.

**Prevention of Injuries in Tree Care**

To help reduce work-related injuries and fatalities, an advisory group of arborists, government and insurance agencies, and manufacturers developed an industry standard in accordance with the American National Standard Institute (Ryan et al. 2006). The ANSI Z133.1 – 2006 highlights safe work practices and is designed to aid in the regulation of industry safety for governing bodies such as the Occupational Safety and Health Administration (OSHA). Established in 1972, the ANSI Z133.1, hereafter referred to as the Standard, has been revised several times (1979, 1982, 1988, 1994, 2000, 2006, and 2012), and is currently revised every six years.

According to the Standard, PPE required for tree care includes a hard hat, hearing protection, foot protection, eye protection, and chainsaw-resistant pants or chaps. According to NIOSH, the proper use of PPE comes highly recommended for improving safety in the tree care industry (Castillo 2009). Consistent use of a hard hat can protect workers from falling objects, including climbing and rigging gear, and branches. Noise-induced hearing loss has become one of the most common work-related concerns addressed by OSHA (OSHA 2012). Arborists, who are frequently exposed to noise from
chippers and chainsaws that operate at a range of 110 to 117 decibels, may experience hearing loss in the future. Casale (2009) recommends use of hearing protection if conversation with a worker an arm’s length away requires raising one’s voice. Finally, consistent use of chainsaw-resistant pants would greatly reduce the number of injuries to legs and feet. However, this precaution will not eliminate all chainsaw injuries without proper operation of the equipment. Poor positioning or one-handing chainsaws during cuts frequently results in fatal to near-fatal incidents, including kickback and cutting one’s rope.

The Standard outlines specific guidelines for safely operating an aerial lift. Incidents associated with aerial lifts are common among several industries, including construction, logging, tree work, and painting. According to Pan et al. (2007), a majority of incidents associated with boom lifts (distinguished from scissor lifts) occurred from 20-39 feet off the ground, roughly the span of utility line heights. Lack of harness or safety belt and lanyard appeared in 18% of cases collected from the CFOI data, OSHA incident investigation records, and FACE reports. In 13% of boom lift ejections, the worker or lift was struck by a falling branch or tree (Pan et al. 2007). Diligent training, careful equipment placement, and fall protection could greatly reduce the frequency of aerial lift fatal and nonfatal injuries.

**Accreditation**

Accreditation is an extensive process, administered by TCIA, which requires better business practices on all levels (Table 1.1). Accreditation was designed to develop a higher standard of tree care, giving a special designation to companies that uphold a code of ethics, employ professional staff, and adhere to the Standard. Companies that
apply for accreditation are inspected for their business plan, accounting, ethics, customer satisfaction, insurance, safety, personnel, quality control, and professional staff. Each area includes a widespread look at how the business functions, allowing TCIA auditors or accreditation consultants to make suggestions for improvement. For the purposes of this study, only safety requirements were in question. Safety requirements that companies must meet to become accredited include a safety orientation for new employees, a Certified Treecare Safety Professional (CTSP) for companies with more than ten employees, weekly safety training meetings, and operations that meet with the ANSI – Z133.1 Safety Requirements for Arboricultural Operations. Companies must also employ at least one certified arborist or person with an associate’s degree or more education in a field related to tree care for every ten employees. Accredited companies must be re-accredited after their first three years, and annual safety inspections associated with re-accreditation are unannounced and random (TCIA 2009-2010).

Certified Arborists

ISA arborist certification is granted to an individual who holds the minimum credential of three years of full-time experience in the tree care industry or college degree in a related field, and who successfully completes a professional exam. After completing the exam, which covers basic principles of arboricultural practice, arborists must maintain their certification by accumulating 30 continuing education units (CEUs) over subsequent periods of three years (ISA 2012). These can be acquired through workshops, publications, quizzes, and other varied sources. Certified arborists should be well acquainted with the safety protocol outlined in the Standard, as these guidelines are included on the arborist exam. Arborists can complete any or all of six different
certifications including certified tree worker, utility specialist, municipal specialist, climber specialist, aerial lift specialist, and board certified master arborist. Each requires different levels of technical knowledge, as well as field experience. Holding an ISA certification, arborists can earn increased income and further their professional development through attending conferences and earning CEUs. It is implied that certified arborists provide a better breadth of arboricultural knowledge than those without certification (Lilly 2001). Similar to the accredited companies, certified arborists also undergo not only an extensive exam, but must maintain their certification over the years. The certified arborist exam only tests knowledge and does not require proficiency in practical skills.

Other types of qualifications are available to arborists in New England. Arborist associations in Massachusetts and New Hampshire administer voluntary certification programs in those states. Applicants must pass an exam to become certified. Anecdotally, such certifications are specialized because they require detailed local knowledge of plants, insects, and diseases, which is not tested on the ISA exam. Individuals who wish to practice arboriculture in Connecticut must obtain a license, after passing an exam administered by the CT Department of Environmental Protection.

**Research Needs**

Given the extensive process required for a company to become accredited, it may be presumed that such a company would operate more safely with highly trained employees. Current research regarding fatal and nonfatal injuries does not include the certification/accreditation status of the company by which the worker was employed. Such information, when analyzed further, may indicate a lesser prevalence of injuries
among accredited companies. Only speculation can be made as to what kind of companies are employing unsafe workers based on the currently available data. Presuming that the arborist exam sufficiently tests participants in their knowledge of tree care, their work behavior should be safer than those working for informally trained tree care companies.

Due to a lack of empirical data regarding safe work behavior, only speculation can be made as to the cause of these fatal incidents. Much has been attributed to singular events where a worker has made a single poor decision at the wrong time. To develop a better understanding of common workplace behavior, the researcher developed surveys to take a new look at tree care work first-hand, and to determine if unsafe work behavior is, in fact, habitual.

The specific objectives of this study are to 1) determine whether certification and accreditation in the tree care industry are associated with safer workplace behavior, 2) identify the most common aspects of the ANSI Z133.1 by which tree workers do not abide, and 3) establish a baseline for common workplace behavior among the varying classes of tree care companies.
Figure 1.1. Surveillance techniques used to assess employees (Regan 1998).
Table 1.1. Definitions of the three classes of tree care companies assessed.

Accredited (Class A): A commercial tree care company that, upon inspection by the Tree Care Industry Association (TCIA), has proven to facilitate operations that abide by the safety standard for TCIA accreditation. Companies must first apply for accreditation and go through a rigorous process to obtain this title. All accredited companies must have at least one certified arborist or equivalent on staff. Accreditation is voluntary, but helpful for companies to increase professionalism, recruit employees, and improve company visibility. *TCIA Accreditation Standard 2009-2010 (Draft 6 Version 4)*

Certified Arborist (Class C): An individual in the field of arboriculture who has passed the International Society of Arboriculture (ISA) certification exam, or a state certification equivalent. This is a voluntary professional certification that tests individuals in all areas of arboriculture, including tree biology, urban forestry, climbing, rigging, soil, safety, and plant health care. *(Lilly 2001)*

Non-accredited, non-certified (Class N): A company in the area of tree care that only employs workers without any professional certification. These companies can range from two-person operations to larger companies with many crews, but none of the employees are certified by ISA nor state certified. The company may be a member of TCIA.
CHAPTER 2

METHODS

Study Design

Commercial and utility tree care companies were observed in the field for compliance with the Standard, to assess the level of safe work behavior. A cross-sectional comparative study design was used. The independent variable was accreditation/certification status of tree care companies in the northeastern United States. The dependent variable was the level of safe work behavior, or compliance. As defined for this study, compliance was abiding by practices as outlined in the Standard (when applicable) at all times while on the job site. Potential covariates included time of day, day of the week, real estate value of the property on which crews worked, and the median household income of the city occupied by that residence. Possible covariates were not used to assess worker safety, but rather, to determine whether companies worked in similar neighborhoods. As such, it was determined within which socioeconomic areas companies worked, and how far companies traveled for work. Finally, they were used to assess if any of these variables affected their overall compliance. Had these variables proven to cause a significant difference in safe work behavior, they would have been accounted for in the statistical analysis to properly track influences on worker compliance.

Study Area

Geographical Information Systems (GIS) was used to generate the study area and locate accredited companies and certified arborists operating within the area. The study area was defined as an 80-mile radius around Amherst, Massachusetts (01002),
encompassing any zip code tabulation areas (ZCTA) that are partially or entirely within this distance. This includes parts of Massachusetts, Connecticut, Rhode Island, New York, New Hampshire, and Vermont (Figure 2.1). The study area was chosen to include major Northeast cities, such as, Boston, Springfield, New Haven, Albany, Hartford, and Providence. Maine was not included in the study area because it was beyond the range of the study area. Searching by each individual state’s GIS website, census tracts for each zip code and maps were acquired for every relevant state. The projection of the maps was changed to Geographical Projection NAD 1983 Massachusetts Mainland.

**Study Population**

A total of 63 companies were observed in this study. Companies were stratified by accreditation/certification level and included 21 accredited companies (Class A); 20 non-accredited companies that have at least one ISA or state certified arborist on staff (Class C); and 22 non-accredited tree care companies without any ISA or state certified arborists (Class N). Names of each accredited company were acquired from the TCIA website (www.tcia.org/public/accreditation_map.htm), listing all accredited companies, as of March 2010, in the six states, as well as their addresses and dates of accreditation. The ISA website (www.isa-arbor.com/findArborist/find arborist.aspx) provided all the names of ISA certified arborists, cities and companies of employment, and type of certification(s) in the six aforementioned states. State certified arborists, such as a Massachusetts Certified Arborist (MCA), were not included in the stratification, but in one instance, a company originally determined as Class N, was later proven to have an MCA on staff and was moved to Class C. All companies in Class N were cross-checked with the state certification websites to verify their status: New Hampshire
Initially, the online Yellow Pages (www.yellowpages.com) were used to find members of Class N, but this method proved unreliable because these companies not only have insufficient public information available, but new companies are frequently launched and terminated, making the Yellow Pages quickly outdated. Although it was not always possible to know the companies’ current certification statuses upon inspection, that information was later obtained by an online search through the ISA website, TCIA website, and state certification websites.

Certified arborists are listed by state, including what city they work in, what company they work for, and their level of certification (e.g. certified arborist, tree climber, master arborist, utility specialist) on the ISA website. It is possible for an arborist to opt out of including his/her name on ISA’s list of certified arborists, limiting the scope to those arborists with available public information. A total of 1,661 certified arborists were listed in the six relevant states. A list of company names was compiled using the names of employers supplied by the certified arborist list on the ISA website. These companies were individually assessed for what services they provide using company websites and merchantcircle.com. Arborists not employed by a commercial or utility tree care company, or without any employer listed, were excluded from the list. Only certified arborists employed by a commercial or utility tree care company were identified for this study. Certified arborists worked for a total of 161 companies, owned or operated by 132 different employers.
Data regarding the accredited companies and certified arborists were entered into ArcCatalog and then placed in ArcMap. With all the attributes tables and map layers added to ArcMap, fields were related to determine what ZCTA’s would be used. Many of the zip codes did not relate because on the state GIS layers, where there was a high concentration of zip codes, the census tracts lumped them into a grouped category indicated by ###HH (the pound signs represent the first three digits in the zip code). Because of this discrepancy, the spreadsheets were modified to match these census tracts for all the zip codes to correctly relate. Each table was related twelve times, twice for each state: once for the certified arborists, once for the accredited companies. This allowed all the companies to be spatially related. ArcMap automatically related the attributes tables to the buffer layers. Each state was individually selected to determine how many accredited companies and certified arborists were within the study area. It was determined that 36 out of 72 accredited companies were within the study area, and 257 of 634 total certified arborists were within the study area (Figure 2.1). Companies with multiple offices were treated as individual operations in both observations and the statistical analysis. Prior research has demonstrated the importance of safety awareness and communication from the crew leader (Kines et al. 2010), so it was assumed that a different crew leader might result in different safety behavior from the employees. TCIA’s method for reaccreditation of multi-branched companies includes reassessing a random sample of 10% of the branches every three years, called a continuous audit program. It is possible for a branch not to pass reaccreditation, but then it must pass additional actions to maintain its accreditation (Rouse 2011). For this reason, it seemed appropriate to observe branches individually.
Each company and arborist within the study area was designated a unique number: Class A (1-36) and Class C (37-293). Using R version 2.9.2, two random number series were generated to compile two lists, one including twenty numbers equal to or under 36, and the other including twenty over 36. The numbers in these two lists indicate the specific accredited companies and certified arborists to be studied. An extra list of reserve companies was made in the case of failure to locate a company originally listed. This reserve list was compiled by the same method as the original list. Class N companies were not pre-selected because of their unreliability for regular jobs, limited public information, and for their widespread presence in the study area. The prevalence of companies in Class N throughout the study area allowed for the researcher to non-systematically find and assess them. The assumption was made that this would still provide a representative sample of Class N companies, as no neighborhoods were eliminated from the study area. In addition, there were no limits set as to the distance driven between observations, allowing the researcher to make observations varying distances apart. Several companies in Class C were eliminated due to limited public information as to their location. In several cases, addresses turned out to be residential and not commercial.

Data Collection Form Development

Individual aspects of the Z.133.1 Safety Standard were chosen according to three conditions: 1) their importance, which was assessed based on likelihood of standard violations resulting in incidents, 2) suspected frequency of standard violation, based on personal observation and anecdotal evidence, and 3) the ease with which the researcher could determine compliance from a distance, as it was important to reduce the potential
of the researcher’s presence causing a change in worker behavior. The importance of individual aspects of safety was determined from all accident reports in TCIA Magazine, from October 2006 to March 2010. Later research into the accident investigation reports on the OSHA website (http://www.osha.gov/pls/imis/accidentsearch.html) for SIC 0783 confirmed the original choice in individual aspects of the Standard. Appendix B lists the selected aspects of the Standard and changes made in prior versions. One additional aspect of safety was added to the form: not operating a chainsaw above the shoulders. This aspect was added because this suggestion is made in chainsaw user manuals (Stihl Chain Saw Safety Manual 2000 & Husqvarna Chain Saw Operator’s Safety Manual 1991), but is not specifically stated in the Standard. Aspects of the Standard included on the form were grouped into six summary categories: work perimeter, PPE, chainsaw, brush chipper, rope and climbing, and bucket truck.

A simple data collection form was developed with the guidance of the National Grid safety checklist (Appendix A). Individual aspects of the Standard, arranged in categories, were printed in black ink on an 8½” x 11” sheet of paper. The sheet also included space to record company name, job site information, and time of day and day of the week (Appendix C). The latter information was collected because of the suspected difference in worker behavior with respect to time and day (Marren 2010). Space was also reserved at the bottom of the form for notes to describe specific scenarios that were extraordinary or questionable, such as expired vehicle registration or broken taillights. To reduce the likelihood of subjective interpretation of a company’s compliance with individual aspects of the Standard, compliance was recorded as a binary variable (yes=1,
no=0). On the data collection form, individual aspects of the Standard were copied verbatim or phrased similarly to reduce the likelihood of misinterpretation of a standard.

The data collection form was intended only for the use of the observer and was tested in the field for inter-rater reliability. Two researchers observed the same job site and individually completed data forms. These were compared against each other, which determined that selected aspects of the Standard were easily observable and that the form was repeatable by multiple observers. As it was cost prohibitive, only two job sites were compared and proved to have 94% repeatability.

**Identifying / Locating Companies for Observation**

Examinations of accredited companies and certified arborists were interspersed throughout the observation period to increase the probability that each type of company was equally observed at varying times of day, days of the week, and time of the year. Companies were observed between July and December 2010. Observations were recorded each weekday during July and August, and only on Mondays, Wednesdays, and Fridays during September through December. Companies were grouped by location to reduce time spent driving between observations. On any given day, companies were selected for observation based on the researcher’s current location, allowing her enough time to arrive at the companies’ shops by 7:00 a.m. For instance, if the researcher spent a week in the Boston area, a list of five companies (Classes A and C) was compiled, including the company name, address, and distance from the researcher’s current location. Companies from this list were targeted in the morning and followed to their first job. For selected companies, workers in bucket trucks with chippers were followed from the garage to the job site. If bucket trucks did not leave the garage, any work vehicles
with chippers were followed. To eliminate any suspicion of being followed and to give workers time to set up, once the workers were at the job site, a Garmin nüvi 265W automotive global positioning system (GPS) receiver was used to map the current location so that the researcher could leave and then return after 30-40 minutes. By using the “Where Am I?” feature, the researcher was able to ascertain the exact address of the job site. Information was entered into “Favorites” of the Garmin and coded randomly by any sequence of numbers or letters having no traceable meaning. At the end of a field day, all favorites were deleted to further eliminate the possibility of breached confidentiality. While waiting for the selected crew to set up a job site, the researcher also searched for other companies to observe. After observing the first company, the researcher drove around until finding another company to observe, attempting to find two per day.

During observations, the distance between the researcher and the workers varied, depending on the location of the work on the property. The researcher remained a safe distance from any working perimeters and remained on public property, including streets and sidewalks. Any jobs conducted in backyards were either observed or eliminated from the data, depending on visibility. In some cases, observations were terminated and discarded if workers were too far away to see clearly. Observations were limited to a total of 30 minutes to reduce the likelihood of fatigue biasing the researcher’s observations. For some companies, the 30 minutes of observation was completed in one uninterrupted time period, but for others, the 30 minutes of observation was broken up into two or more shorter periods, with breaks in between. Depending on how quickly the job was undertaken, observations were completed in anywhere from 30 minutes to four hours.
Although longer jobs resulted in some fatigue, the total minutes of observation remained constant. The longer jobs took to complete, the more likely the researcher might have caught violations had time not been taken into account. For longer jobs, the researcher only observed particular tasks for a limited time and then returned to her vehicle, out of eyesight until a new task was undertaken. Verbal contact was rarely made between observer and workers, and only occurred when the workers initiated contact. If inquiries were made as to the reason for the researcher’s presence, the researcher simply stated that she was an arboricultural student at UMass, but no reference was made to the research being conducted. For the most part, workers noticed the researcher, but rarely engaged in conversation or appeared to change their behavior.

**Parameters for Recording Observations**

While observing companies, the researcher assumed that safe behavior shall be observed at all times while on the job site. The Standard acts as a guideline for safe work behavior, but directs workers to uphold strictly to the Standard only if doing so does not render the work more dangerous. Due to the method of observation in this study, it was not possible to determine if workers were avoiding a more dangerous situation and thereby acting incompliantly. As such, it was always assumed that workers were acting incompliantly instead, without sound reason. Further, this study only took a snapshot of time on the job site, and did not observe a full workday, thereby potentially missing certain behaviors. The researcher also recognized that not every aspect of the Standard would apply to each job. For example, perimeters were only necessary when equipment was not entirely on private property and there was potential danger to pedestrians and/or vehicular traffic. For any jobs in backyards, perimeters were not applicable.
Once work commenced on the job site, hard hat, glasses, and foot protection were required at all times, until all overhead dangers were eliminated and equipment use was terminated. This does not include time spent away from potential dangers or beyond the perimeters of the job site during work breaks. Due to the required distance between the workers and the observer, it was not possible to determine if the eye protection used was rated Z87.1. For the purpose of this study, if workers wore any eye protection, it was assumed that they were rated and workers received a “1” for compliance. Similarly, hard hats were also assumed to be rated and compliant with the Standard. Hearing protection was only necessary when operating loud equipment, including chippers and chainsaws. In those situations, all workers on the job site required hearing protection, even if they were not operating the piece of equipment, as the high decibel level could still cause noise-induced hearing loss. The assumption was made that per OSHA noise restriction requirements, workers would be exposed to chainsaws for greater than 30 minutes per day, and brush chippers for greater than 15 minutes per day. Such exposure would require hearing protection (“Occupational Noise Exposure” 2008).

To be compliant with the pertinent aspects of chainsaw safety, operators were required to use all PPE and safe work practices at all times, including when starting up equipment from the ground only to be used while climbing or in the bucket. Chaps, or chainsaw-protective pants, must be worn at all times on the ground, and properly clipped around the legs. Because the Standard does not specify the length, operators who wore chaps that only reached their shins were still given a “1” for compliance. As the Standard does not clearly specify the proper method for starting a chainsaw while aloft, drop-starts were considered compliant only when aloft, including in the bucket or climbing. Chipper
use required all PPE (except chaps) at all times of operation, as well as a working reverse bar. Assessment of safe chipper use varied depending on its location, including curbside, in a yard or parking lot, and/or disconnected from a truck. Depending on the scenario, certain aspects of the Standard were not applicable. Any “unusual” chainsaw or chipper use was noted at the end of the survey, including safety features removed from equipment, or any particularly risky behavior, such as operating a chainsaw in a chipper infeed, while the drums are moving.

When applicable, climbers were assessed for safe climbing, including how they treated their equipment and the tree (e.g., using spikes for a pruning job). Ground workers using ladders were not treated as climbers unless they moved from the ladder into the tree. The Standard states that operators must have solid footing while operating chainsaws. Finally, aerial buckets were assessed for proper application. Only one person shall be in the bucket at a time and the truck shall not be moved while the operator is still aloft. Workers were observed for full-body harnesses. However, it was not always possible to see if they had lanyards attached, nor if they had a body belt. For this reason, it cannot be assumed that the presence of a full-body harness or body belt meant a lanyard was also used. Any full-body harness observed in use received a “1” for compliance unless it was otherwise observed that a lanyard was not in use. There is a chance for over-reporting of harness use for this reason. However, given the difficulty of observing a body belt, workers received a “0” whenever they were not wearing the full-body harness. There is a chance for under-reporting of harness use for this reason. Any “NA” responses on the surveys were treated as “not applicable,” which was differentiated from “no response” where the observer could not see a particular practice while in the
field. A response resulting in a “0” indicated a violation. In several cases, either a behavior could not be observed, or it was not applicable to the job.

**Data Analysis**

To ensure that each type of company performed similar types of work, each job observed was classified by 1) tasks (e.g. climbing, rigging, ornamental pruning, all other pruning, removal), 2) tools required for each task (e.g. chainsaws, chainsaws off the ground, chainsaws on the ground, bucket truck, chipper, crane), and 3) location within the job site (e.g., street side, private property, utility). It would be inappropriate to compare Class N with Class A, for instance, if Class N only performed removals while Class A only performed ornamental pruning. Three other potentially confounding continuous variables were considered in this analysis: real estate value of the job sites, median household income of the job site’s city, and the distance traveled from the companies’ office to the job site. Real estate value was estimated from Zillow (www.zillow.com), and distance traveled came from Mapquest (www.mapquest.com). Median household incomes were acquired from the U.S. Census Bureau’s American Fact Finder (http://factfinder.census.gov) from the 2000 census. Not all jobs were applicable for all the measures. Utility work and other contracts (e.g., university or commercial properties) were not applicable for real estate value. Addresses for Class N were usually unavailable, making it nearly impossible to determine their distance traveled. Further, utility clearance workers often did not operate out of a specific office.

The distributions of all site variables were tested for normality and found to follow a log-normal distribution. They were log transformed using Excel® (Version 12.3.0, Microsoft Inc.). A Shapiro-Wilk test showed that log-transforming variables
normalized their distributions. Due to the log-normal distribution of the factors, a one-way lognormal ANOVA was used to determine if these factors were significantly different among the company classes. A one-way ANOVA was also run to determine if the total compliance percentage differed between the company types. Total compliance was calculated by using the total affirmative compliance observations for each class, divided by the sum of the affirmative and negative compliance observations for each class. Total observations only included those that were applicable to the job, as well as visible to the observer. Where an observation was not clear, a response was not recorded for analysis. This method was also used to calculate the total compliance for each summary safety group, such as overall chainsaw safety. For these, each aspect of the Standard categorized for that specific item was grouped for a total number of observations. Linear regression was used to determine whether any of the [log-transformed] variables were correlated with compliance. Tukey’s Honestly Significant Difference test (HSD) was used to compare the means of the variables to determine if they were significantly different among the three company classes.

Using Pearson’s chi-square tests in conjunction with Fisher’s Exact Test (Adler 2010), frequency distributions were examined to ensure that observations were randomly conducted throughout the week and at different times of the day. Next, using a series of logistic regression models, compliance with each aspect of the Standard, based on certification parameters, was conducted to determine whether safe behavior was related to certification status. Significance was determined at $\alpha = 0.05$ and $p=0.025$, using Bonferroni Correction, as each logistic regression model was run twice for the three classes (e.g. Test 1 = A-N, A-C, Test 2 = C-N, A-N). Finally, proportion tests were run to
establish overall compliance with summary safety groups, such as overall chainsaw safety. Significance was set at $\alpha = 0.05$ and $p=0.017$, as the test was run three times (e.g. Test 1 = A-N, Test 2 = A-C, Test 3 = C-N). These proportion tests were run to compare how the proportion of compliance for each company compared to one another. All analyses were performed using R (Version 2.14.0, R Foundation for Statistical Computing 2011).

**Human Subjects Approval**

The main risk was that a company could lose accreditation in the unlikely event that a breach of confidentiality occurred. For the purposes of this study, there was no need to expose any specific names of companies investigated. All records that included names of companies investigated were shredded immediately following this study. The University of Massachusetts, Amherst School of Public Health and Health Sciences Institutional Review Board approved this study for human subjects testing.
Figure 2.1 GIS map showing locations of accredited companies (Class A) and certified arborists (Class C) within the study area for which information was available. This represents an 80-mile radius around the city of Amherst, MA (ZCTA 01002) and includes many major cities, such as Boston, New Haven, Albany, and Concord.
CHAPTER 3

RESULTS

Company Demographics

Between July 2010 and December 2010, 63 jobs were observed. There are 36 accredited companies and 257 individual certified arborists within the study area. Observations were made of 21 companies in Class A (representative of 58% of the regional accredited population), 20 companies in Class C (representative of 13% of the estimated population), and 22 companies in Class N (representative of an estimated 0.5% of the population, although this is a difficult calculation to support given limited information). Of the companies observed, 60.3% were members of TCIA: six companies in Class N, eleven in Class C, and all of Class A. The number of observations made varied by state: 40 in Massachusetts, 15 in Connecticut, four in Vermont, and two each in New Hampshire and Rhode Island. No companies were observed in New York. Days and times of observations were distributed randomly among the company classes (Table 3.1). Observations of different types of companies were evenly distributed throughout the week, although a majority of the observations were made on Mondays, Wednesdays, and Fridays. Only four observations were made in the afternoon. There were no significant differences in percent compliance based on day of the week or time.

Table 3.2 summarizes tasks performed, tools used, and type of location of the job site. Different tools, tasks, and locations were observed between classes, but only a few were significantly different: more common use of chainsaws (aloft and on the ground) for companies in Classes C and N compared to companies in Class A; only companies in Class A performed ornamental pruning; companies in Classes A and N more commonly
worked on private property, while companies in Class C more commonly did utility work. On every job, either an overhead hazard was present, or given the equipment used, head, hearing, eye, and foot protection were required by the Z133.1 Safety Standard.

**Real Estate Value, Median Household Income, Distance Traveled, and Compliance**

Distance traveled to job sites did not differ among the company types (Table 3.3). Companies in Class A worked on properties in neighborhoods with significantly higher real estate value (Table 3.4) and median income (Table 3.5) than companies in Class N. However, the latter differences do not appear to have confounded the analyses because none of the potential covariates was associated with the percent compliance for any class of company (Figures 3.1-3.3).

**Accreditation/Certification Status and Compliance with the Z133.1 Safety Standard**

Overall compliance with the Standard was 64% and differed among types of company (Table 3.6). Companies in Class N were significantly less compliant than companies in Classes A and C, which were similarly compliant (Figure 3.4). Differences in compliance between classes of companies also occurred when examining four of the six summary safety groups listed in Table 3.6: perimeters, personal protective equipment, chainsaw safety, and brush chipper safety. Further differences occurred on a gradient for climbing safety, as Class A was most compliant and Class N was least compliant, but the sample size was smaller than the other summary groups.

**Setting Up A Perimeter**

Overall compliance for setting up a perimeter was 56.2%. Significantly more companies in Class C were compliant with the requirements than in Classes A and N (Figure 3.5). Across all companies, the mean compliance with setting up a perimeter
when climbing was 27%, and small sample sizes made it difficult to detect different rates of compliance among classes (Figure 3.6). Across all companies, the mean compliance with setting up a perimeter when chipping was 57%, but significantly more companies in Class C were compliant than in Classes A and N, which were equally compliant (Figure 3.7). Across all companies, the mean compliance with setting up a perimeter when rigging was 44% (Figure 3.8). Across all companies, the mean compliance with setting up a perimeter around a bucket truck was 72.7%. Differences in compliance were non-significant, but proportionately more observations were made of Class C operating a bucket where a perimeter was necessary (Figure 3.9).

**Personal Protective Equipment**

Overall compliance with wearing PPE was 57.0%. Significantly more companies in Classes A and C were compliant with the requirements than in Class N (Figure 3.10). Across all companies, the mean compliance with wearing head protection was 55.6%. Classes A and C were significantly more compliant than Class N (Figure 3.11). For all companies, the mean compliance with wearing hearing protection was 38.7%. Again, Classes A and C were significantly more compliant than Class N (Figure 3.12). The mean compliance with wearing foot protection was 96.8%, and compliance was similar among all classes (Figure 3.13). Finally, for all companies, the mean compliance with wearing eye protection was 36.5%. Classes A and C were significantly more compliant than Class N (Figure 3.14).

**Chainsaw Safety**

Overall compliance with chainsaw safety was 49.6%. Significantly more companies in Class A were compliant with the requirements than in Class N, but Classes
A and C were similarly compliant (Figure 3.15). Companies in Classes C and N were similarly compliant with chainsaw safety requirements. For all aspects of chainsaw safety, except keeping two points of attachment while climbing, proportionately more observations were made of Class N and the least of Class A. Despite the overall difference in compliance between Classes A and N, there were few significant differences between the classes for any individual chainsaw safety practice. Across all companies, the mean compliance with wearing chainsaw protective pants was 28.6%, but compliance was greater for companies in Class A and Class C than Class N (Figure 3.16). There was weak evidence that compliance was better for Class C than Class N (Figure 3.16). For all companies, the mean compliance with setting the chain brake if walking with the chainsaw was 40%. Though compliance was statistically similar among all classes, Class A was twice as compliant as Class N (Figure 3.17). Across all companies, the mean compliance with keeping two hands on a chainsaw was 40%, and Class A was twice as compliant as both Class C and Class N, though no significant differences emerged (Figure 3.18). All chainsaws started during ground operations were drop-started, regardless of class (Figure 3.19). When climbing with a chainsaw, Class A was more than three times more compliant than Class N with keeping two points of attachment, at 66.7% compliance, though no significant differences emerged (Figure 3.20). Almost all chainsaws were in proper working order, except when a worker for one company in Class N operated a chainsaw from which the chain brake had been removed (Figure 3.21). Across all companies, the mean compliance with shutting off a chainsaw when it was set on the ground was 76.6%, but compliance was greater for companies in Class A and Class C than Class N. Compliance was similar between companies in Classes A and C
(Figure 3.22). Across all companies, the mean compliance with not operating a chainsaw above one’s shoulders was 42.6%. Compliance was twice as high for Class A than Class N, but the difference is not statistically significant (Figure 3.23).

**Brush Chipper Safety**

Overall compliance with brush chipper safety was 70.1%. Class A was significantly more compliant with the requirements than Class N, but there were no other significant differences between classes (Figure 3.24). Across all companies, the mean compliance with wearing proper attire when feeding the chipper was 67.2%. Only Class A was significantly more compliant than Class N. (Figure 3.25). Across all companies, the mean compliance with keeping body parts out of the infeed hopper while feeding brush was 93.4%, and the companies were progressively less compliant from Class A to N (Figure 3.26). Across all companies, the mean compliance with feeding brush butt-cut end first was 96.7%, and compliance was similar among all classes (Figure 3.27). In contrast, across all companies, the mean compliance with feeding the chipper from curbside, rather than feeding brush adjacent to traffic, was only 28.6%. Classes A and N were similarly compliant and almost three times more compliant than Class C, though no significant differences emerged (Figure 3.28). Across all companies, the mean compliance with feeding the chipper from the side, rather than from directly in line with the rollers, was 16.4%, with Class A and Class C performing over four times more compliantly than Class N (Figure 3.29). On only seven job sites were chippers disconnected from the chip trucks. Across all companies, compliance with properly chocking chippers was 42.9%, and compliance was similar among all classes (Figure 3.30). Only one chipper was observed with the quickstop bar removed (Figure 3.31).
Climbing Safety

Overall compliance for climbing safety was 85.2%, and was similar for all classes (Figure 3.32). Only six observations were made of visual inspections prior to working, but due to the study design, it was not always possible to witness the inspections. Because witnessing a visual inspection confirmed compliance, but not observing one could not confirm noncompliance, this result was inconclusive. Across all companies, the mean compliance for placing a tie-in point well above the working area when climbing was 82.4%. Compliance was 100% for companies in Class A, but there were too few observations for other companies to detect statistical differences (Figure 3.33). Too few observations were made to draw conclusions about workers safely using ladders (Figure 3.34), although one Class A worker was observed drop-starting a chainsaw while standing, unsecured at the top of a ladder, and not wearing PPE.

Bucket Truck Safety

Overall compliance for bucket truck safety was 98.9%, and compliance was similar among all classes (Figure 3.35). Companies in all classes were 100% compliant with respect to only allowing one person in the elevated platform of a bucket truck (Figure 3.36) and not moving the bucket truck while there was a person aloft in the bucket (Figure 3.37). Across all companies, the mean compliance with using a fall-arrest harness and lanyard when working from an elevated platform was 95%. Though no significant differences emerged, Class A and Class C were similarly more compliant than Class N (Figure 3.38).

Other Aspects of the Z133.1

Across all companies, the mean compliance with properly storing sharp objects and using equipment for its intended use (not improvising) was 89.5% and 83.9%,
respectively. For both of these aspects, there was similar compliance among all classes (Figure 3.39 and 3.40). Similar to visual inspections, witnessing improper storage was more easily noticeable, but study design and lack of visibility resulted in too small of a sample size to draw any conclusions.
Figure 3.1. Best-fit lines depicting the relationship between percent compliance and log-transformed mean real estate value of properties on which companies worked. The axes do not intersect at zero. The relationship for each type of company was weak ($R^2 = 0.1613$ for Class A, $R^2 = 0.1335$ for Class C, $R^2 = 0.1618$ for Class N). The slopes ($m$) of the best-fit lines for each type of company were non-significant: $m = -0.02$ ($p = 0.8260$) for Class A, $m = -0.12$ ($p = 0.5144$) for Class C, $m = 0.06$ ($p = 0.6807$) for Class N.
Figure 3.2. Best-fit lines depicting the relationship between percent compliance and log-transformed mean distance traveled to properties on which companies worked. The axes do not intersect at zero. The relationship for each type of company was weak ($R^2 = 0.16$ for Class A, $R^2 = 0.1126$ for Class C, $R^2 = 0.1625$ for Class N). The slopes ($m$) of the best-fit lines for each type of company were non-significant: $m = -0.03117$ ($p = 0.737$) for Class A, $m = 0.02506$ ($p = 0.7418$) for Class C, $m = 0.00741$ ($p = 0.9387$) for Class N.
Figure 3.3. Best-fit lines depicting the relationship between percent compliance and log-transformed median household income of zip code tabulation area (ZTCA) in which the company worked. The axes do not intersect at zero. The relationship for each type of company was weak ($R^2 = 0.0034$ for Class A, $R^2 = -0.0146$ for Class C, $R^2 = -0.0319$ for Class N). The slopes ($m$) of the best-fit lines for each type of company were non-significant: $m = -0.07592$ ($p = 0.3143$) for Class A, $m = -0.06784$ ($p = 0.3878$) for Class C, $m = -0.06757$ ($p = 0.56$) for Class N.
Figure 3.4: Box-whisker plot depicting the overall compliance with the Z133.1 safety standard. Medians, 25th- and 75th-percentiles shown by box. Compliance was similar (p=0.5370) between Class A (72.3% compliant) and Class C (70.1% compliant). Companies in Class N (51.1% compliant), however were significantly less compliant than companies in Class A (p<0.001) and Class C (p<0.001). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.017$. 
Figure 3.5. Bar chart depicting the frequency of total perimeter observations. Class C companies were significantly more compliant (89.3%) than companies in Class A (41.2% compliant, p=0.006) and Class N (41.5% compliant, p<0.001). Companies in Classes A and N were equally compliant (p=1.000). A Bonferroni Correction was used to determine significance for α = 0.05, p = 0.017.
Figure 3.6. Bar chart depicting the frequency of perimeter setup while climbing. There were no significant differences between the three classes, largely due to small sampling numbers: Classes A (0% compliant) and C (100% compliant, p=0.996); Classes A and N (25% compliant, p=0.997); and Classes C and N (p=0.998). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.7. Bar chart depicting the frequency of setting up a perimeter while chipping. There was no significant difference between Class A (36.4%) and N (45.0% compliant, p=0.642). Significant differences emerged between Classes A and C (87.5% compliant, p=0.011), and Class C and N (p=0.015). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, p = 0.025.
Figure 3.8. Bar chart depicting frequency of perimeter setup while rigging. There were no significant differences between Classes C (33.3%) and N (50.0% compliant, p=0.638). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.9. Bar chart depicting frequency of perimeter setup while operating a bucket truck. There were no significant differences between any classes: Class C (90.9%) and N (42.9% compliant, p=0.046); Classes A (75.0%) and C (p=0.440); Classes A and N (p=0.312). A Bonferonni Correction was used to determine significance for α = 0.05, p = 0.025.
Figure 3.10. Bar chart depicting the frequency of personal protective equipment (PPE) observations. Class N companies were significantly less compliant (35.2%) than companies in Classes A (66.3% compliant, p<0.001) and C (71.3% compliant, p<0.001). There was no significant difference between Classes A and C (p=0.605). A Bonferroni Correction was used to determine significance for α = 0.05, p = 0.017.
Figure 3.11. Bar chart depicting frequency of proper head protection. There was no significant difference between Classes A (61.9%) and C (85.0% compliant, p=0.105). There were significant differences between Classes A and N (22.7% compliant, p=0.012) and Classes C and N (p<0.005). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.12. Bar chart depicting frequency of proper hearing protection. There was no significant difference between Classes A (55.0%) and C (50.0% compliant, p=0.752). There were significant differences between Classes A and N (13.6% compliant, p=0.008) and Classes C and N (p=0.016). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.13. Bar chart depicting frequency of proper foot protection. There were no significant differences between any classes: Classes C (100%) and N (90.9% compliant, p=0.998); Classes A (100%) and C (p=1.0); Classes A and N (p=0.998). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, p = 0.025.
Figure 3.14. Bar chart depicting frequency of proper eye protection. There were significant differences between Classes C (50.0%) and N (13.6% compliant, p=0.016), and Classes A (47.6%) and N (p=0.021). There was no significant difference between Classes A (47.6%) and C (p=0.879). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.15. Bar chart depicting the frequency of chainsaw observations. Class A (62.0% compliant) was significantly more compliant than Class N (38.9% compliant, $p<0.001$). There was no significant difference between Classes A and C (51.3% compliant, $p=0.153$) nor Classes C and N ($p=0.065$). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.017$. 
Figure 3.16. Bar chart depicting frequency of use of chainsaw-protective pants. There were no significant differences between Classes A (50.0%) and C (38.5% compliant, p=0.562), nor Classes C and N (5.0% compliant, p=0.051). There was a significant difference between Classes A and N (p=0.019). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.17. Bar chart depicting frequency of setting chain brake when walking with chainsaw. There were no significant difference between any classes: Classes A (54.5%) and C (46.2% compliant, p=0.682); Classes A and N (25.0% compliant, p=0.126); Classes C and N (p=0.239). A Bonferonni Correction was used to determine significance for α = 0.05, p = 0.025.
Figure 3.18. Bar chart depicting frequency of operating a chainsaw with two hands. There were no significant differences between any classes: Class A (60.0%) and C (31.6% compliant, p=0.103); Classes A and N (33.3% compliant, p=0.117) or Classes C and N (p=0.906). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.19. Bar chart depicting frequency of not drop-starting a chainsaw. There were no significant differences between any classes: Classes A (0.0%) and C (0.0% compliant, p=1); Classes A and N (0.0% compliant, p=1); Classes C and N (p=1). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.20. Bar chart depicting frequency of using two points of attachment when operating a chainsaw in the tree. There were no significant differences between any classes: Class A (66.7%) and C (50.0% compliant, $p=0.600$); Classes A and N (20.0% compliant, $p=0.141$); Classes C and N ($p=0.355$). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.21. Bar chart depicting frequency of using a chainsaw in proper working order. There were no significant differences between any classes: Class A (100%) and C (100% compliant, p=1); Classes A and N (95.2% compliant, p=0.998); Classes C and N (p=0.998). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.22. Bar chart depicting frequency of shutting off or setting chain brake on chainsaw when setting down. There were no significant differences between any classes: Classes A (92.9%) and C (86.7% compliant, p=0.590); Classes A and N (55.6% compliant, p=0.040); Classes C and N (p=0.066). A Bonferonni Correction was used to determine significance for α = 0.05, p = 0.025.
Figure 3.23. Bar chart depicting frequency of not operating a chainsaw above the shoulders. There were no significant differences between any classes: Classes A (60.0%) and C (42.1% compliant, p=0.303); Classes A and N (30.0% compliant, p=0.081); Classes C and N (p=0.433). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.24. Bar chart depicting the frequency of brush chipper observations. Class A was significantly more compliant (79.1%) than Class N (61.9% compliant, p=0.006). There were no significant differences between Classes A and C (69.4% compliant, p=0.133) nor Classes C and N (p=0.290). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.017$. 
Figure 3.25. Bar chart depicting frequency of wearing proper attire when chipping. There was a significant difference between Class A (95.2%) and N (38.1% compliant, p=0.002). There were no significant differences between Classes A and C (68.4% compliant, p=0.051), nor Classes C and N (p=0.059). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.26. Bar chart depicting frequency of not placing body parts on the infeed hopper, including hands and feet. There were no significant differences between any classes: Classes A (100%) and C (94.7% compliant, p=0.994); Classes A and N (85.7% compliant, p=0.994); Classes C and N (p=0.361). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.27. Bar chart depicting predicted outcomes for feeding brush into chipper butt end first. There were no significant differences between any classes: Classes A (95.2%) and C (94.6% compliant, p=0.942); Classes A and N (100% compliant, p=0.996); Classes C and N (p=0.996). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, p = 0.025.
Figure 3.28. Bar chart depicting frequency of feeding chipper from the curbside. There were no significant differences between any classes: Classes A (37.5%) and C (11.1% compliant, p=0.223); Classes A and N (36.4% compliant, p=0.960); Classes C and N (p=0.217). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.29. Bar chart depicting frequency of feeding chipper from the side. There were no significant differences between any classes: Classes A (23.8%) and C (21.1% compliant, p=0.835); Classes A and N (4.8% compliant, p=0.110); Classes C and N (p=0.152). A Bonferroni Correction was used to determine significance for α = 0.05, p = 0.025.
Figure 3.30. Bar chart depicting frequency of chocking a chipper when detached from vehicle. There were no significant differences between any classes: Classes A (50.0%) and C (33.3% compliant, $p=0.711$); Classes A and N (50.0% compliant, $p=1$); Classes C and N ($p=0.711$). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.31. Bar chart depicting frequency of operating a chipper equipped with a quickstop. There were no significant differences between any classes: Classes A (100%) and C (100% compliant, p=1); Classes A and N (95.2% compliant, p=0.998); Classes C and N (p=0.998). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, p = 0.025.
Figure 3.32. Bar chart depicting the frequency of climbing observations. There were no significant differences between any classes: Classes A (92.9% compliant) and C (80.0% compliant, p=1); Classes C and N (75.0% compliant, p=1); Classes A and N (p=0.597). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.017$. 
Figure 3.33. Bar chart depicting frequency of placing a tie-in point well above working area when climbing. There were no significant differences between any classes: Classes A (100%) and C (66.7% compliant, p=0.996); Classes A and N (60.0% compliant, p=0.996); Classes C and N (p=0.851). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, p = 0.025.
Figure 3.34. Bar chart depicting frequency of not working off a ladder. There were no meaningful findings for any classes, due to the small sample size.
Figure 3.35. Bar chart depicting the frequency of bucket truck observations. There were no significant differences between any classes: Classes A (100% compliant) and N (96.4% compliant, p=1), Classes C (100% compliant) and N (p=0.847), and Classes A and C (p=1). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.017$. 
Figure 3.36. Bar chart depicting frequency of only placing one person in a bucket at a time. There were no significant differences between any classes: Classes A (100%) and C (100% compliant, p=1); Classes A and N (100% compliant, p=1); Classes C and N (p=1). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.37. Bar chart depicting frequency of not moving a bucket truck when the platform is elevated. There were no significant differences between any classes: Classes A (100%) and C (100% compliant, p=1); Classes A and N (100% compliant, p=1); Classes C and N (p=1). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.38. Bar chart depicting frequency of using a fall-arrest harness and lanyard when working in an elevated platform. There were no significant differences between any classes: Classes A (100%) and C (100% compliant, p=1); Classes A and N (20.0% compliant, p=0.999); Classes C and N (p=0.998). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.39. Bar chart depicting frequency of properly storing sharp objects. There were no significant differences between any classes: Classes A (88.9%) and C (100% compliant, $p=0.997$); Classes A and N (83.3% compliant, $p=0.758$); Classes C and N ($p=0.997$). A Bonferroni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Figure 3.40. Bar chart depicting frequency of using equipment for their intended use. There were no significant differences between any classes: Classes A (88.9%) and C (84.2% compliant, p=0.679); Classes A and N (78.9% compliant, p=0.419); Classes C and N (p=0.677). A Bonferonni Correction was used to determine significance for $\alpha = 0.05$, $p = 0.025$. 
Table 3.1. Day and time of observations classified by company class.

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<th>Day of the Week</th>
<th>Class A (N=21)</th>
<th>Class C (N=20)</th>
<th>Class N (N=22)</th>
<th>Total (N=63)</th>
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<td>Class N (N=22)</td>
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<td>Chainsaws</td>
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<td>19  95%</td>
<td>21  95%</td>
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<td>20 100%</td>
<td>22 100%</td>
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<td>0   0%</td>
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<tr>
<td>Street side</td>
<td>12  57%</td>
<td>15  75%</td>
<td>19  86%</td>
<td>0.105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private property</td>
<td>20 95%</td>
<td>9   45%</td>
<td>17  77%</td>
<td>0.001***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td>0   0%</td>
<td>7   35%</td>
<td>0   0%</td>
<td>0.001***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.3. ANOVA Summary Table for distance traveled (mi) among the classes.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Mean (SD)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Type</td>
<td>2</td>
<td></td>
<td>0.2909</td>
<td>0.1454</td>
<td>0.9131</td>
<td>0.408</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.8 (12.0)a</td>
<td></td>
</tr>
<tr>
<td>Group C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.7 (15.3)a</td>
<td></td>
</tr>
<tr>
<td>Group N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.6 (8.42)a</td>
<td></td>
</tr>
<tr>
<td>Jobs</td>
<td>52</td>
<td></td>
<td>8.2826</td>
<td>0.1593</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td></td>
<td>8.5735</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA = analysis of variance; df = degrees of freedom; SS = sum of squares for distance traveled; MS = mean squares; means followed by the same letter are not significantly different (P>0.05) by Tukey’s HSD test.
Table 3.4. ANOVA Summary Table for real estate value among the classes.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Mean (SD)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Type</td>
<td>2</td>
<td>0.6148</td>
<td>0.3074</td>
<td>3.2939</td>
<td>0.046*</td>
<td>$857,400 (926,970)a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$857,400 (926,970)a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$417,100 (262,230)ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$381,700 (259,900)b</td>
<td></td>
</tr>
<tr>
<td>Jobs</td>
<td>45</td>
<td>4.1999</td>
<td>0.0933</td>
<td></td>
<td></td>
<td>$381,700 (259,900)b</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>4.8147</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA = analysis of variance; df = degrees of freedom; SS = sum of squares for distance traveled; MS = mean squares; means followed by the same letter are not significantly different (P>0.05) by Tukey’s HSD test.
Table 3.5. ANOVA Summary Table for median household income among the classes.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Mean (SD)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td>1.0367</td>
<td>0.5183</td>
<td>3.4938</td>
<td>$69,750 (30,090)a</td>
<td>0.037*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$59,560 (23,650)ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$48,680 (16,490)b</td>
<td></td>
</tr>
<tr>
<td>Jobs</td>
<td>55</td>
<td></td>
<td>8.1598</td>
<td>0.1484</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td></td>
<td>9.1965</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA = analysis of variance; df = degrees of freedom; SS = sum of squares for distance traveled; MS = mean squares; means followed by the same letter are not significantly different (P>0.05) by Tukey’s HSD test.
Table 3.6. Summary statistics of compliance by company class.

<table>
<thead>
<tr>
<th>Company Type</th>
<th>Class A</th>
<th></th>
<th>Class B</th>
<th></th>
<th>Class C</th>
<th></th>
<th>Class D</th>
<th></th>
<th>All Companies</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Site Perimeters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td>n(%)</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site Perimeters</td>
<td>7(41)</td>
<td>10(59)</td>
<td>26(84)</td>
<td>5(16)</td>
<td>17(41)</td>
<td>24(59)</td>
<td>50(56)</td>
<td>39(44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climbing</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>3(27)</td>
<td>8(73)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chipping</td>
<td>4</td>
<td>7</td>
<td>14</td>
<td>2</td>
<td>9</td>
<td>11</td>
<td>27(57)</td>
<td>20(43)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigging</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>44(56)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>16(73)</td>
<td>6(27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPE</td>
<td>55(66)</td>
<td>28(34)</td>
<td>57(71)</td>
<td>23(29)</td>
<td>31(35)</td>
<td>57(65)</td>
<td>143(57)</td>
<td>108(43)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>13</td>
<td>8</td>
<td>17</td>
<td>3</td>
<td>5</td>
<td>17</td>
<td>35(56)</td>
<td>28(44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>3</td>
<td>19</td>
<td>24(39)</td>
<td>38(61)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td>2</td>
<td>61(97)</td>
<td>2(3)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Eye</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>3</td>
<td>19</td>
<td>23(37)</td>
<td>40(63)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chainsaw Safety</td>
<td>62(62)</td>
<td>38(38)</td>
<td>58(51)</td>
<td>55(49)</td>
<td>49(37)</td>
<td>85(63)</td>
<td>169(49)</td>
<td>178(51)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective pants</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>16</td>
<td>12(29)</td>
<td>30(71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk with brake set</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>12</td>
<td>16(40)</td>
<td>24(60)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two hands on saw</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>13</td>
<td>7</td>
<td>14</td>
<td>22(40)</td>
<td>33(60)</td>
<td></td>
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</tr>
<tr>
<td>Not drop-started</td>
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<td>12</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>16</td>
<td>0(0)</td>
<td>40(100)</td>
<td></td>
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</tr>
<tr>
<td>Two attachment points</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>7(47)</td>
<td>8(53)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In working order</td>
<td>15</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>20</td>
<td>1</td>
<td>53(98)</td>
<td>1(2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safely set down</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>36(77)</td>
<td>11(23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not above shoulders</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>11</td>
<td>6</td>
<td>14</td>
<td>23(43)</td>
<td>31(57)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brush Chipper Safety</td>
<td>91(79)</td>
<td>24(21)</td>
<td>75(69)</td>
<td>33(31)</td>
<td>73(62)</td>
<td>45(38)</td>
<td>239(70)</td>
<td>102(30)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No body parts used</td>
<td>21</td>
<td>0</td>
<td>18</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td>57(93)</td>
<td>4(7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper attire</td>
<td>20</td>
<td>1</td>
<td>13</td>
<td>6</td>
<td>8</td>
<td>13</td>
<td>41(67)</td>
<td>20(33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butt or cut end first</td>
<td>20</td>
<td>1</td>
<td>18</td>
<td>1</td>
<td>21</td>
<td>0</td>
<td>59(97)</td>
<td>2(3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fed curbside</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>8(29)</td>
<td>20(71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fed from the side</td>
<td>5</td>
<td>16</td>
<td>4</td>
<td>15</td>
<td>1</td>
<td>20</td>
<td>10(16)</td>
<td>51(84)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company Type</td>
<td>Class A</td>
<td>Class C</td>
<td>Class N</td>
<td>All Companies</td>
<td>Total Observed</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------</td>
<td>---------</td>
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<td>--------------</td>
<td>----------------</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Standard</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brush Chipper Cont’d</td>
<td>91(79)</td>
<td>75(69)</td>
<td>73(62)</td>
<td>239(70)</td>
<td>341(28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocked if detached</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick-stop present</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climbing Safety</td>
<td>13(93)</td>
<td>4(80)</td>
<td>6(75)</td>
<td>23(85)</td>
<td>27(2)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Visual assessment</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tied above work</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>14</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe ladder use</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket Truck Safety</td>
<td>20(100)</td>
<td>41(100)</td>
<td>24(86)</td>
<td>85(96)</td>
<td>89(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One person in bucket</td>
<td>8</td>
<td>0</td>
<td>12</td>
<td>35</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arborist out if moved</td>
<td>8</td>
<td>16</td>
<td>11</td>
<td>34</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-body harness</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>24(89)</td>
<td>20(87)</td>
<td>20(80)</td>
<td>64(85)</td>
<td>75(6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharp tools stored</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>17</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No improvising</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>47</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>272(72)</td>
<td>281(70)</td>
<td>226(51)</td>
<td>779(64)</td>
<td>1219(100)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A ‘yes’ response denotes compliance with a standard, ‘no’ denotes noncompliance, and ‘n’ equals number of observations. Means were calculated based on total applicable observations, and were not weighted by class. The denominator for mean calculations corresponds with the total count of standard category, by each class. Total means were calculated using 1219 (the total number of observations) as the denominator. Summary safety groups were assessed for each class, and their significance is noted after the ‘No’ response. Compliance followed by the same letter is not significantly different (P>0.05).
CHAPTER 4
DISCUSSION

Overall, accreditation and certification status appears to be associated with better compliance among workers. In terms of the individual safety groups, accreditation appears to be associated with better compliance for chainsaw and chipper safety. Certification appears to be associated with better compliance for perimeters. Finally, certification and accreditation appear to be associated with better compliance for PPE-use. Class N was least compliant in these aforementioned safety groups, but was equally compliant for bucket truck and climbing safety. Despite this improved safety behavior among certified arborists and accredited companies, there is still room for improvement, as compliance is well below 100 percent. Compliance varied among the safety groups: workers were most compliant with bucket truck safety and least compliant with chainsaw safety. The biggest cause for concern is compliance with drop-starting the chainsaw, operating the saw with two hands, keeping the chainsaw below shoulder level, and feeding the chipper from the side. Though the small sample size limited assessing any significant difference between classes in many categories, there were still several differences in compliance apparent in each category. Although this study does not focus on causation, there is an evident link between these credentials and increased safety behavior.

Less compliance in Class N than those in Class A and Class C indicates that some aspect of accreditation and ISA certification reveals a significant distinction between arborists. Although this self-selection process cannot directly account for a cause in this difference, the processes allow for clients to distinguish between the more or less
compliant companies. Though no research highlights the demographics of tree care clients, one can assume that with Internet access, any client can research how to choose an arborist for the job. ISA provides online information regarding what professional affiliations to look for in an arborist or company, and further describes the kinds of jobs these people should be qualified to complete (ISA 2011).

**Secondary Findings**

Variability of job characteristics proved not to be significant in the overall assessment of company performance. Jobs were observed during all five days of the workweek, and observations by company class were not concentrated on particular days or times. Marren (2010) found most injuries to occur in the middle of the week before lunch. More specifically, Buckley et al. (2008) established that most landscape injuries occurred on Wednesdays and Thursdays, in July and August, when a majority of the observations were made for this study. Most observations for this study occurred Monday and Wednesday mornings. This was largely because from September to December, observations could only be made on Mondays, Wednesdays, and Fridays, because of scheduling. Further, most observations were made in the morning because it was easier to follow a company to its job site than it was to find them serendipitously.

As predicted, Class A worked in areas with a significantly higher real estate value and median household income. It is TCIA’s claim that the publicity provided from obtaining accreditation allows for a larger scope of prospective clientele, who will be better able to identify those companies with a history of high customer satisfaction (TCIA 2009). This extra publicity includes fifteen additional zip codes added to search engines for online consumer searches for tree care companies, as well as use of accreditation
logos, and listings on the TCIA website (TCIA 2009). Although the mean distance traveled by companies in different classes was similar, the greater variability about the mean for companies in Class C was peculiar. It might be due to more highly qualified workers needing to compete with possibly low bids made by Class N, but outbidding the better reputation of Class A, although there is no clear evidence to support this claim. Alternatively, it could be due to crews that work for a specific headquarters, but park and operate out of another location further away.

Types of jobs carried out by the companies revealed that members of Class A performed more ornamental pruning, and used chainsaws less frequently than the other two classes. Retention of customers and continued landscape maintenance might provide more revenue in the long-term than quick removals. Further, the skill set required for fine pruning might only be offered by those in Classes A and C, as these people have presumably honed their ornamental pruning skills through years of experience and continued education (Lilly 2001). Conversely, for removals, the knowledge of knots and cuts required might be universal among the classes, as these two items are used frequently in arboriculture. In comparison, it is not clear if ornamental pruning or removals require more skill. In terms of frequency, workers in Class A will be more commonly found conducting light pruning jobs than Class N. Finally, that members of Classes A and N were working on more private properties than Class C may be a result of selection bias for Class C. These members were found conducting more utility line clearance, which is more visible while driving than finding a company tucked within a residential property. As such, this sample is not entirely representative of the Class C population. Whereas the original population of certified arborists within the study area
included 9.9% utility companies, the final 20 companies assessed were made up of 40% utility companies. Despite this discrepancy, there is no reason to believe that utility crews should not be a representative sample of commercially-employed certified arborists.

**Compliance with the Z133.1**

Clarke (1999) found that there is a difference between workers’ perceptions of their own safety and managers’ and supervisors’ perceptions of worker safety. In a survey regarding perceived organizational safety, workers rated working conditions as most essential to a safe working environment, higher than managers and supervisors rated it. Supervisors perceived that managers would rank working conditions as less essential to worker safety, whereas managers perceived that supervisors would rank working conditions as most essential. Alternatively, supervisors felt that if given the choice, local management was more important than working conditions. This belief demonstrated a lack of consistency and shared understanding from managers and supervisors. The effect that this can have on safety culture is great when considering that strides made toward a safer workplace might not meet the needs of the worker. While managers work on improving local management, the workers desire a safer work environment more immediately. Griffin et al. (2000) found that factors affecting safety compliance include safety knowledge, compliance motivation, participation motivation, and safety participation, all of which are affected by safety climate. Though this current study is limited to looking at associations without finding causation, it might be considered that these aforementioned factors contribute to the overall compliance of tree workers.
The following section will refer to the aspects of the Z133.1 – 2006 addressed, based on their specific subsection number. See Appendix B for the exact wording, and a reference list of the revisions made to each subsection.

**8.1.1: Visual Inspections**

Added in 1994, this section refers to performing a visual assessment of the job site prior to commencing any work. Due to the method of observation, lack of visibility and auditory references limited the ability to confirm that a visual inspection had been conducted. Further, because the researcher left at the beginning of jobs to seek out other companies for the study, visual inspections may have been missed during this time. Only six observations were made of visual inspections prior to working. Because the investigator left the job site once the location was recorded, the possibility of missing a visual inspection made it difficult to ever know with certainty that a company did not properly assess the situation. Given that difficulty, conclusive measures could not be made. A high level of compliance with visual inspections would be inconsistent with prior research from Ball (2011), who found that most workers who sustain falls from trees fell with the tree, as opposed to from the tree. The risk associated with falling can be reduced by properly inspecting the root zone, trunk, and canopy prior to ascending.

**3.2.2, 5.2.9, & 8.6.1: Working Perimeters**

Included in the original 1972 version of the Z133.1, effective perimeters to control pedestrian and vehicular traffic are of the utmost importance to reducing the likelihood of people wandering into the work area. This issue is also addressed in section 5.2.9 for establishing appropriate clearances for traffic when operating an aerial device. The high compliance of Class C in comparison with the other two classes may be
influenced by the large sample of utility tree workers, who might be inspected more by contractors and/or incur harsher penalties for noncompliance. Presumably, higher emphasis is placed on reducing on-site traffic when electrical lines are involved. Insight from a lead forestry supervisor at National Grid confirms that consistent messages from the company about safe roadside setups and regular training programs have helped to increase worker compliance with roadside safety (Rooney 2012). The Utility Work Zone Traffic Control Field Guide Book (2009) illustrates, in varying scenarios, the attention placed on proper traffic control perimeters. Further investigation of the results revealed that all five cases of Class C noncompliance for perimeter setup came from non-utility workers. As utility workers’ main concern should be eliminating direct or indirect contact with power lines, the proper placement of a traffic perimeter would aid in reducing another danger in the workplace, as well as reduce further work distractions.

According to Ball (2011), transportation accidents account for 8% of nonfatal injuries. However, these incidents usually occur while in transit, not during the job. Compared to Class N, the fewer perimeters required for Class A jobs might be a result of working further in on properties, away from utility lines. Class N worked more frequently on street sides, requiring perimeters, and where there was a higher probability of utility lines being present. These jobs undertaken by Class N may be those turned down by those of Classes A or C because these people are aware of the need to stay more than ten feet from a power line (unless they are qualified line clearance tree trimmers), and therefore bid much higher due to the added danger. As such, Class N might not be aware of the increased danger of working within ten feet of a power line, as they are
presumably unfamiliar with the Z133.1. However, records were not always kept as to the presence of power lines on the job site, so it is not possible to confirm this assertion.

The importance of chipper perimeters for traffic control was added in the 2006 revision (subsection 8.6.1). The high compliance for Class C when setting up perimeters around chipping may also be explained by the large sample of utility line clearance workers who nearly always work street side. These utility companies are frequently seen working in conjunction with police enforcement when operating in an urban area, for which traffic control is pertinent. Ineffective perimeters were present, including ones where the workers conducted tree work outside the perimeter set (Class N), as well as in one instance, in Class C, where a patron was allowed onto the job site without PPE and began chipping with the crew. In one case, a perimeter was set up around a disconnected and chocked chipper, but the perimeter was removed prior to chipping (Class A).

3.4.1: Personal Protective Equipment

As hearing, foot, eye, and head protection have been required since the first ANSI Z133.1 (1972), it is understandable why Class N is significantly less compliant than both Classes A and C, as these people might not be aware of the level of protection PPE provides and the reduced potential of fatal injuries by properly using PPE. The low compliance of Class A indicates a disconnect between education and safety culture. Companies in Class A must wear all PPE to pass inspection for accreditation. However, at some point following achieving accreditation status, PPE compliance diminishes, potentially due to safety culture. Haviland et al. (2010) found PPE noncompliance to be the fourth most frequently cited OSHA violation, accounting for three of the major injury categories, including eye injury, caught-ins, and bodily reaction and exertions. Because
of the study design, it is difficult to say definitively if observations made of Class C were directly made of certified arborists, or if the people observed without PPE were the non-certified arborists. But given that overall, Class C was equally compliant with Class A, it reveals that the dissemination of information from co-workers is equally as effective at conveying the message as accreditation. This is a good sign that safety culture positively creates a self-evaluation system. On the other hand, accreditation uses enforcement to change workers’ behaviors, and does not necessarily affect the overall safety culture in the long term. In several instances, ground workers did not wear PPE, despite PPE being present on many of the job sites. This may be explained by the main emphasis being placed on safety while working aloft, but minimal emphasis being placed on ground worker safety. Ball (2011) noted that of 172 worker fatalities, 35% of those were from contact with objects or equipment. Additionally, Buckley (2008) found that the part of the body most injured in landscape, lawn, garden, and tree services was the head (26.3%). Given this evidence that groundwork is no safer than working aloft, a greater emphasis must be placed on working safely from the ground. Some examples of noncompliance included not wearing head protection while removing hangers (Class C), and leaving hearing protection hanging on the chipper (Class N). Aksorn et al. (2007) equated lack of PPE compliance with five factors: group norms that ignore PPE use, overconfidence that accident potential is low, being uncomfortable in the PPE, and prior experience with no PPE becoming a habit. In addition, Cavazza et al. (2009) concluded that safety climate is positively affected by attitudes toward safety from supervisors, company safety concern, and senior managers’ safety concern. Alternatively, safety climate is negatively impacted by work pressure, which is potentially why the workers were observed without PPE.
Specifically related to “self-protecting behaviors,” Cavazza et al. (2009) uncovered that workers’ compliance corresponded with their ambivalence toward wearing PPE, when their perceived benefits of wearing the PPE conflicted with the future potential costs. Further, the researchers suggested that it was possible that managers were placing too high an emphasis on safety compliance for regulatory reasons (such as OSHA inspections), instead of for personal safety benefits. They noted that this ambivalence toward wearing PPE was directly related to their likelihood to lapse from regular PPE use.

**3.4.2: Head Protection**

In terms of using head protection, the differences in compliance for the three classes may be explained by the large number of utility workers observed. When the utility jobs are removed from the sample, head protection compliance for non-utility Class C is similar to Class A. Though virtually no research has been conducted on safety culture for linemen or utility line clearance workers, it is possible that both the high risk of electrocution and the high-visibility for OSHA inspectors might be incentives for workers to comply with wearing head protection. It is not clear if policing is the cause of this adherence, or if safety culture plays a role in this as well.

The low compliance for Class A cannot be explained by the ornamental pruning observations, as when ornamental pruning observations were eliminated from the analysis, compliance decreased from 61.9% compliant to 60.0%. It was suspected that there may be an attitude of lower stakes due to these activities undertaken, but the statistics do not support this speculation. Although it is difficult to ascertain why members of Class N do not wear head protection, it may be due to discomfort, safety
culture, or their personal conflicts regarding how wearing a hard hat can impact their work experience. For those who had PPE on site but did not wear the protection, noncompliance with the Standard may have been a matter of safety culture, and without that influence, workers might have felt insecure about wearing all their protection while their co-workers were devoid of PPE. In this case, Wu et al. (2010) found that four factors affect safety culture: regulation, informing, caring, and coordination. For these tree workers, PPE is present, but neither coordination from supervisors nor strict enforcing from management is in place to procure safe workers. Evanoff et al. (2011) found high PPE compliance among apprentice carpenters because these workers were immediately removed from the job site for noncompliance.

3.4.4: Foot Protection

The high compliance with wearing protective footwear can be explained by the ease with which proper shoes can be worn. Although Elsey (2003) found conflicting data regarding proper footwear use in the workplace, it is reassuring to see that in the case of tree workers, they are compliant with foot protection. The inconsistency between Elsey’s findings and those of this study can possibly be explained by the emphasis placed on slip-resistance in the occupational footwear industry. In the service industry, for example, where workers are operating on slick floors, workers experience frequent slips and falls (Hodgin 1992). Given their work environment, tree workers will likely experience more trips and crushing injuries. As such, tree workers are not seeking shoes with specifically rated anti-slip soles, but need to find decently sturdy shoes that are able to withstand crushing injuries. Unlike other protective wear, shoes are rarely removed on the job site and can be worn for all tasks. In contrast to hearing protection, which can hinder verbal
communication among workers, the same shoes can be worn for climbing and groundwork, without negatively affecting any job activity.

3.4.6: Hearing Protection

Regulation of noise exposure dates back to 1972, and in 1981, OSHA began regulating workers, limiting exposure of 85 dBA to the eight-hour workday (NIOSH 1998; OSHA Occupational Noise Exposure). Prior to the 2000 revision of the Standard, hearing protection was categorized in its own specific section on noise, emphasizing how conditional the use of hearing protection was presumed to be. In the event that there might be a noise that cannot be reduced by a significant level, one must wear hearing protection. In 2000, hearing protection received its own subsection with eye, foot, and leg protection, leaving head protection on its own. It was not until 2006 that all the PPE were grouped together, stating that people will most likely need to use all these forms of PPE at some point on one job. It was at this point that noise exposure appeared to be as important as preventing head and eye injuries.

Employers are presumably providing the most basic hearing protection possible – ear buds – which might explain why people are not using them effectively. Poor design, given the job at hand, might act as a disincentive to wearing them, as they may get dislodged, dropped, lost, or forgotten. The more expensive earmuffs are certainly bulkier for a climber, but are easier to take on and off, and harder to misplace. Future studies might explain type of hearing protection provided and the compliance of workers, but as these data were not collected, it is not possible to assess if this is an accurate explanation of this finding. Further, compared to other tree equipment and PPE, hearing protection is one of the least expensive preventative measures, and therefore price is presumably not a
disincentive for employers. More likely, the safety culture does not foster proper PPE compliance.

All jobs observed for each class required hearing protection, implying that loud equipment is now an everyday occurrence, and the use of hearing protection should no longer be considered conditional, but instead, equally as necessary as eye, head, leg, and foot protection. Given that OSHA restricts noise exposure to eight-hour periods at 85 decibels, and that chainsaws and brush chippers operate at 110-117 decibels, this means that arborists must limit their use of these tools, and use hearing protection regularly to avoid causing permanent damage.

3.4.7: Eye Protection

Of all the different PPE, workers were least compliant with wearing eye protection. This low compliance might be explained by the ease with which glasses may be removed, as well as their tendency to get foggy during the more humid times or highly aerobic activities. Such observations were made during this study, but were not considered cases of noncompliance, as it would potentially make a situation more dangerous if a worker could not see. This fogging can result in loss of visibility while working, perhaps making the job more dangerous than if the glasses were left behind. If provided with fog-resistant safety glasses, workers might be more enticed to wear them throughout the workday, instead of constantly removing them to wipe away the fog, and potentially not reapplying them. Though it is not possible to know if this is exactly the reason for noncompliance, it might also be possible that workers do not perceive high risk when not wearing eye protection. Although it might seem like common sense to some people, Elsey (2003) states that in reference to workplace footwear injuries, the
BLS reported that only one out of four workers wore approved footwear. This was directly responsible for their injuries, showing that whereas for some, PPE might seem like common sense, this is not necessarily true for everyone on the job site. It is difficult to draw the line between common sense and compliance, and in the case of eye protection, no definitive conclusions can be drawn.

**3.4.8: Chainsaw Protective Pants**

Although leg protection was added to the Standard in 1994, it was not until 2000 that the phrase “chainsaw-resistant” was added. O’Connor (1989) found that when chainsaw pants were introduced in 1978, leg injuries due to chainsaws were reduced by two-thirds. In 1999, the U.S. Consumer Products Safety Commission Report (U.S. CPSC) found that 10,310 chainsaw injuries occurred between the upper and lower leg. These could have been prevented by the proper use of chainsaw protective pants. Once again, perhaps the difference between Class A and Class N compliance might be explained by budget, but presumably only in the cases where one pair of chaps was shared among the crew. In this sense, it is not necessarily that the chaps are too expensive to purchase, but the employer does not perceive a high enough benefit to buying a pair for each worker. Presumably, Class A employers either provide a pair for every worker or designate a specific chainsaw operator. Members of Class N might not own any, or have one pair to share among the crew. Because leg protection compliance was, overall, quite low, it is possible that the industry as a whole holds a certain level of ambivalence toward wearing PPE. This may be due to safety culture, discomfort, overconfidence with a chainsaw, or perceived low benefits of wearing protective chaps. Furthermore, given the exposure to safety education that members of Class N might be lacking, they could be
unaware of the importance of leg protection. However, the use of leg protection is encouraged in the Husqvarna Chain Saw Operator’s Safety Manual (1991) and the Stihl Chain Saw Safety Manual (2000). In some instances, chaps were worn, but were not buckled correctly. This behavior was evaluated as noncompliant, as they were therefore not worn according to the manufacturer’s specifications (Classes A, C). Some chaps did not extend down to the ankles (Class A), but it is not specified in the Standard or chainsaw user manuals how far down the chaps need to fit (ANSI 2006; Stihl Chain Saw Safety Manual 2000; Husqvarna Chain Saw Operator’s Safety Manual 1991).

5.2: Bucket Truck Safety

High overall compliance with bucket truck safety among all three classes might establish that either people are mostly compliant or that the aspects of the Standard studied were not the ones with which people were mostly noncompliant. As is, this finding was inconsistent with Castillo’s (2009) finding that almost one-third of deaths from falls occurred out of a bucket truck. On the other hand, it might be a result of the small sample size, or that it was difficult to observe lanyard attachments and body belts. Observations made in the field that were not part of the statistics include one bucket truck that was observed on the road with an expired registration, and another truck and chipper had broken tail lights. Ball (2011) surmised that a majority of bucket truck accidents occurred from boom failures. Maintenance and safety inspections of equipment could not be addressed in this study, which might better explain the number of bucket truck fatalities.
5.2.2: Securing to a Raised Platform

The original 1972 version of the Standard stated that aerial devices must have an attachment point for a lanyard. It was not until 1994 that its use was mandatory. Due to difficulty observing body-belts in a bucket, few observations were made of how a worker was protected within a raised platform. All company classes were equally compliant, at almost 100% compliance. Poor visibility of a body-belt might have changed all the normally noncompliant responses to become “no response” because an exact answer could not be achieved. Many companies were in compliance with wearing a full-body harness and lanyard, but it is unclear how many workers either wore only a body belt, or had no fall protection.

5.2.10: Maximum Occupancy in Bucket Basket

This section of the Standard emphasized the importance of only having one person in the bucket basket at a time. Given that falls from buckets account for a large number of fatalities (Castillo 2009), this result shows that this aspect of the Standard is not the reason workers are falling out of bucket baskets. This section was part of the original version of the Standard and is perhaps enforced by the seemingly confined space of the aerial bucket basket, out of which an arborist operates.

5.2.18: Moving the Bucket Truck

Similarly, originating from the 1972 version, not moving a bucket truck while the boom is elevated was not a likely cause of accidents because of universal compliance by all three classes. In every instance where a bucket truck was moved on the job site, the boom was lowered prior to moving the truck. Perhaps because these last two sections were part of the original version of the Standard, and have been therefore embraced as a reasonable guideline, people are more willing to abide by this. However, this would not
explain Class N, for whom it has been assumed are unfamiliar with the Standard. Though common sense might appear to be responsible for this high level of compliance, Elsey (2003) suggests that common sense is not always a predictor of compliance in the workplace. Alternatively, Edmondson (1999) suggests that behaviors can frequently be accounted for by communication within a teamwork setting. Team psychological safety, as Edmondson (1999) refers to it, can be influenced by both workers’ relationships with one another, as well as workers’ belief that information will be useful to his/her coworkers. In this case, more experienced workers might be communicating with their coworkers about the risks associated with moving the bucket truck, either from prior experience or information related to them. If these workers have a poor relationship with one another, they are less likely to admit mistakes they have made in the past. Though it is possible that workers do not move bucket trucks while the boom is elevated because of learned behavior, it is also possible that this is due to perceived risk, or the expense of potentially breaking the truck. Likewise, this is also probably not a common reason that there are a large number of deaths from performing aerial bucket work.

5.3: Brush Chipper Safety

Greater compliance among companies in Class A regarding brush chipper safety can be explained by the emphasis placed on safety training for accredited companies and the frequency of chipper use. There are five specific aspects of proper chipper operation that the TCIA Accreditation Standard addresses, including proper positioning of the chipper, how to feed the chipper, and how to stack and drag brush. All of these topics aid in safe chipper practices. Ball and Vosberg (2010) found that only 53.4% of tree care companies (of no specified accreditation status) provided chipper training, compared to
aerial lift training, which was provided 77.6% of the time. Less training might be due to the user-friendly nature of operating a chipper, compared to aerial lifts, which might be perceived as higher risk due to the height.

The low overall compliance might be explained by workers’ perception of danger while operating the chipper. Though Castillo (2009) did not specify type of machinery involved in fatalities, 7% of fatalities occurred from machinery, while 3% occurred from chippers, leaving only 4% for all other types of machinery. Low compliance might be due to the addition of the feed wheels blocking direct contact with the knives, creating a false sense of security for workers. Future detailed observations of worker behavior around a chipper might create a clearer picture of where the mistakes lie. Additionally, future research on types of chipper used during fatal incidents might reveal if the newer chippers are used differently. Observations made in the field include one chipper that required clamps to keep the engine running (Class N), as well as one chipper that was fed while the boom of the aerial lift was amid the power lines (Class C), potentially ignoring the possibility of the chipper becoming charged.

5.3.5: Quick-stops and Reverse Bars

The necessity for quick-stops and reversing devices in a chipper was not addressed until the 1982 revision. The fact that all but one company had their reverse bar and quick-stop fully intact might be explained by the benefit it serves when clearing brush jams, making this safety measure more helpful than bothersome. Mostly, the reverse bar was used to clear brush of the rollers to readjust the wood positioning. In one instance, a chipper was left unattended in the street with the rollers running, leaving it open for a bystander to engage with the running rollers.
5.3.8: Chocking Brush Chippers

First required in 1972, chippers must be chocked or secured by some means when detached from vehicles. High compliance among all three classes with chocking their chippers suggests that arborists, despite any emphasis in the certification and accreditation processes, recognize a need to chock a detached mechanism on wheels. Whether they understand why it is necessary cannot be determined from these data.

6.3: Chainsaw Safety

Compliance with chainsaw safety varied, depending on the aspect of safety addressed. Greater compliance from Class A in comparison to Class N, shows that some aspect of accreditation either creates or attracts safer chainsaw users in the accreditation program. However, given the low level of compliance from Class N, Class A need not be too compliant to create this significance. The low level of compliance from Class A shows that there must be some degeneration of quality safety behavior from the time of accreditation to the time of observation, or that the standard for accreditation is not 100% compliance. Not surprisingly, chainsaws do not account for a large number of fatalities as most incidents result instead in major injuries. These injuries presumably result in higher workers’ compensation costs, and time off work (Castillo 2009). Alternatively, falls from trees might be attributed to workers cutting their climbing lines, either with a chainsaw or handsaw. Examples of poor chainsaw operations observed in this study included using the chainsaw left-handed, not wrapping the left thumb, and filling the saw with gas on the bed of the truck. One observation was made of a worker sharpening the chainsaw without eye protection (Class C). However, that was not counted as an infraction, as it was not clearly stated anywhere in the Standard or chainsaw user manuals how to properly protect oneself when sharpening the saw. An additional frequent infraction included operating
the chainsaw in the brush chipper while the feed rollers were still moving (Class N). Ground saws were occasionally used in the tree, but it could not be verified if they exceeded 15 pounds (Class N).

6.3.2: Chainsaws in Proper Working Order

Added to the Standard in the 2006 revision, operating chainsaws in proper working order only, and not modifying the saw, turned out not to be problematic for the three classes. However, it appears that most companies are now compliant with regard to not removing or modifying safety devices. No companies were observed with a modified chainsaw, either ground or climbing, except for one worker who was seen climbing with a newer model chainsaw without the chain brake present (Class N).

6.3.3: Securing Heavier Chainsaws

It could not be confirmed if arborists operated any chainsaws over 15 pounds while aloft. However, most used climbing saws. This shows that most arborists are using the lighter climbing saws while climbing, which are presumably more manageable than a heavier saw. Because of this lack of confirmation, no workers observed required a second line to attach the chainsaw. In 1972, the Standard (subsection 6.2.2) stated that a chainsaw over 10 pounds required a second line for attachment. If this statement were still true today, there would have been far more instances where a second line was required. Alternatively, climbing saws might be more affordable than in previous years, allowing companies the luxury of buying saws specifically intended for climbing.

6.3.4 & 6.3.5: Starting a Chainsaw

This first subsection was rephrased throughout the revisions, including the period of time from 1979 to 1994, when it was acceptable to drop-start a chainsaw under 15
pounds, as well as outside an aerial lift basket when the saw is over 15 pounds. In 2000, this subsection was reduced to only ensuring secure footing, and an additional two subsections were included regarding the specific body motions and positioning regarding starting a chainsaw (ANSI 7.2.4 and 7.2.5 – 2000). Drop-starting was moved to 7.2.5 and was still permissible. Not until 2006, in section 6.3.5, does it state that drop-starting is prohibited. However, it does not specify whether this only applies to ground operations, or if this includes bucket and climbing work, as well. Because of this ambiguity, this study found drop-starting while aloft only to be permitted, but not during ground operations. Consistently drop-starting the chainsaw from all three classes shows that clearly there is a failure, somewhere, in communicating the importance of safely starting a saw. The noncompliance from all three classes shows that this might not be a result of limited access to information, but instead a disregard for the section entirely, as chainsaw manuals describe proper starting methods, (including both on the ground and between the legs), and discourage drop-starting (Stihl Chain Saw Safety Manual 2000; Husqvarna Chain Saw Operator’s Safety Manual 1991). Although the ISA Arborists’ Certification Study Guide does not specifically state how to start a chainsaw, the TCIA Accreditation Standard requires employers to instruct workers how to properly start a chainsaw. However, this guide does not specify what is an approved method of starting the saw.

For companies that have been in business for several decades, noncompliance might be a result of the constantly changing standard and workers’ unwillingness to change behaviors. However, for newer companies in Class N, old habits and misleading information from ANSI should not explain this. It is possible that workers do not perceive any danger of drop-starting a chainsaw. No chainsaws were started correctly,
which cannot clearly be explained by a deficiency in the accreditation or certification programs, or the Standard. Finally, the ambiguity in the Standard, itself, regarding operations aloft might be misleading to arborists, as it only specifies one scenario where drop-starting is not allowed.

**6.3.7: Handling a Chainsaw**

Keeping two hands on the chainsaw, with a thumb wrapped around the front handle, is only a newer addition to the Standard, introduced in 2000. In its original form, the subsection 7.2.7 allowed for an exception, stating that one hand could be used on a saw over 15 pounds, if the situation was found to be more dangerous with two hands. The 2006 version eliminated this exception entirely, prohibiting the use of one-handed operation. The U.S. CPSC showed that there were 10,200 injuries to the left hand, due to chainsaw use. This is over one-third of the total 28,543 injuries for all chainsaw users (U.S. CPSC 1999). Given that there were no differences between any of the classes for this section, this behavior might be a result of that 2000 exception, indicating that there is a gap in dissemination of information from the Standard to the workers.

Records were not kept in this study, whether the chainsaws were over or less than 15 pounds when one-handed. Much like drop-starting the chainsaw, this noncompliance might be a result of perceived danger. Although kickback is commonly discussed in the industry and certainly can cause an injury, people might not accept that it could happen to them. As chainsaws are manufactured to weigh less, with more refined designs and lighter-weight materials, it is much easier to hold a chainsaw with one hand. Lightweight, top-handled climbing saws are more evenly balanced, and allow for one-handed operation, unlike the back-handled ground saws. However, it is not clear if top-handled or
rear-handled chainsaws create more kickback. In either case, this does not make one-handing a chainsaw the safer option. These innovations in chainsaw manufacturing might be causing degeneration in operator safety.

Kickback occurs when the upper quadrant of the chainsaw bar touches an object while the chain is rotating. This exposes the cutting edge of the chain, causing the chain to skip suddenly and transfer all that energy back into the saw. This causes the chainsaw to recoil backwards in a fraction of a second. Although it happens too quickly for a person to stop the kickback, by operating the chainsaw with two hands, there is a greater chance that the left wrist will hit the chain brake when the chainsaw is propelled toward the operator. Innovations with today’s chainsaws include safety features designed to reduce the chance of kickback, including low-kickback chains and the straight guide bar.


6.3.8: Two Points of Attachment

Another more recent addition to the Standard, 6.3.8 was not added until 2000, requiring that workers use two points of attachment when operating a chainsaw while working in a tree. Significant differences between any classes might have shown that workers in the accreditation and certification programs work more safely than those not in the programs. A larger sample size may have shown different results, but few arborists actually climbed, and of those climbing, even fewer used chainsaws. The overall higher compliance with this safety section when compared to other chainsaw safety sections addressed demonstrates that perhaps workers perceive a greater danger from relying upon only one attachment point, in the event that they were to cut their primary climbing line.
6.3.10: Setting Down a Chainsaw

Introduced in the original 1972 version, this subsection involves engaging the chain brake or shutting off the chainsaw when it is set down. Despite having been eliminated from the 2000 version (but reinstated in 2006), compliance was high among all three classes. It is possible that there is the perceived danger from tripping over a running chainsaw, but it might also be that workers used the chainsaw for several consecutive cuts, completing much of the work prior to setting the chainsaw down. This would cut down on gas from leaving the saw running between bucking fallen limbs and dragging brush. The high compliance of Class A for this section indicates that some aspect of accreditation, whether it is from safety, budgetary, or other planning, is making workers more compliant with this section, especially when compared to the low compliance of Class N.

6.3.11: Walking With a Chainsaw

In the 2000 version of the Standard, the Accrediting Standards Committee left out the subsection regarding engaging the chain brake or shutting down a chainsaw before walking more than two steps. Noncompliance from all three classes shows the importance of its inclusion, as is evident by its re-inclusion in the 2006 version. Class N accounted for a majority of the observations for ground saw operation, as fewer workers in Class A operated chainsaws at all, and those in Class C worked mostly from a bucket truck. A large influence on compliance for this section may relate to perception of danger regarding the likelihood of a chainsaw injury while walking, influenced by job intensity and terrain. Future research could quantify tree density and obstacles on the job site to assess if workers are more likely to engage the chain brake if they perceive more danger from tripping hazards.
6.3.12: Work Positioning While Operating a Chainsaw

Introduced in 2006, this section emphasizes proper work positioning with a chainsaw, assuring that workers do not become off balance or lose control of the saw. For this study, this section was interpreted to include not operating a chainsaw over the shoulders, as is specified in chainsaw user manuals. This section was also used when observations were made of workers using chainsaws on ladders, as this would not cater to secure footing. Given that there were no differences between companies for operating a chainsaw over the shoulders, it is possible that workers are unfamiliar with the chainsaw user manuals (as these clearly indicate safe work positioning), and that workers perceive that there is a greater need for accomplishing the task than doing it safely. As overall compliance was at 42.6%, there is clearly either a misinterpretation of this section, or workers find that this is an easier area for cutting corners to expedite the job. By operating the saw above the shoulders, workers are eliminating the need to readjust tie-in points, altering work position, or otherwise adjust to make the work safer. The high occurrence of workers operating a chainsaw over their shoulders could explain the frequency of chainsaw injuries to upper extremities (U.S. CPSC 1999), as well as arborists accidentally cutting themselves out of trees (Wiatrowski 2005). Of the 28,543 chainsaw injuries reported in 1999 by the U.S. CPSC, the upper body and head area were cut in 5,138 of these instances. Further, Wiatrowski (2005) uncovered anecdotal evidence of some workers cutting through their lines and falling out of trees as a result. Relating to subsection 8.1.20, fewer observations were made of workers on ladders, which is why little can be concluded from the data available. However, because bucket trucks with chippers were mainly followed for this study, it is no reflection on the frequency of ladder use in the industry. Overall ladder data were inconclusive.
7.1.1: Proper Application of Hand Tools

Section 7.1 refers to the general proper use of hand tools, including storage and application. For this study, subsection 7.1.1 was examined to determine if workers were using tools for their intended purpose and not improvising. The high compliance of all three classes for this subsection shows that people are purchasing the correct tools for the job and understand their practical applications. Examples of improvising witnessed in this study included using a pole pruner and a hard hat to move electrical lines away from the boom (Class C), as well as using a boat hook to rip-cut living branches when a pole saw was not available (Class C). Poor rigging technique was also evident and often avoided when possible by bucking out smaller pieces, presumably to avoid damage to the obstacles below (Class N). Frequently, hinges were either cut through or broke unexpectedly, and booms were used to push wood off spars (Class N). Another company was clearly unfamiliar with knots and wrapped their rope around a higher branch several times, preventing the cut piece from releasing, due to excessive friction (Class N).

8.1: Climbing Safety

Section 8.1 refers to climbing equipment, including ropes. As no differences in compliance emerged from climbing, it is possible that either the aspects of the Standard chosen were those not commonly disregarded by workers, or companies are equally compliant, regardless of class. The small sample size of climbing observations makes it difficult to come to any significant conclusions. Observations made of noncompliant climbers included some climbers who worked within a 10-foot proximity of power lines (Class N), those who only climbed with a lanyard (Class N), and workers who were otherwise not always attached to the tree (Class N). Other examples included a climber who worked off a foot-locking prussik cord (Class A), climbers who tied around branches
instead of the trunk (Classes A, N) tied into deadwood (Class A), and climbers using
gaffs or spurs for non-removals (Class N).

8.1.16: Proper Storage

This section specifically involves the proper storage of ropes away from sharp or
corrosive objects. An example of poor storage is a chainsaw that became entangled with a
climber’s lanyard while climbing. The similarity of compliance among all three classes
could be a result of many factors. There was a low sample size, largely because it was too
difficult to observe storage on the ground when standing a distance from the scene.
Further, observations made could not assess the overall quality of rope care once the site
was cleaned and stowed away. Any incident reports resulting from poor rope care could
be a result of poor storage back at the office, and as such, might not be exemplified in
how workers treat their ropes in the field. Largely, lack of visibility made observations
difficult for this particular subsection.

8.1.23: Tie-In Positioning

Introduced in 1972, a high tie-in position is emphasized for climbers to reduce
swing, in the event that the climber loses his/her footing. It also serves to increase the
ease of limb walking. Few workers were observed climbing, and as such, low sample
numbers resulted when observing tie-in positions while climbing. The higher number of
climbing observations made of Class A illustrates the highly technical skills involved
with tree climbing, often exclusive to those who have gone through extensive training.
The fewest climbing observations came from members of Class C, mostly due to the high
number of utility workers pruning from bucket trucks. Finally in Class C, workers
climbed, but usually not safely, and chose poor tie-in points. The high tie-in points
chosen by Class A while climbing reveals that they comply with this aspect, but this study cannot conclude that they understand why it is necessary. What it does show, however, is that they possess the skills to set their ropes higher.

8.6.3: Proper Chipping Attire

The importance of wearing appropriate clothing while chipping is emphasized by the detailed account of what shall and shall not be worn while chipping, in subsection 8.6.3. Common infractions included wearing gauntlet gloves (Classes A, C, N), climbing harnesses (Classes C, N), jewelry (Class N), and torn or baggy clothing (Classes C, N). The higher compliance of Class A in comparison to Class N might be explained by the emphasis placed on chipper safety during accreditation. Outlined by TCIA in its Accreditation Package, all ground workers must be strictly trained in the proper work ethic while operating a chipper, including how to stack and drag brush, how to feed the chipper, how to perform maintenance, and how to position oneself while chipping (TCIA 2009-2010). Further, members of Classes A and C might have work uniforms that would prohibit them from wearing such attire. By simply not wearing such improper attire on the job site, workers can significantly reduce the danger of being sucked into a chipper. The low compliance of Class N might be from lack of education, which according to Struttmann (2004), would teach workers that there is a high potential for amputation from brush chipper use. The mixed results from Class C might be due to the varied companies’ uniforms, whether they had them or not.

8.6.7: Side Chipper Feeding, Butt-End First

Subsection 8.6.7 came from the original standard, but only included that brush should be fed from the side. It was not until 2000 that the Standard specified feeding
brush butt-end first. For this study, this section was divided into two, first assessing if the butt-end was fed first, and then whether the chipper was fed from the side of the feed table. Workers were mostly compliant with feeding brush butt-end first, presumably because it was easier to drag brush from the butt-end. Further, when brush has been reduced from the branches prior to chipping, feeding it butt-end first allows workers to remain untangled from unwanted brush. When feeding brush from the side of the chipper, the perceived danger of standing directly in front of the feed rollers might not be high. Kaskutas et al. (2011) discovered a difference between injuries caused by falls from ladders and workers’ perception of danger caused by ladders. Given this, it is possible that tree workers do not view feeding the chipper from in front of the feeding chute as risky behavior. By feeding brush in from the side, workers must torque their bodies to the side in such a way as to remove their bodies from the feed table. By doing this, workers cannot always carry large loads of brush, and they cannot manually feed the brush as far into the feed table. This reduced productivity might be a disincentive for workers to comply. As all three classes exhibited evidence of this behavior, this finding could indicate that their actions are not the result of lack of education, but instead reveal that workers blatantly disregard this safety aspect for any number of reasons, including, but not limited to, productivity, convenience, and habit. As most people were compliant with the other aspects of chipper safety, this might be one of the greatest causes for chipper incidents, because it would usually result in a person becoming propelled into the chipper. This finding supports research conducted by Struttman (2004), who found that 68% of chipper fatalities were a result of being caught or crushed by the chipper.

Although no data exist as to the body positioning of workers while chipping, one can
speculate that to be caught by the chipper, a worker must be near the feed table, as opposed to anywhere else in the vicinity of the chipper. Struttman’s (2004) estimated high numbers of amputations resulting from chippers would further support misplacement of body parts within the feed table area. Conversely, lack of compliance with feeding the chipper curbside would more likely result in a traffic accident, as opposed to an amputation.

8.6.11: No Body Parts in the Brush Chipper

Despite having been only included in the 1972, 2000, and 2006 versions of the Standard, most workers were compliant with not placing body parts in the chipper. The relatively high compliance of all three classes potentially illustrates that the Standard is not responsible for high compliance among Class A and Class C. Similarly, the high number of fatalities and amputations referenced by Struttmann (2004) leads one to disregard common sense as an answer, as well. Given that overall chipper safety compliance was low for all three classes, regulations and fear of OSHA are also probably not responsible for this behavior. It is possible that a positive safety culture has resulted in a universal aversion toward putting body parts in the brush chipper, with only a few exceptions. It is also conceivable that compliance with this section would not slow down work as much as other sections, such as repositioning oneself to keep two hands on a chainsaw. Although a few workers were observed with feet and arms outreached into the chippers, workers usually used other tools or branches to help push brush into the rollers.

8.6.13: Curbside Chipper Feeding

Consistently included in all versions of the Z133.1 since 1972, the importance of feeding the chipper curbside is clearly not understood by workers. The low compliance
with chipping curbside would explain the number of workers hit by oncoming cars. Castillo (2009) found that from 1992 to 2007, 56 workers died from direct contact with a vehicle. However, it is not specified if the decedent was in another moving vehicle at the time, or if s/he was conducting tree work too close to oncoming traffic. Since this is a problem across all classes, street side chipper feeding might be a design problem that can be corrected to avoid needing to make behavioral changes. As the human population is mostly right-handed and feeding brush curbside would usually mean using the left arm, perhaps parking the chipper to oppose traffic might help to avoid this scenario entirely. In one observation, the chipper was oriented in a driveway perpendicular to traffic, forcing the workers to walk into the street to feed the chipper, clearly creating a hazard for the workers (Class N).

**Implications**

**Class A**

Begun in July 2004, accreditation is intended to take the guesswork out of hiring a qualified company, ensuring customer satisfaction through reputation and retention of accreditation. Although it is the hope that these companies participate in this program because they believe in the safety culture upheld by TCIA, they might also be attracted to the perceived financial benefits of the accreditation. As this study showed, compliance among accredited companies is not consistent, nor always better than those without accreditation or certification. Given the supposed financial incentives for companies that earn their accreditation, including increased insurance coverage, revenue, and publicity, it is possible that some less qualified companies were capable of looking safe and professional during the evaluation process, only to regress after obtaining their
accreditation (TCIA, “Guesswork”). If this is not the case, it is clear that well-meaning companies eventually begin to lose safety awareness, only to be renewed during the re-accreditation process. According to TCIA, only 30% of companies receive accreditation after their first inspection, without needing to make many adjustments, although TCIA does not specify as to why these companies require a revisit (TCIA, “Guesswork”). Future studies on injuries or fatalities within accredited companies might find differences in frequency between these two passing rates for accredited companies.

In some respects, arborists working for accredited companies are far superior with their safe work practices when compared to members of Class N. For instance, Class A was more compliant with chipper and chainsaw safety, overall. Further, they more frequently donned chainsaw-protective pants when necessary. But this higher compliance is long outweighed by the overall low and inconsistent compliance when individual aspects of these two categories are further inspected. One possible explanation for overall low compliance of accredited companies is the Hawthorne Effect, wherein workers improve their behavior because they know they are being watched. During the accreditation process, workers are observed randomly for compliance, and during this time, they might improve their behavior to pass inspection. Conversely, once there is no perceived observer, workers potentially lose that safety awareness and revert to their usual behavior, until the next reviewing process. The TCIA Accreditation Information Package states that reaccreditation is performed every three years, and TCIA will randomly conduct on-site audits throughout that period. According to the Vice President of Industry Standards and Credentialing, Robert Rouse, companies with 11 or more branches are reviewed systematically in their “continuous audit program,” annually.
looking at a minimum of six branches or 10% of all branches (whichever is greater). That could potentially leave a branch free of observation for a decade, depending on the size of the company. Though one might assume education brings a change in attitudes, accreditation cannot be entirely to blame for poor behavior. Safety climate is at its highest during these auditing periods. Though accreditation could potentially be credited for safe work behavior during these times, the true test comes when workers are not watched and the workers’ actual safety culture is revealed.

According to Stricoff (2005), the difference between safety culture and safety climate is that safety culture is in the hands of the workers, while safety climate depends on the leadership. Safety culture is described as the “shared values and beliefs” leading to social norms for behavior within the company. Safety climate, on the other hand, is the main thrust of a company at the moment, and can change quickly (Stricoff 2005). Safety climate can include safety, production, quality, or other factors, and is often influenced by current events, such as low sales, or a recent injury or fatality. According to Johnson, factors that contribute to safety climate include “caring, compliance, and coaching” (Johnson 2007). Though TCIA might coach safe work behavior, and OSHA and the crew leaders enforce compliance, it is up to the worker to care about his/her own safety. Wu et al. (2010) mentioned regulation, informing, caring, and coordination as factors of safety culture. Given these assessments of safety culture versus climate, accreditation certainly can change the safety climate of a company, most effectively during the accreditation and re-accreditation processes, but the main safety thrust will only last as long as the safety culture will allow. Ideally, the optimal accreditation process would improve the safety
culture long-term, but given the findings of the current study, there is a deterioration of worker safety behavior.

**Class C**

ISA certified arborists vary in their work experiences, occupations, and knowledge. Though they all must pass one common exam, people use this knowledge for any number of career paths. Designing varied exams that focus on specific areas in arboriculture, using the overall knowledge base combined with a concentration in a specific arboricultural field (much like what already exists for utility and municipal arborists, for example), might aid in creating better tree workers in more specialized areas. Currently, the program in existence appears to be underutilized, as only 8.2% of the original 1,661 certified arborists had an additional ISA certification, such as utility or tree worker certifications. There are no reported financial benefits to obtaining additional credentials, except the possibility that an employer might increase salary for earning additional credentials. Some companies might not accept these other certifications as adequate proof of skills and proper training, but obtaining these certifications might help workers to distinguish themselves from other skilled arborists. Alternatively, Fertig (2011) found that there was no association between workers holding a certification and their perceived job competency. However, this study further found that motivation to certify, largely an internal motivation, was associated with both perceived job competence and occupational commitment. As such, it is not necessarily the exam itself that makes an arborist more competent to perform tree work, but the motivation and preparation that effects change.
The high percentage of observations of utility work might explain the varied compliance behaviors by this class. The overall high compliance with perimeters shows the large portion of utility workers in Class C who clearly place emphasis on one of their largest hazards – traffic control. Current certification exams and necessary CEUs to maintain the certification do not always distinguish workers from non-certified arborists. However, overall, this study showed that it is even more difficult to distinguish certified arborists from accredited companies. As such, improved safety culture might explain the similarities in behavior between Classes A and C, as it is unlikely that a certified arborist was on every crew in Class C. In some manner, the individually self-motivated education required by ISA keeps those arborists who are most cognizant of industry changes updated and aware of their work behavior.

**Strengths and Limitations**

Because tree crews were observed in their natural work setting, this study has a high degree of ecological validity. Limited interaction with worker and observer meant that the Hawthorne Effect was reduced, as worker behavior did not change as a result of knowing they were involved in a study (Shortall 2003). Observations made in this study are therefore likely to be representative of workers’ usual behavior at a typical job site. Further, limiting the amount of time and days of the week for which observations were made reduced the effect that fatigue might have on worker performance. Additionally, the study area chosen made a clear picture of overall New England tree workers, as it included most of the metropolitan areas, as well as the rural towns in between.

One limitation of this study was not being able to record what occurred out of view of the observer, including the occurrence of gear and equipment inspections, or the
presence of first-aid kits. Such safety behaviors would have to be assessed using self-report measures. Ball and Vosberg (2010) were attempting to capture more of the safety behavior that occurs during training sessions. They used survey data, which were self-selected and self-evaluated by the workers themselves. This method allowed the workers to share what happens back at the office, or during short training sessions in the field. However, it depends on the honesty and memory of the workers. Further, it is limited by self-selection, in that those least compliant are least likely to respond.

Other limitations in the current study included assumptions about the gear, namely the ratings on personal protective equipment. Because of the distance between the workers and the observer, it was necessary to assume that if someone wore protective glasses, they were rated, per the Standard. Similarly, if a hard hat was worn, it was assumed that it was in proper working condition, and not cracked or otherwise unsuitable for use. Other situations also made observations difficult, including visibility in bucket trucks and the use of lanyards. Unless otherwise noted, it was assumed that lanyards were properly attached from the worker to the bucket truck basket, although it was not always possible to see them. Further, the lack of communication between worker and observer meant that it was not possible to determine who the certified arborists on crew were, and other detailed facts about the workers. Therefore, it is quite possible that no certified arborists were on the crews, but worked for the companies in another capacity. Additionally, where the Standard was not entirely clear, it was at the discretion of the observer to decide if certain behavior should be considered noncompliant. In these cases, even the most compliant companies might not have interpreted the Standard in a way the observer felt was necessary to keep workers safe. Thus, although direct observation
eliminated potential biases associated with self-reported data, the subjective nature of the assessments made for this study introduces the possibility of other forms of bias.

**Directions for Future Research**

Though this study sought to investigate compliance based on certification and accreditation status, other possible contributing factors to noncompliance were not assessed based on the limitation of the data. Several of these companies operated out of multiple offices, which if investigated, may have shown varying results within a single company. This could be due to different training programs or safety cultures within each office. Further, based on the range of tasks executed on a job site, variability in compliance might be prevalent, depending on the specific tools used and tasks required. For instance, one might find personal protective equipment usage different based on if people were only climbing or chipping. In addition, future research should explore ways to improve compliance with chainsaw and chipper safety protocols, specifically. Given the high risk involved with these tools, and the low levels of compliance while operating such machinery, there is clearly a need for improvement in this area of tree work. Based on this known risky behavior in the tree care industry, future studies on the economics of injuries and owners’ awareness of these costs might be valuable.

With more time, a detailed look at the TCIA accreditation and ISA certification processes would be valuable to determine if such people involved become more compliant after it is completed, or if these programs prove to be more inviting to the already compliant people/companies. Given the extensive procedure companies go through to become accredited, this program might discourage unsafe companies from applying, thus weeding out the less compliant. On the other hand, it might attract
companies of all types, and progressively make them safer until they obtain their accreditation. Although this study did not examine arborists’ compliance with the ANSI A300 for tree work quality, it did aid in determining if having a person on the crew who was knowledgeable about the Standard made for safer work, as this comprises 10% of the certified arborist exam. Becker et al. (2004) found that workers who underwent safety training in the chemical industry showed improved participation in training other workers, as well as an increased rate of workers attempting to effect further health and safety changes. Additionally, training showed an increased use of safety references. As such, the presence of certified arborists can help expose non-certified workers to additional resources, as well as increase the arborist’s desire to train other workers in health and safety. Further analysis of tree workers and differentiating behaviors of individuals on a single crew and their certification statuses could better assess influence and the benefit of having a certified arborist on staff. A future study might survey workers to determine from what sources they receive most of their safety information, whether it be from publications, crew leaders, conferences, or other sources. As this study limited the scope of certified arborists who worked for utility or commercial tree care companies, compliance was not assessed for those who work on private settings, such as arboreta, campuses, municipalities, or cemeteries. Future research in these areas might better assess ISA certified arborists, as a whole.

Additionally, as this study found that compliance for Class A was well below 100%, future research might determine why safety compliance among tree workers decreases over time. This could also include intervening in the workplace and asking workers why they are not compliant, to understand worker perception. Finally, this study
was limited to only assessing if there were different behaviors among the three classes. It could not determine if these credentials were directly causal to the levels of compliance, nor could it determine differences in compliance. Studies directed at exposing causation would determine why there are differences in the company classes, and could potentially help uncover what is missing from the processes. Studies on policy enforcement, safety culture, and safety training may improve our understanding of compliance.
## APPENDIX A
### NATIONAL GRID COMPLIANCE FORM

### Compliance Assessment Forestry

#### General Information
- **Observation Date**: 
- **Primary Task of Crew**: (e.g., isolating wires, fusing gas line, etc.)
- **Observed Department**: 
- **Additional info on Crew Task**: 
- **Time**: 
- **AM / PM**: 
- **Who did you observe?**
  - Employees
  - Contractor
- **# of People Observed**: 
- **Observers**
- **Observed Employees or Contractor Company Name**: 

#### Location of Observation
- **Site Name**: 
- **Address**: 
- **City**: 
- **State**: 
- **Location Type**
  - Company Site
  - Non-Company Site
  - (e.g., Office, Right of Way, etc.)

#### Observation Items

**Manual Handling**
1. Maintains a safe position, clear of load, should it fall
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
2. Positions their body and hands to avoid pinch points
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
3. Uses a method of lifting or moving suitable for the load (weight and size)
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
4. Uses mechanical handling methods whenever practicable
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
5. Uses the correct manual lifting techniques: straight back and bent legs, don't stretch, twist, bend back, push/pull
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
6. While carrying, keeps load close to body, upper arms close to sides, arms at 90 degrees
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good

**Communication & Risk Assessment**
7. Crew members demonstrate clear understanding of job hazards and conditions
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good
8. Written Job Brief has been completed and performed with crew at a level of quality that meets company standards
   - Safe
   - Unsafe
9. Job Brief identifies the most significant hazards and controls to mitigate risk (i.e., proximity of energized lines, grounding, shoring, low hanging pipes, etc.)
   - Poor
   - Needs Improvement
   - Fair
   - Good
   - Very Good

**Personal Protection**
10. Maintains PPE in good condition
    - Poor
    - Needs Improvement
    - Fair
    - Good
    - Very Good
11. Wears suitable head protection
    - Safe
    - Unsafe
12. Wears suitable eye protection
    - Safe
    - Unsafe
13. Wears suitable hand protection
    - Safe
    - Unsafe
14. Wears suitable hearing protection
    - Safe
    - Unsafe
15. Wears proper footwear with sufficient tread, ankle support and toe protection (EH rated if applicable)
    - Safe
    - Unsafe
16. Uses appropriate Fall Arrest equipment when working at height
    - Safe
    - Unsafe

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<table>
<thead>
<tr>
<th>Personal Protection</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wears appropriate clothing (Fire Retardant Garment, Gloves and Hood, Natural Fibers, High Visibility, Arc Flash ensemble, Chaps, Knee pads, etc)</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work Area Safety</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aktively Managing Work Area - Good Housekeeping, maintains walking and work surfaces, clear areas of egress and good lighting for task</td>
<td>Poor*</td>
<td>Needs Improvement*</td>
</tr>
<tr>
<td>Maintains adequate barriers and signs to protect others from the work area</td>
<td>Poor*</td>
<td>Needs Improvement*</td>
</tr>
<tr>
<td>Properly manages the debris generated by their work</td>
<td>Poor*</td>
<td>Needs Improvement*</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Rescue devices / equipment is readily available</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintains proper Work Zone Traffic Protection (flags, signs, cones and ROW sign) in place</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
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<table>
<thead>
<tr>
<th>Using Tools and Equipment</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigging Equipment inspected and tags legible</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Tools / Equipment Safety guards are in place</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Using correct equipment or tool for the job, not improvising</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Checks that equipment or tool is fit for purpose before use</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Insulated sticks/saws care, inspection and use</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Knives and other sharp tools are used cutting away from the body?</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Maintains the equipment and tools in good working condition</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Proper rope size, condition and use</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Proper use and storage of ladders</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vehicles / Mobile Equipment</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio tested and in good working order</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Seat belts in use</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Spill clean-up kit</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>If required, vehicle / equipment is properly grounded when operating near energized lines</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>DOT Inspection Logs complete</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Drinking water clean and available</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Fire Extinguisher accessible and certified</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>First aid kit available and fully stocked</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Follows safe vehicle backing procedures</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Tractor / Chipper properly hitched / chained</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work Methods and Procedures</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper Clearance and Control procedures are being followed and necessary documents are on-site</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Use of proper chipping techniques</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Use of proper climbing techniques</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Use of proper sawing techniques</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work Practices</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not climbing or walking over materials, equipment or waste</td>
<td>Safe</td>
<td>Unsafe*</td>
</tr>
<tr>
<td>Work Practices</td>
<td>Safe</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>56. Takes precautions when working in unique conditions - uneven surfaces, slopes, steps.</td>
<td></td>
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<tr>
<td>57. Displays 3-points of contact while exiting equipment and vehicle when appropriate</td>
<td></td>
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</tr>
<tr>
<td>58. Follows regulatory and company safety standards for working at height</td>
<td></td>
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</tr>
<tr>
<td>59. Maintains awareness of other activities in the work area (distance from moving equipment, work overhead, near excavations, confined areas etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60. Stays focused at the task on hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61. Takes adverse weather conditions into account</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62. Takes appropriate precautions to protect others in the work area</td>
<td></td>
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</tr>
</tbody>
</table>
### APPENDIX B

**ANSI SUBSECTION REVISIONS FROM 1972 – 2006**

<table>
<thead>
<tr>
<th>Standard Subsection</th>
<th>2006 version</th>
<th>Included in:</th>
<th>Rephrasing</th>
</tr>
</thead>
</table>
| 3.1.2               | Employers shall instruct their employees in the proper use, inspection, and maintenance of tools and equipment, including ropes and lines, and shall require that appropriate working practices be followed. | 1972 – 3.1.3  
1979 – 3.1.3  
1982 – 3.1.3  
1988 – 3.1.3  
1994 – 4.1.2  
2000 – 4.1.2  
2006 – 3.1.2 | 1972, 1979, 1982 – Employers shall instruct their employees in the proper use of all equipment provided for them and shall require that safe working practices be observed. A job briefing, work procedure, and assignment shall be worked out carefully before any tree job is begun.  
1988, 1994 – Employers shall instruct their employees in the proper use of all equipment provided for them and shall require that safe working practices be followed. A job briefing, work procedure, and assignment shall be worked out carefully before any tree job is begun. |
<table>
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<tr>
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<th>Rephrasing</th>
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</thead>
</table>
| 3.2.2               | Effective means for controlling pedestrian and vehicular traffic shall be instituted on every jobsite where necessary, in accordance with the U.S. Department of Transportation (DOT) Manual on Uniform Traffic Control Devices (MUTCD) or applicable state and local laws and regulations. | 1972 – 3.5.1-2  
1979 – 3.4.1-2  
1982 – 3.4.1-2  
1988 – 3.4.1-2  
1994 – 4.4.1-2  
2000 – 4.4.1-2  
2006 – 3.2.2 | 1972, 1979 – Effective means for control of pedestrian and vehicular traffic shall be instituted on every job site where necessary. 3.5.2 (3.4.2) Traffic control devices used in tree operations shall conform to the applicable federal and state regulations or applicable section of American National Standard Manual on Uniform Traffic Control Devices for Streets and Highways, D6.1 – 1971.  
1982 – Effective means for control of pedestrian and vehicular traffic shall be instituted on every job site where necessary. 3.4.2 Traffic control devices used in tree operations shall conform to the applicable federal and state regulations or applicable section of American National Standard Manual on Uniform Traffic Control Devices for Streets and Highways, D6.1 – 1978.  
1988 – Effective means for control of pedestrian and vehicular traffic shall be instituted on every job site where necessary. 3.4.2 Traffic-control device used in tree operations shall conform to the applicable federal and state regulations or to applicable sections of ANSI D6.1 – 1978 and ANSI D6.1b – 1983.  
1994 – Effective means for control of pedestrian and vehicular traffic shall be instituted on every job site where necessary following U.S. Department of Transportation (DOT) Standards and Guidelines Work Zone Traffic Controls, or applicable state/local laws and regulations. 4.4.2 Traffic-control devices used in tree operations shall conform to the applicable federal and state regulations.  
2000 – Effective means for controlling pedestrian and vehicular traffic shall be instituted on every job site where necessary in accordance with U.S. Department of Transportation (DOT) Manual on Uniform Traffic Control Devices (MUTCD), or applicable state and local laws and regulations. 4.4.2 Traffic-control devices used in tree operations shall conform to the applicable Federal and state regulations. |
<table>
<thead>
<tr>
<th>Standard Subsection</th>
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</tr>
</thead>
<tbody>
<tr>
<td>3.4.1</td>
<td>Personal protective equipment (PPE), as outlined in this section, shall be required when there is a reasonable probability of injury or illness that can be prevented by such protection. Training shall be provided in the use, care, maintenance, fit and life of personal protective equipment.</td>
<td>1972 – 3.2.1&lt;br&gt;1979 – 3.2.1&lt;br&gt;1982 – 3.2.1&lt;br&gt;1988 – 3.2.1&lt;br&gt;1994 – 4.2.1&lt;br&gt;2000 – 4.2.1&lt;br&gt;2006 – 3.4.1</td>
<td>1972, 1979, 1982, 1988 – Personal protective equipment as outlined in 3.2 shall be required where there is a reasonable probability of injury or illness that can be prevented by such protection. Employees shall use such protection.&lt;br&gt;1994, 2000 – Personal protective equipment as outlined in 4.2 shall be required where there is a reasonable probability of injury or illness that can be prevented by such protection.</td>
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<tr>
<td>Standard Subsection</td>
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</table>
| 3.4.2               | Workers engaged in arboricultural operations shall wear head protection (helmets) that conforms to ANSI Z89.1. Class E helmets shall be worn when working in proximity to electrical conductors, in accordance with ANSI Z89.1. Workers shall not place reliance on the dielectric capabilities of such helmets. | 1972 – 3.2.2  
1979 – 3.2.2  
1982 – 3.2.2  
1988 – 3.2.2  
1994 – 4.2.2  
2000 – 4.2.2  
2006 – 3.4.2 | 1972, 1979 – Head protection shall be worn by workers engaged in tree operations. It shall conform to the applicable provisions of American National Standard Safety Requirements for Industrial Head Protection, Z89.1-1969. Class B helmets only shall be worn when working in proximity to an electrical conductor, as per American National Safety Standard Requirement for Industrial Protective Helmets for Electrical Workers, Class B, Z89.2-1971. The tree worker shall not place reliance on their dielectric capabilities.  
1982 – Head protection shall be worn by workers engaged in tree operations. It shall conform to the applicable provisions of American National Standard Safety Requirements for Industrial Head Protection, Z89.1-1981. Class B helmets only shall be worn when working in proximity to an electrical conductor, as per American National Safety Standard Requirement for Industrial Protective Helmets for Electrical Workers, Class B, Z89.2-1981. The tree worker shall not place reliance on their dielectric capabilities.  
1988 – Head protection shall be worn by workers engaged in tree operations. It shall conform to the applicable provisions of American National Standard Safety Requirements for Industrial Head Protection, Z89.1-1986. Class B helmets only shall be worn when working in proximity to an electrical conductor, as per American National Safety Standard Requirement for Industrial Protective Helmets for Electrical Workers, Class B, Z89.2-1986. The tree worker shall not place reliance on their dielectric capabilities.  
(continued on page 133) |
<table>
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<th>Rephrasing</th>
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</table>
| 3.4.2 (cont’d)      | Workers engaged in arboricultural operations shall wear head protection (helmets) that conforms to ANSI Z89.1. Class E helmets shall be worn when working in proximity to electrical conductors, in accordance with ANSI Z89.1. Workers shall not place reliance on the dielectric capabilities of such helmets. | 1972 – 3.2.2  
1979 – 3.2.2  
1982 – 3.2.2  
1988 – 3.2.2  
1994 – 4.2.2  
2000 – 4.2.2  
2006 – 3.4.2 | 1994 – Head protection shall be worn by workers engaged in tree operations. It shall conform to the applicable provisions of ANSI Z89.1. Class B helmets shall be worn when working in proximity to an electrical conductor, in accordance with ANSI Z89.1. The tree worker shall not place reliance on the dielectric capabilities of such helmets.  
2000 – Workers engaged in arboricultural operations shall wear head protection that conforms to ANSI Z89.1. Class E helmets shall be worn when working in proximity to electrical conductors, in accordance with ANSI Z89.1. Workers shall not place reliance on the dielectric capabilities of such helmets (head protection). |
| 3.4.4               | Clothing and footwear appropriate to the known job hazards shall be approved by the employer and worn by the employee. | 1972 – 3.2.5  
1979 – 3.2.5  
1982 – 3.2.5  
1988 – 3.2.5  
1994 – 4.2.5  
2000 – 4.2.7  
1994 – Employees shall wear clothing and footwear as approved by employer appropriate to the work location and condition.  
2000 – Clothing and footwear appropriate to the known job hazards shall be approved by the employer and worn by the employee. |
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</thead>
<tbody>
<tr>
<td>3.4.6</td>
<td>Hearing protection provided by the employer shall be worn when it is not practical to decrease or isolate noise levels that exceed acceptable standards.</td>
<td>1972 – 3.7.1 1979 – 3.6 1982 – 3.6 1988 – 3.6 1994 – 4.6 2000 – 4.2.5 2006 – 3.4.6</td>
<td>1972, 1979, 1982, 1988 – When employees are required to work in areas in which the noise levels exceed acceptable standards as established by federal regulations, the employer shall take appropriate measures to suppress the noise to safe levels. When it is not practicable to decrease the noise or isolate the workers from it, the workers shall wear effective hearing protective equipment as provided by the employer. 1994 – When employees are required to work in areas in which noise levels exceed acceptable standards as established by federal regulations, the employer shall take appropriate measures to suppress noise levels. When it is not practicable to decrease the noise or isolate the workers from it, the workers shall wear effective hearing protective equipment as provided by the employer. 2000 – When noise levels exceed acceptable standards, as established by Federal regulations, the employer should take appropriate measures to suppress noise levels. Approved hearing protection as provided by the employer shall be worn when it is not practical to decrease the level of or isolate the noise.</td>
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<tr>
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<tr>
<td>3.4.8</td>
<td>Chain-saw-resistant leg protection shall be worn while operating a chain saw during ground operations.</td>
<td>1994 – 4.2.6, 2000 – 4.2.8, 2006 – 3.4.8</td>
<td>1994 – Leg protection should be worn while operating a chainsaw during ground operations. 2000 – Chain saw-resistant leg protection shall be worn while operating a chain saw during ground operations.</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Aerial devices shall be provided with an approved point of attachment on which to secure a full-body harness with an energy-absorbing lanyard or body belt and lanyard, which shall be worn when aloft.</td>
<td>1972 – 5.2.4, 1979 – 5.2.3, 1982 – 5.2.3, 1988 – 5.2.3, 1994 – 6.2.2, 2000 – 6.2.2, 2006 – 5.2.2</td>
<td>1972 – Aerial buckets, platforms, or booms of such equipment shall be provided with some means of anchorage to which a safety belt or lanyard can be secured. 1979, 1982, 1988 – Buckets, platforms, or booms of aerial-lift equipment shall be provided with some means of anchorage to which a safety belt or lanyard can be secured. 1994 – Buckets, platforms, or booms of aerial-lift equipment shall be provided with some means of anchorage to which a safety belt or lanyard can be secured. When aloft, the operator shall be secured with a body belt and personnel lanyard. 2000 – Aerial devices shall be provided with a point of attachment to secure a full body harness with a shock-absorbing lanyard or body belt and lanyard. Fall protection shall be worn when working aloft.</td>
</tr>
<tr>
<td>5.2.9</td>
<td>Clearances from passing vehicles shall be maintained, or traffic control shall be provided when booms or buckets are operated over roads.</td>
<td>1972 – 5.2.11, 1979 – 5.2.10, 1982 – 5.2.10, 1988 – 5.2.10, 1994 – 6.2.8, 2000 – 6.2.8, 2006 – 5.2.9</td>
<td>1972, 1979, 1982, 1988, 1994 – When booms are operated over roads, safe clearances from passing vehicles shall be maintained or traffic control shall be provided. 2000 – Clearances form passing vehicles shall be maintained or traffic control shall be provided, when booms or buckets are operated over roads.</td>
</tr>
<tr>
<td>Standard Subsection</td>
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<tr>
<td>5.2.10</td>
<td>One-person buckets shall not have more than one person in them during operations.</td>
<td>1972 – 5.2.12, 1979 – 5.2.11, 1982 – 5.2.11, 1988 – 5.2.11, 1994 – 6.2.9, 2000 – 6.2.9, 2006 – 5.2.10</td>
<td>1972, 1979, 1982, 1988 – A one-man bucket shall not have more than one person riding in it during work operations around electrical conductors. 1994 – A one-person bucket shall not have more than one person riding in it during work operations. 2000 – One-person bucket shall not have more than one person in them during arboricultural operations.</td>
</tr>
<tr>
<td>5.2.18</td>
<td>Aerial devices shall not be moved with an arborist on an elevated platform (for example, a bucket) except when equipment is specifically designed for such operation.</td>
<td>1972 – 5.2.18, 1979 – 5.2.17, 1982 – 5.2.17, 1988 – 5.2.17, 1994 – 6.2.15, 2000 – 6.2.16, 2006 – 5.2.18</td>
<td>1972 – Workers should not ride in the bucket while the truck is being moved. 1979, 1982, 1988 – An aerial-lift truck shall not be moved when the boom is elevated in a working position with men in the basket, except for equipment which is specifically designed for this type of operation. The booms of a fully articulated aerial device shall not be considered elevated in a working position when the basket is “landed” directly in front of or behind the truck with the booms held as low as feasible and low enough so that the operator’s head is below the highest point of the vehicle. 1994 – An aerial device truck shall not be moved when the boom is elevated in a working position with an operator in the bucket, except for equipment that is specifically designed for this type of operation. The booms of a fully articulated aerial device shall not be considered elevated in a working position when the bucket is “landed” directly in front of or behind the truck with the booms held as low as feasible and low enough so that the operator’s head is below the highest point of the vehicle. 2000 – Aerial devices shall not be moved with an arborist in an elevated bucket, except for equipment that is specifically designed for such operation. Booms of a fully-articulated aerial devices shall not be considered elevated in a working position when the bucket is positioned just above the ground and directly in front of or behind the vehicle.</td>
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<td>Standard Subsection</td>
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| 5.3.5               | Chippers equipped with a mechanical infeed system shall have a quick-stop and reversing device on the infeed system. The activating mechanism for the quick-stop and reversing device shall be located across the top, along each side, and close to the feed end of the infeed hopper within easy reach of the worker. | 1982 – 5.3.4  
1988 – 5.3.4  
1994 – 6.3.4  
2000 – 6.3.4  
2006 – 5.3.5 | 1982 – Each disk-type tree or brush chipper with a mechanical infeed system shall have a quick stop and reversing device on the infeed. The activating lever for the quick stop and reversing device shall be to the feed end of the infeed hopper as practicable and within easy reach of the operator.  
1988 – Each disk-type tree or brush chipper with a mechanical infeed system shall have a quick stop and reversing device on the infeed. The activating mechanism for the quick stop and reversing device shall be located across the top, along each side of, and as close to the feed end of the infeed hopper as practicable and within easy reach of the operator.  
1994 – A brush chipper equipped with a mechanical infeed system shall have a quick stop and reversing device on the infeed. The activating mechanism for the quick stop and reversing device shall be located across the top, along each side of, and close to the feed end of the infeed hopper within easy reach of the operator.  
2000 – Brush chippers equipped with a mechanical infeed system shall have a quick stop and reversing device on the infeed system. The activating mechanism for the quick stop and reversing device shall be located across the top, along each side, and close to the feed end of the infeed hopper within easy reach of the worker. |
| 5.3.6               | Vision, hearing, and/or other appropriate personal protective equipment shall be worn when in the immediate area of a brush chipper in accordance with section 3.4, Personal Protective Equipment. | 1972 – 5.3.5  
1979 – 5.3.4  
1982 – 5.3.6  
1988 – 5.3.6  
1994 – 6.3.6  
2000 – 9.6.2  
1994 – The operator and workers in the immediate area shall wear vision, hearing, or other personal protective equipment as required by the federal Occupational Safety and Health Administration (OSHA) in Title 29, part 1910, subpart I as well as requirements in 4.2.1.  
2000 – Personal protective equipment shall be worn when in the immediate area of chipping operations in accordance with Sections 4.2.1. and 9.6.6. |
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</table>
| 5.3.8               | When trailer chippers are detached from the vehicles, they shall be chocked or otherwise secured in place. | 1972 – 5.3.4 1979 – 5.3.3 1982 – 5.3.5 1988 – 5.3.5 1994 – 6.3.5 2000 – 6.3.6 2006 – 5.3.8 | 1972, 1979, 1982, 1988, 1994 – Trailer chippers detached from trucks shall be chocked or otherwise secured.  
2000 – Trailer chippers, when detached from the vehicles, shall be chocked or otherwise secured in place. |
<p>| 6.3.2               | Chain saws shall not be operated unless the manufacturer’s safety devices are in proper working order. Chain-saw safety devices shall not be removed or modified. | 2006 – 6.3.2                          |                                                                           |</p>
<table>
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<tr>
<td>6.3.3</td>
<td>When an arborist or other worker is working in a tree other than from an aerial device, chain saws weighing more than 15 pounds (6.8 kg) service weight shall be made safe against falling (i.e., supported by a separate line or tool lanyard).</td>
<td>1972 – 6.2.2 1979 – 6.2.2 1982 – 6.2.2 1988 – 6.2.2 1994 – 7.2.2 2000 – 7.2.2 2006 – 6.3.3</td>
<td>1972 – Power saws weighing more than 10 pounds (service weight) that are used in trees shall be supported by a separate line, except when working from an aerial lift device. 1979 – Power saws weighing more than 15 pounds (service weight) that are used in trees shall be supported by a separate line, except when used from an aerial-lift device. 1982, 1988, 1994 – Power saws weighing more than 15 pounds (6.8 kg) (service weight) that are used in trees shall be supported by a separate line, except when used from an aerial-lift. 2000 – When an arborist or other worker is working in a tree other than from an aerial device, chain saws weighing more than 15 pounds (6.8kg) service weight shall be supported by a separate line or tool lanyard. Exception: This requirement does not apply during removal operations where no supporting limb will be available.</td>
</tr>
<tr>
<td>6.3.4</td>
<td>Secure footing shall be maintained when starting the chain saw.</td>
<td>1972 – 6.2.3 1979 – 6.2.3 1982 – 6.2.3 1988 – 6.2.3 1994 – 7.2.3 2000 – 7.2.3 2006 – 6.3.4</td>
<td>1972 – The operator shall have secure footing when starting the saw. The saw shall be firmly supported. 1979 – The operator shall have secure footing when starting the saw. Power saws weighing less than 15 pounds (service weight) may be drop started. Drop starting of saws over 15 pounds is permitted outside the basket of an aerial lift only after ensuring that the area below the lift is clear of personnel. 1982, 1988, 1994 – The operator shall have secure footing when starting the saw. Power saws weighing less than 15 pounds (6.8 kg) (service weight) may be drop started. Drop starting of saws over 15 pounds (6.8 kg) is permitted outside the basket of an aerial lift only after ensuring that the area below the lift is clear of personnel. 2000 – Secure footing shall be maintained when starting the chain saw.</td>
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| 6.3.5               | When starting a chain saw, the operator shall hold the saw firmly in place on the ground or otherwise support the saw in a manner that minimizes movement of the saw when pulling the starter handle. The chain saw shall be started with the chain brake engaged, on saws so equipped. Drop-starting a chain saw is prohibited. | 2000 – 7.2.4  
2006 – 6.3.5 | 2000 – When being started, chain saws shall be held firmly in place on the ground or otherwise held in a manner that does not allow movement of the saw when pulling the starter handle. The chain brake shall be engaged on saws so equipped. |
| 6.3.7               | When operating a chain saw, the arborist or other worker shall hold the saw firmly with both hands, keeping the thumb and fingers wrapped around the handle. | 2000 – 7.2.7  
2006 – 6.3.7 | 2000 – Chain saws shall be held with the thumbs and fingers of both hands encircling the handles during operation.  
*Exception:* This requirement does not apply when an employer can demonstrate that a greater hazard is posed by keeping both hands on the chain saw in a particular situation. This exception should not apply to lightweight chain saws (under 15 pounds [6.8 kilograms]) when used in a tree. |
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</table>
| 6.3.8               | Arborists shall use a second point of attachment (for example, lanyard or double-crotched climbing line) when operating a chain saw in a tree, unless the employer demonstrates that a greater hazard is posed by using a second point of attachment while operating a chain saw in the particular situation. | 2000 – 7.2.8  
2006 – 6.3.8 | 2000 – Arborists shall use a second point of attachment (work-positioning lanyard or double-crotched rope) when operating a chain saw in a tree, unless the employer demonstrates that a greater hazard is posed by using a second point of attachment while operating chain saws in that particular situation. |
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<tr>
<td>6.3.10</td>
<td>The chain brake shall be engaged, or the engine shut off, before setting a chain saw down.</td>
<td>1972 – 6.2.5, 1979 – 6.2.5, 1982 – 6.2.5, 1988 – 6.2.5, 1994 – 7.2.5, 2000 – Absent 2006 – 6.3.10</td>
<td>1972, 1979 – The engine shall ordinarily be stopped when carrying power saws. The saw need not be stopped between cuts when performing consecutive felling, bucking, or limb-cutting operations on reasonably level ground. The chain shall not be turning and the hand shall be off the throttle lever while moving between work locations. One-man saws shall be carried to the side with the guide bar to the rear; two workers shall carry a two-man saw. 1982, 1988 – The engine shall ordinarily be stopped when carrying power saws. The saw need not be stopped between cuts when performing consecutive felling, bucking, or limb-cutting operations on reasonably level ground. The chain shall not be turning and the hand shall be off the throttle lever while moving between work locations. One-man saws shall be carried by the worker on his/her side with the guide bar of the saw pointed to the rear; two workers shall carry a two-man saw. 1994 – The engine shall ordinarily be stopped when power saws are being carried. The saw need not be stopped between cuts when performing consecutive felling, bucking, or limb-cutting operations where there is secure footing. The chain shall not be moving and the operator’s hand shall be off the throttle lever while operators move between work locations. One-person saws should be carried by the worker on the side with the guide bar of the saw pointed to the rear; two workers should carry a two-person saw.</td>
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<tbody>
<tr>
<td>6.3.11</td>
<td>When a chain saw is being carried more than two steps, the chain brake shall be engaged or the engine shut off. The chain saw shall be carried in a manner that will prevent operator contact with the cutting chain and the muffler.</td>
<td>1972 – 6.2.5 1979 – 6.2.5 1982 – 6.2.5 1988 – 6.2.5 1994 – 7.2.5 2000 – Absent 2006 – 6.3.11</td>
<td>See 2006 – 6.3.10 for revisions from 1972 - 1994.</td>
</tr>
<tr>
<td>6.3.12</td>
<td>The chain-saw operator shall be certain of footing before starting to cut. The chain saw shall not be used in a position or at a distance that could cause the operator to become off-balance, have insecure footing, or relinquish a firm grip on the saw.</td>
<td>2006 – 6.3.12</td>
<td>See 2006 – 6.3.4 for revisions regarding secure footing.</td>
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<tr>
<td>Standard Subsection</td>
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<tr>
<td>8.1.1</td>
<td>A visual hazard assessment, including a root collar inspection, shall be performed prior to climbing, entering, or performing any work in a tree.</td>
<td>1994 – 9.1.1 2000 – 9.1.1 2006 – 8.1.1</td>
<td>1994 – Prior to climbing operations, a visual inspection of the entire tree (including root collar) should be performed. During climbing operations, tree limbs should be inspected before weight is applied to them. The climber should not trust the capability of a dead branch to support the climber’s weight. Dead branches should be removed on the way up, if possible. Hands and feet should be placed on separate limbs, if possible, maintaining three points of contact with the tree while climbing. While climbing, the worker should climb on the side of the tree that is away from electrical conductors, if possible. Climbers should have a minimum of two means of attachment available. 2000 – A visual hazard assessment including the root collar shall be performed prior to climbing, entering or performing any work in the tree.</td>
</tr>
<tr>
<td>8.1.16</td>
<td>Ropes and climbing equipment shall be stored and transported in such a manner to prevent damage through contact with sharp tools, cutting edges, gas, oil, or chemicals.</td>
<td>1972 – 7.9.3 1979 – 7.9.3 1982 – 7.9.3 1988 – 7.9.3 1994 – 8.9.2 2000 – 8.7.10 2006 – 8.1.16</td>
<td>1972, 1979, 1982, 1988, 1994 – Ropes shall be stored away from all cutting edges and sharp tools. Corrosive chemicals, gas, and oil shall be kept away from rope. 2000 – Ropes and climbing equipment shall be stored and transported in such a manner to prevent damage through contact with sharp tools, cutting edges, gas, oil or chemicals.</td>
</tr>
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<tr>
<td>8.1.20</td>
<td>While ascending a ladder to gain access to a tree, the arborist shall not work from or leave the ladder until he or she is tied in or otherwise secured.</td>
<td>1972 – 8.1, 1979 – 8.1, 1982 – 8.1.1, 1988 – 8.1, 1994 – 9.1, 2000 – 9.1.2, 2006 – 8.1.20</td>
<td>1972, 1979, 1982 – A tree worker shall be tied in with an approved type of climbing rope and safety saddle when working above ground. The climbing rope shall always be used even when working from a ladder or scaffold. A safety strap or rope with snaps may be used for additional protection. 1988 – A tree worker shall be tied in with an approved type of climbing rope and safety saddle when working above ground. This does not necessarily apply to a worker ascending into a tree. Work may be performed while standing on a self-supporting ladder, including the top rung, but only when the worker is tied in as required. 1994 – Tree workers shall be tied in with an approved climbing line and a tree climber’s saddle when working above the ground. This does not necessarily apply to a worker ascending into a tree. Work may be performed while standing on a ladder, including the top rung, but only when the worker is tied in as required. 2000 – Arborists shall be tied in or secured while ascending the tree and remain tied in or secured until the work is completed and they have returned to the ground. Exception: (1) While ascending a ladder to gain access to a tree, however, arborists shall not work from or leave the ladder until they are tied in or secured. (2) While ascending a tree where the density of branches growing from the stem prevents the arborist from crotching the arborist climbing line or work-positioning lanyard through the branches, then and only then, is the three-point climbing technique acceptable.</td>
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</table>
| 8.1.23              | The tie-in position should be well above the work area so that the arborist will not be subjected to an uncontrolled pendulum swing in the event of a slip. | 1972 – 8.1.4  
1979 – 8.1.4  
1982 – 8.1.4  
1988 – 8.1.3  
1994 – 9.1.3  
2000 – 9.1.5  
2006 – 8.1.23 | 1972, 1979, 1982 – The climbing rope should be passed around the trunk of the tree as high as possible using branches with a wide crotch to prevent any binding of the safety rope. The crotch selected for tying in should be over the work area as much as possible but located in such a way that a slip or fall would swing the worker away from any electrical conductor. The rope should also be passed around the main leader or an upright branch using the limb as a stop. Feet, hands, and ropes should be kept out of tight-V shaped crotches.  
1988 – The climbing rope should be passed around the trunk of the tree as high as possible using branches with a wide crotch to prevent any binding of the safety rope.  
Exception: Palms and other trees with similar growth characteristics that will not allow a climbing rope to move freely.  
The crotch selected for tying in should be directly above the work area, or as close to such a position as possible, but located in such a way that slip or fall would swing the worker away from any electrical conductor. The rope should also be passed around the main leader or an upright branch, using the limb as a stop. Feet, hands, and ropes should be kept out of tight V-shaped crotches.  
1994 – The climbing line shall be passed around the trunk of the tree as high above the ground as possible using branches with a wide crotch to prevent any binding of the climbing line.  
Exception: Palms and other tree with similar growth characteristics that will not allow a climbing rope to move freely.  
The crotch selected for tying in shall be directly above the work area, or as close to such a position as possible, but located in such a way that slip or fall would swing the worker away from any electrical conductor. The rope should also be passed around the main leader or an upright branch, using the limb as a stop. Feet, hands, and ropes should be kept out of tight V-shaped crotches. |
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<tr>
<td>8.6.1</td>
<td>Traffic control around the jobsite shall be established prior to the start of chipping operations along roads and highways (see section 3.2, Traffic Control Around the Jobsite).</td>
<td>2006 – 8.6.1</td>
<td></td>
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<tr>
<td>8.6.3</td>
<td>To prevent an entanglement hazard, loose clothing, climbing equipment, body belts, harnesses, lanyards, or gauntlet-type gloves (for example, long-cuffed lineman’s or welder’s gloves) shall not be worn while operating chippers.</td>
<td>1979 – 8.6.6, 1982 – 8.6.6, 1988 – 8.6.6, 1994 – 9.6.6, 2000 – 9.6.6, 2006 – 8.6.3</td>
<td></td>
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</tbody>
</table>

1979, 1982, 1988 – Loose clothing, gauntlet-type gloves, rings, and watches shall not be worn by workers feeding the chipper.

1994 – Operators shall not wear loose clothing or gauntlet-type gloves while feeding the chipper.

2000 – Loose clothing, climbing equipment, body belts or gauntlet-type gloves (for example: long cuffed linemen or welder’s gloves) shall not be worn while operating chippers.
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<tr>
<td></td>
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<td>1994 – All workers feeding brush into chippers shall wear personal protective equipment as required. See 4.2 of this standard.</td>
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<td>2000 – Personal protective equipment shall be worn when in the immediate area of chipping operations in accordance with Sections 4.2.1 and 9.6.6.</td>
</tr>
<tr>
<td>8.6.7</td>
<td>Brush and logs shall be fed into chippers, butt or cut end first, from the side of the feed table center line, and the operator shall immediately turn away from the feed table when the brush is taken into the rotor or feed rollers. Chippers should be fed from the curbside whenever practical.</td>
<td>1972 – 8.6.3, 1979 – 8.6.3, 1982 – 8.6.3, 1988 – 8.6.3, 1994 – 9.6.3, 2000 – 9.6.3, 2006 – 8.6.7</td>
<td>1972, 1979, 1982, 1988 – Brush chippers shall be fed from the side of the centerline, and the operator shall immediately turn away from the feed table when the brush is taken into the rotor. Chippers shall be fed from the curbside whenever practical.</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>8.6.11</td>
<td>Hands or other parts of the body shall not be placed into the infeed hopper. Leaning into or pushing material into infeed hoppers with feet is prohibited.</td>
<td>1972 – 8.6.4 1979 – Absent 1982 – Absent 1988 – Absent 1994 – Absent 2000 – 9.6.8 2006 – 8.6.11</td>
<td>1972 – Workers shall never place hands, arms, feet, legs, or any other part of the body on the feed table when the chipper is in operation or the rotor is turning. The chipper chute shall not be raised for repairs, while the rotor is running. 2000 – Hands or other parts of the body shall not be placed into the infeed hopper. Leaning into or pushing material into infeed hoppers with feet is prohibited.</td>
</tr>
<tr>
<td>8.6.13</td>
<td>When feeding a chipper during roadside operations, the operator shall do so in a manner that prevents him or her from stepping into traffic or being pushed into traffic by the material that is being fed into the chipper.</td>
<td>1972 – 8.6.3 1979 – 8.6.3 1982 – 8.6.3 1988 – 8.6.3 1994 – 9.6.3 2000 – 9.6.3 2006 – 8.6.13</td>
<td>See 2006 – 8.6.7 for revisions regarding feeding the chipper.</td>
</tr>
</tbody>
</table>
# APPENDIX C

## CHECKLIST USED BY RESEARCHER

<table>
<thead>
<tr>
<th>Company</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Site Address</td>
<td>Time AM/PM</td>
</tr>
<tr>
<td>City</td>
<td>State</td>
</tr>
</tbody>
</table>

### On-Site Tree Care Survey

**Site:** Effective perimeter set up to control pedestrian and/or vehicular traffic prior to:
- Climbing
- Chipping
- Rigging
- Other

**PPE:** At all times, workers were wearing proper:
- Head protection
- Hearing protection*
- Foot protection
- Eye Protection

### Chainsaws
- (C_pants) Protective chainsaw pants shall be worn on the ground at all times.
- (C_brake2step) Chain brake was engaged when carried more than two steps.
- (C_15lbs) Chainsaws over 15lbs are secured against falling.
- (C_2hands) Chainsaws were always used with two hands.
- (C_dropst) No chainsaws were drop-started.
- (C_2pts) Two points of attachment were secured while operating the chainsaw.
- (C_working) Chainsaws were in proper working order, and not modified.
- (C_shutoff) Chain brake was engaged or engine was shut off before setting down.
- (C_shlders) Chainsaws were not operated above shoulders.

### Brush Chippers
- (b shove) No body parts were used to shove brush into the chipper while running.
- (b attire) Proper attire was worn to prevent entanglement.
- (b buttcut) Brush was fed butt or cut end first.
- (b curb) Chippers fed from curbside.
- (b side) Chippers were fed from the side.
- (b chocked) If detached from vehicle, chipper was chocked and properly secured.
- (b quickstop) Chippers equipped with a quick-stop and reversing device.

### Ropes & Climbing Equipment
- (visual) A visual hazard assessment was performed prior to climbing.*
- (tie above) Tie-in position was secured well above the climber.
- (ladder) When ascending a ladder, arborist did not work from or leave the ladder.
- (sharp) All sharp tools were used and stored properly to avoid contact with ropes.

### Buckets
- (one bucket) Only one person was in a one-person bucket at any time.
- (elev) Aerial devices were not moved with an arborist still in an elevated platform.
- (harness) Operator is wearing full-body fall arrest harness while in the bucket.
- (improvising) Correct equipment or tool was used for the job, not improvising.

**Other Notes:**

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LITERATURE CITED


Tree Care Industry Association. Accreditation Information Package. Londonderry, NH: TCIA.

Tree Care Industry Association. [pamphlet] Take the Guesswork out of Tree Care Bids!


