Is Performance Variability Necessary Or Counterproductive For Safely Felling Trees In The Coastal Region Of British Columbia?

A Qualitative Study With Manual Tree Fallers

Thesis/Project work submitted in partial fulfillment of the requirements for the M.Sc. in Human Factors and System Safety

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IS PERFORMANCE VARIABILITY NECESSARY OR COUNTERPRODUCTIVE FOR SAFELY FELLING TREES IN THE COASTAL REGION OF BRITISH COLUMBIA?

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ABSTRACT

In the work of manual tree falling, conditions exist and develop that are complex and unpredictable and cannot be handled entirely by following procedures, therefore, adjustments are necessary. The objective of this research is to determine whether performance variability is actually necessary or counterproductive to safely fell trees in the coastal region of British Columbia (B.C.). The overall aim was to empirically sustain or refute some of the existing resilience theories that claim that performance variability is necessary. In this study two perspectives were contrasted: The traditional view of safety and the resilience perspective. To explore how safety is created in a forestry setting, 22 participants with experience in manual tree falling were interviewed. The empirical evidences collected are discussed within four assumptions which were derived from the theoretical literature: (1) resilient practices may induce discomfort, (2) procedures don't fit every situation, (3) procedures alone cannot create safety and (4) performance variability is necessary. Overall, the empirical evidence establishes that while safe work procedures provide a good foundation, it is individual performance variability shaped by experience and "know-how" that guides the application of technical skills in complex, dynamic, high risk environments.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

THESIS DEVELOPMENT

INTRODUCTION

In the profession of manual tree falling, work takes place amongst dead, heavy leaning, rotten and windblown trees that have the potential to produce unexpected and often escalating situations. Day-to-day, fallers carry upwards of 80 pounds of tools and fuel, axes and a heavy backpack up steep hillsides into remote, difficult-to-access and potentially dangerous areas. Unlike most any other professions, they deal with a full range of high-hazard, unpredictable, and demanding conditions as a regular part of their work. While exposure to this level of risk and extreme environments is not typical for most workers, it is considered normal in this industry. One faller explained:

> "You're 'handcuffed' – blocked off by a rock bluff with nowhere to go and you're seeing the butt-end of the tree…..the whole section is windblown - all cross-hatched and old with some under a lot of tension and you just can't tell how 'loaded' it is until you start cutting it and even then, you're not expecting it and the cut drops and goes sailing by…it just narrowly missed me because I had just taken a half step to the left – and all the while I'm thinking, this could go bad."

So how are manual tree fallers able to safely and successfully managing the work in this complex, high-risk environment? Two contrasting perspectives: The traditional safety perspective and the resilience perspective provide two very different explanations. According to the traditional view of safety, systems are simple and humans are independent actors subtracting safety from the system. In this paradigm, humans are considered as a source of risk. As a result, advancing safety involves protecting the system from people who may degrade it. The practice is to introduce constraints which limit actions in order to

prevent unsafe behaviour and restrict individual performance variability. One of these constraints is the application of safe work procedures (Dien, 1998; Lautman & Gallimore, 1987). In the forest, procedures are written and enforced to ensure among many things, that stumps are cut accurately, two escape routes are always cleared, face shields are kept down, and snags are felled progressively.

However, strictly following the rules is often not how real work is performed. In reality, work is accomplished by intelligently and freely applying the rules based on context. This is in sync with the perspective and theories of resilience which claim people - with multiple goals, limited resources and in the context of uncertain circumstances – have the ability to anticipate, respond and flexibly adjust to safely manage their work in dynamic conditions. In this view, humans are deemed the valuable and positive components of the system. Their behaviour is the same regardless of the outcome. Therefore there is utility in examining system performance through successes and not just failures to understand how the interactions work and why sometimes they don't. In this perspective, systems are complex and not inherently safe (Hollnagel, n.d.; Dekker, 2006). Safety is an emergent property. It doesn't exist independent of the system and its interactions. Safety is not just reflected in the absence of incidents or injuries. Work by Hollnagel (n.d.) and others (Woods, n.d.; Dekker, 2003a), asserts that performance variability is necessary and useful. Claiming that progress in safety comes from enhancing people's adaptive capacity in the face of systemic vulnerabilities (Woods, n.d.) has gained appreciable momentum. However, very little research is available that links resilience principles in an industrial safety context. In addition, limited empirical evidence exists to substantiate resilience theories which maintain that performance variability and resilience at the worker level are pivotal to creating safety.

The purpose of this qualitative research study is to determine whether performance variability is necessary or counterproductive for safely felling trees. It was conducted to empirically validate some of the existing resilience assumptions. Resilience theories and concepts are examined and discussed according to four assumptions that emerged from the theoretical literature. To explore the research question, the assumptions are supported with thematic dialogue that was extracted from interviews with fallers and falling supervisors and linked with theoretical work.

This work adds to the scholarly research because the theories of resilience have not been introduced or studied in the context of the unique coastal forestry environment. In particular, the perspective that fallers and supervisors have regarding the necessity of performance variability in order to create safety, remains unexplored.

Literature Review

The understanding that systems are purely mechanistic or technical has evolved to where humans and technology fitting/working together are described as "components" interacting inside a system. In response to the limitations of traditional methods for addressing increasingly complex, interactive systems, systems theory was introduced. Consistent with this view, Ramo (n.d.) explains, "Properties of systems can only be treated adequately in their entirety, taking into account all facets and relating the social to the technical aspects" (p. 13). To help promote this understanding, non-linear models and theories have been developed. A hallmark of systems theory or systems thinking is distinguishing and describing failures relative to the whole system. Components do not exist or function in isolation and/or separate from the system, they are interdependent. The system effectively maintains itself through the compatible interaction of its parts and humans respond flexibly to manage the complexities and risks of the system.

Understanding context is one of the most vital aspects of systems thinking. Researchers, Orasanu, Martin and Davison (n.d.) promote a "systems perspective [which] suggests that a more productive approach to identifying decision errors is to examine the interaction between situational factors and individual cognitive factors" (p. 5). They continue to say, "Current trends emphasize analysis of "behaviour shaping features of the environment" [as well as identifying] "objectives, constraints, options for action and subjective performance criteria" (p. 5). The whole system should be examined to understand the context of the environment and how the features of that environment influenced the actions of workers.

Determining safety in complex settings is not possible by just scrutinizing workers' practices. Safety emerges in and can only be determined by the relationship between the

workers and other components including the task itself, the actual external environment and the organization - that is, in the context of the whole. How workers "operate safely, is 'holistic', in the sense that is a property of the interactions, rituals, and myths of the social structure of the whole organization" (Rochlin, 1999, p. 1557). He continues to say, "operational safety depends on more than a set of observable rules or procedures, externally imposed training or management skills, or easily recognized behavioural scripts" (p. 1557). Collectively, the above mentioned theorists believe and advocate that it's not just important, but also necessary to consider the whole system of work in order to understand how work is actually performed and safety is maintained.

Related, is the work of researchers Marais, Dulac and Leveson (2004) who also state that safety is an emergent or system property that functions as a whole. It is something a system does – not something it has. Similarly, the work conducted by Slovic (1992) describes safety as "a constructed human concept, more easily judged than defined" (p. 1550). It's not just the absence of adverse events and "the avoidance of error or even the control of risk" (p. 1550). Safety is not a dormant ingredient but is rather an active organizational condition which is more than just adaptation to circumstances. Rochlin (1999) supports this view in stating that it is not difficult to obtain measurements of error and consequences but rather more challenging to indentify the "empirical indicators of broader social and organizational definitions of safety" (p. 1550). He further describes, "The position of any [organization or actor is] situational and dynamically constructed, and evaluations of safety are not easily connected to objective measures of real world performance" (p. 1551). Hence, the resilience perspective is not about the absence of safety but rather how individuals actually create safety.

From the Traditional View of Safety to Resilient Practices

The idea of accepting or adopting resilience strategies is unexplored in most industrial (occupational) safety structures. For this reason, closing or even narrowing the gap between where traditional safety and the current literature on resilience is a courageous step. The present divide is wide but can be bridged with the support of new perspectives on how workers actually create and maintain safety to accomplish work and often protect the system from adverse outcomes.

The Traditional View of Safety

The traditional safety perspective focuses on the prevention of adverse events by constraining human performance. Safety is indentified in the absence of negative or unwanted outcomes and systems are deconstructed in an attempt to understand failure.

The practice of creating and maintaining safety has for many generations been consistent in its philosophy, structure and application. Therefore, the idea of moving beyond the traditional approach and adopting new perspectives and strategies may be uncomfortable and unknown to many safety practitioners. Traditionally, safety is equated with workers following rules and procedures to stay safe in the belief that if behaviour is controlled, operations will be safe and adverse outcomes will not occur. In this view, the desired goal is to protect the system from the performance variability of individuals because it is felt that the variability could bypass the system's defenses.

There are several foundational elements to the traditional view. Initially, when things go wrong there is an immediate focus on the proximal worker's decisions and actions. This stems from a commonly held belief that there is a rational choice to err, or that workers are not motivated to follow rules and choose to work unsafely (Dekker, 2005). Accidents are

seen as being caused by individuals making bad decisions or poor choices. This supports the perspective that they are a liability and the system that would function perfectly well if they did what they're supposed to do. When things go wrong, finding fault with an individual heightens the belief that they are the source of risk and this can lead to demotion, retraining or dismissal of workers to fix the problem. However, this approach is ineffectual in the long term because it does not address any system level deficiencies.

Related to the dualism or individualistic approach, this subscription of thought makes distinctive separations between the human's actions and the tools, equipment and work environment. This drives the quest to find deficiencies with one or the other – mechanical or human. According to Newtonian's mechanistic thinking, the actions of the individual as well as the mechanical operations are dissected and deconstructed to understand which one failed (Dekker, 2005). Post incident, if no mechanical or technical deficiencies can be found, it often leads to the label of human error. However, applying a label only provides a false sense of comfort since Dekker (2005) explains that "error is neither fully human, nor fully engineered … you need both to succeed; you need both to fail" (p. 7). Having evolved from the early pioneering work of Newton, this perspective (that served well to advance science) is still used to describe failure and often makes sense to many. It remains the foundation of many accident investigation processes and offers a measure of perceived control over the system of work.

It is the desire for control that has lead to the introduction and enforcement of procedures as a means to minimize performance variability and increase safety. In order for supervisors, auditors or regulators to manage safety, these detailed prescriptions are prominent and often relied upon to control safety critical elements of the work process. Procedures support a

principle element in the traditional view because they attempt to constrain behaviour and make it impossible to do things unsafely. In many industrial domains there is a solid commitment to rules and reluctance to introduce alternative methods of control because rules offer a formal reassurance of safety. They are relatively easy and inexpensive to implement and "allow the responsibility for safety to be delegated to the people who do the job' (Reason, Parker, & Lawton, 1998, p. 298). When rules are observed not being followed, the result is often to tighten procedures which can "increase the likelihood of violations being committed" (Reason, 1997, p. 51). Regardless, procedures are often regarded as restrictive and impractical by those they are intended to protect.

Yet a mystery still remains as to why workers can't or won't follow the rules because at the core it is strongly believed if workers know, and carefully follow safe work procedures, they will avoid incidents and injuries, and the system will be safe. But as Reason, Parker and Lawton (1998) explained tightening rules shrinks the permissible actions to such a narrow scope that procedures have to be routinely violated in order to accomplish the task. This strategy has only been marginally effective because narrowing the gap between procedures and practice with overly detailed rules often has the opposite effect since "rules … grow more and more at odds with the context-dependent nature of practice" (Dekker, 2006, p. 8). However, many see this paper-based approach as positively adding additional lines of defense or layers which can protect workers and the system. While the goal is to reduce human variability in order to increase human and system reliability, one of largest benefits to adding more rules is they can be written and issued and therefore safety appears complete (Reason et al, 1998). They provide a benchmark against which performance can be measured and they can be used as tool for judgment and accountability.

All of these features of the traditional view combine to form the belief that systems are relatively simple. As long as there are rules and procedures coupled with individuals that will follow them, the system will be free of error and adverse events. There is comfort and confidence that the cause of the incident can be found by dissecting the parts of the system and believing that humans are the source of risk in an otherwise operable system. Remaining true to this philosophy provides assurance that the system is safe as long as the human element can be controlled. However, there is a second, alternate perspective offering a contrast to this view: resilience. Its philosophy, structure and application are not rigid and inflexible but rather, highly receptive and adaptive allowing a flexible application of rules which is based on contextual factors.

The Resilience Perspective

Resilience is the system's ability to recognize, and effectively handle anomalies that could occur during work operations. It focuses on how to help people manage complex conditions to achieve success. It finds value in looking at how work is normally successful rather than the seldom occurrence of failures.

The resilience perspective stands in contrast to the traditional approach because safety is not created by tabulating error, nor is it an entity that can be easily measured. Safety doesn't stop at possessing a safety program along with all its due diligence components. It is not a static element that once in place, requires no further re-assessment or re-configuration. Hollnagel and Woods (n.d.) indicate rather, safety is "how a system performs" (p. 347). Resilience doesn't look at the absence of safety but understands "that safety is never complete or absolute" (p. 346). It is not a property to be determined through quantification but through continual assessment of successes as well as failures.

There are four distinctive characteristics of resilience which apply to organizations and individuals. Those are: 1) the ability to respond to changing conditions, 2) the ability to monitor operations 3) the ability to anticipate what's going to/what could happen in the future, and 4) the ability to learn (Hollnagel, 2010). The foundation of resilience practice is to enhance the skills, knowledge and adaptive capabilities of workers. This assists workers in identifying problems before they arrive, allowing them to intelligently and flexibly adapt practices to fit conditions and handle unforeseen perturbations. In dynamic and complex industries, risk assessments are often incomplete beacause frequent changes create new demands and pressures. In contrast, the resilience perspective promotes the ability to recognize and adapt to shifts in processes by applying a repertoire of strategies and co-ordinations. In this respect, resilience is tantamount to coping with complexity (Hollnagel & Woods, 2005) and retaining control.

The resilience perspective, unlike the traditional perspective, doesn't assume that inputs to the work processes are regular and predictable. It doesn't expect that demands and resources are within limits or that working conditions will fall within normal limits. It also knows that outputs will vary from expectations and norms (Grotan, Storseth and Skjerve 2008). More often than not, workers have to adjust their practice to bring the goals to completion while balancing efficiency and safety. Hence, if a system is constantly changing and yet requires reliable outcomes; it needs to have the capacity to deal with the dynamics in a variable manner.

Resilience holds an alternative view of how safety is created and managed. It is about viewing the context in which dynamic work is performed in a different way as well as recognizing the adaptive skills of workers. Humans are ingenious in managing systems and

adaptive skills have to be present in many complex industries where conditions have the capacity to provide brutal audits from errors. Unlike the traditional perspective, "resilience cannot be simply engineered by introducing more procedures, safeguards and barriers" (Hollnagel & Woods, n.d., p. 348). Rather, it recognizes that strict compliance with the rules is often problematic and ultimately may be insufficient to achieve the desired goal - improved safety. A rule cannot be developed for every possible encountered situation. On the contrary, Huber, Wijgerden, Dewitt, and Dekker (2009) explain that the only thing that can close the gap is human interpretation and application. It is now recognized that instead of restricting individual performance with rigid, inflexible rules and procedures that performance variability is actually necessary to cope with the complexities of real world environments.

Performance Variability

Performance variability is the degree of freedom that is available from the strict adherence with predetermined rules. It is action taken by workers which is flexible and efficient to meet the demands of the circumstances. It is the variability of a worker's performance in the context of work.

Hollnagel (2009) explains that performance variability exists because of unpredictable "external conditions and demands, rather than the characteristics of individuals" (p. 92). Performance variability results from individuals trying to meet organizational goals, making-do with limited resources and/or resolving ambiguity and attending to double binds etc. It emerges in response to social, organizational and contextual conditions such as trying to meet the expectations of others, complying with speed and quality work demands, completing deadlines and stretching resources. Hollnagel (2009) provides further details regarding the different types of performance variability:

- Teleological variability emerges in situations where goals are unstable due to external factors (supply and demand) or where expectations or values are revised. People will adjust their performance to meet anticipated changes. This level of variability is often predictable given their knowledge of the system's environment and performance history. The workers will anticipate what may happen and adjust performance accordingly.

- Contextual or situational variability arises as people adjust their performance (or actions) to produce the best possible outcome – given the under-specification of situations. This level of variability is also partly predictable since it describes the tactics or heuristics that people use to get the job done.

- Compensatory variability happens when something is missing or absent (a tool or resource) or when a procedure cannot be remembered. "This may be called *incidental* variability whereas the other two forms can be called *normal* variability" (p. 93). Compensatory variability is the least predictable and may appear to be random and so, "corresponds to an opportunistic performance or level of control" (p. 93).

The resilience perspective believes that these types of variability preserve imperfect systems in largely underspecified conditions. They believe that performance variability is necessary because complexities and dynamics create environments (exogenous variability) that are widely variable. The performance variability that manages these systems (endogenous variability) is largely attributable to workers and teams (Hollnagel & Woods, 2005). Endogenous variability should be seen as an asset rather than wrong or erroneous in any way. Certainly, "performance variability may induce a drift in the situation, but it is normally a drift to success, a gradual learning by people and social structures of how to handle uncertainly, rather than a drift to failure" (Hollnagel, 2009, p. 94). Variable performance is considered "normal" (matching performance to conditions) rather than "normative" (according to rules and procedures) (Hollnagel, n.d., 2005). Providing workers with degrees

of freedom to deviate from expected or pre-determined paths (Patterson, Cook, Woods & Render, n.d) enables them to successfully cope with complexities. However, they have to be confident that there will be no adverse consequences in trading high productivity for safety.

Cook and Nemeth (n.d) discuss features of resilient performance and state that it's an individual's ability to respond to localized demands with minimum performance decrements. Even though their performance may be tempered by other considerations, resilient performance often achieves high levels of success. They provide some excellent examples of performance variability being demonstrated in times of high demand. For instance, medical staff who responds to sudden changes during an emergency such as when multiple serious injuries are admitted at one time, are able to manage these types of situations fluidly, professionally and without decrement to the quality of care. Once they recognize the need, efforts increase to ensure that the system remains operable. They do this while juggling resources to meet multiple goals and fluctuating priorities. Rather than relying heavily on procedures, they draw on their skills, experience and judgment to re-establish and regain order while still accomplishing the work. Reason (2008) informs us that the ability to respond in this manner is vital to many operations and if attempts were made to restrain these behaviours it would actually undermine "the system's most important safeguards: the ability to respond to the unexpected" (p. 239). The practice of constricting performance during these times can be actually inefficient and even detrimental.

Hollnagel (2009) provides insight into why performance variability is necessary. He highlights the dilemmas that workers face day-to-day as they balance being efficient and yet thorough while managing expectations. "For individuals, the decision about how much effort to spend on assessment and action is not usually at the conscious level, but rather one of

habits, social norms and established practice" (p. 60). Thoroughness diminishes once the individual is confident that unwanted side-effects are curtailed and that actions are sufficient to meet the objectives. In real work, Hollnagel (2009) explains that efficiency and thoroughness can compete and conflict for a variety of reasons:

- Limited availability of resources, especially limited time.
- The need to sustain and retain resources that may have to be used at a later, more important time.
- Pressure from upper management and peer pressures to do things by a certain time in a certain way.
- Balancing organizational conflicts between "*safety first"* and the actual practice of being "*ready in time*" (p. 17).

Despite limits of the surrounding organization, people will introduce highly adaptive strategies in order to cope, and manage elements successfully (Amalberti, 2001). Their skill compensates for the gaps between work as prescribed and actual work. "As most gaps are anticipated, identified and bridged and their consequences nullified, gaps rarely lead to overt failure" (Patterson, et al., n.d., p. 4). People look at their ability to reconcile the irrevocable as a source of professional pride which shows a strong sense of highly skilled expertise. It is the strong professionalism that gets the job done.

The adaptability and flexibility of human work is the reason for efficiency. People adjust to system level deficiencies, anticipate recurring variations and take proactive measures to tackle challenges (Hollnagel, n.d). Working conditions are often ambiguous and under specified and so, performance adjustments have to be variable to match conditions

(Hollnagel, 2009) in order to allow the work to proceed as planned and achieve its intended objective.

Safe Work Procedures and Resilience Strategies

During performance, workers are intrinsically proactive and flexible making the operation successful and safe despite resource constraints. While useful, procedures are often insufficient when it comes to representing the complete account of the knowledge, skills, local judgments and experience that are required in practice. Therefore, following procedures is often incompatible with getting the job done. Dien (1998) explains the limitations of procedures stating they are "…only an instantaneous and time frozen reflection of theoretical and practical knowledge of the operation in a process at a given moment" (p. 182). Thus, even if the rules were exhaustive, they will likely always be less than the possible variety of situations that people may have to manage.

In tightly coupled systems (where an action could have an immediate reaction) the system of work is often underspecified because of the high degree of complexity. Although in these conditions systems usually operate with a high degree of certainty, outcomes are probabilistic, not deterministic (Hollnagel, 2009). As such, it would be impossible to provide a detailed set of instructions for each and every scenario as "there will always be situations that are either not covered by the rules or in which the rules are locally inapplicable" (Reason et al., 1998, p. 297). In support, Dekker (2003a) explains that formally documented procedures are typically not well suited to the context because of the unlimited uncertainty and ambiguity involved in work activities. He states that very often "dynamic work not only occurs despite procedures … but without procedures altogether" (Dekker, 2003a p. 234). He continues to say that procedures are often inadequate to cope with local complexities and

therefore, various informal systems of work practices are developed to get work done. However, when procedures aren't followed, it is often perceived by those outside of the professional group as non-compliance but from inside the system, it is a recognition of expertise and professionalism.

Yet, this is not to say that organizations should give up on the use or value of safety rules as they "guide safe behaviour and they also can constitute an important record of an organization's learning about its operational dangers" (Reason, et al., 1998, p. 297). Procedures which aim to standardize work activities play a role in shaping safe practice, but it is now recognized that procedures are not the panacea; "there is ambiguity and evidence that procedures are a … problematic category of human work" (Dekker, 2003a, p. 234). Wholly safe behaviour can never be controlled entirely by procedures because they cannot provide sufficient detail in complex and unpredictable situations.

The difficulty with relying on procedures is that by themselves they cannot create safety. When something changes there are simply so many possibilities for what could happen and so many unknown factors that it is impossible to predict and describe exactly what the situation will be, and therefore it is virtually impossible to provide comprehensive, complete procedures. Hollnagel (2009) explains that "If the situation is to be managed, it is necessary to adjust performance to meet the conditions i.e., to have performance variability" (p. 91). This is because "prescriptive process controls will always lack the requisite variety necessary to guarantee safe behaviour, even if the workforce were scrupulously compliant" (Reason, et al., 1998, p. 301). Therefore, performance variability is necessary to bridge the gap to successfully manage complex work.

Could Performance Variability be Counterproductive to Safety?

Although being adaptive to context is necessary, it may also be the reason that sometimes failures occur. Workers flexibly apply rules using their knowledge, skills and experience to safely accomplish this work but this same flexibility may also make the system vulnerable. When humans interact with systems, many unknown interrelated and interdependent features of the environment suddenly become visible. Felling a tree only has a small percentage of certainty, as to where it will fall and what unexpected conditions may arise from that motion. Yet, often, it is decision errors that are highlighted as causal in incidents but more often than not, expectations are violated because of the unknown interrelatedness of this situation. This is because decisions, actions and responses are usually based on limited information rather than ever a complete analysis of current conditions.

While true that adverse outcomes may differ from what is expected or required, this is usually due to the variability of context and conditions rather than to 'failure' of actions. Local optimization and adjustment is the norm rather than the exception as shown by numerous shortcuts and heuristics that people rely on in their work (Hollnagel, n.d.). Post incident, it is always possible to find people that did not act according to a rule. While performance variability could be labeled as human error, it happens all of the time - not just at times of incidents. Hollnagel (2009) states that human performance is always approximate but when things are going well on a day-to-day operational level, it is not noticed, it is invisible. However, when it leads to adverse outcomes, any performance variability is quickly made visible. On the occasions when something has gone wrong, the resilience perspective recognizes that workers have behaved in the same way, regardless of whether the outcome is right or wrong. "Right and wrong are judgments made after the fact, and it would be miraculous, to say the least, if the 'machinery of the mind' could know the actual outcome of

action ahead of time and change its mode of functioning accordingly" (Hollnagel, 2009, p. 86). If individuals possessed that level of foresight, plans or actions would have changed in order to avoid the adverse outcome.

Due to the sheer complexity of the situations that workers are exposed to, human cognition cannot possibly account for all possible scenarios of what might happen. Staying safe is primarily dependent on what cues are available, if they are recognized, and how they are interpreted and acted upon. Researchers acknowledge that people can cope with a high degree of complexity. They know that "people are able to make tough decisions under difficult conditions such as limited time, uncertainty, high stakes, vague goals, and unstable conditions" (Orasanu & Connolly, 1993, p. 457). Successfully operating in complex environments often requires taking action because taking action means getting feedback and understanding an unknown environment. A reluctance to act could be associated with less understanding and more errors. Action is fueled by contextual cues that workers match with pre-existing schemas to transform the complex into the simple. However, when action is based on preconceptions and it becomes apparent that expectations were wrong, there may be few opportunities to correct - especially in an industry where the consequences are high. This is when performance variability is often considered detrimental to safety.

Weick and Sutcliffe (2007) observed operations within with High Reliability Organizations (HRO's) to understand how individuals managed the unexpected. It appeared that the workers expanded their knowledge to include imagining what's possible. To improve foresight, HRO principles steer people towards imaginative practices. This bolsters anticipation and raises doubts about all expectations. This type of strategy is encouraged because it is only a very brief interval between surprise and success that offers opportunities

to discover what you don't know (Weick & Sutcliffe, 2007). Workers apply resilience strategies (the ability to anticipate as well as the process of continuous monitoring and learning) to refine expectations. Performance variability usually increases the effectiveness of the response but on occasion this variability can lead to failure.

Rasmussen (1997) discusses how variability as well as performance adjustments are also shaped by the objective and constraints of the work system. Workers adapt performance to accommodate organizational pressures, limited resources and multiple goals in order to be successful. During this adaptive process, workers tend to migrate toward the boundary of efficient and functional performance. Most systems have sufficient dampening to ensure that performance variability does not combine or escalate in a way that could de-stabilize the situation but once in a while performance variability is not compatible with the conditions and de-stabilization does occur (Hollnagel, 2009). If this happens, and the boundary is crossed, it is likely that an incident will occur. Typically, incidents are the product of normalized performance that has been produced to counter the effects of the other system elements. The difficultly is, knowing where the boundary of safe performance is and the degree of freedom that is available before an adverse outcome occurs. It is evident that an approach to represent "systems behaviour is necessary which is not focused on error and violations, but on the mechanisms generating behaviour in the actual dynamic work context" (Rasmussen, 1997, p. 190). The goal should not be to dampen the performance variability that is necessary for effective operations, rather to manage it so it remains effective within the boundaries of safe operations.

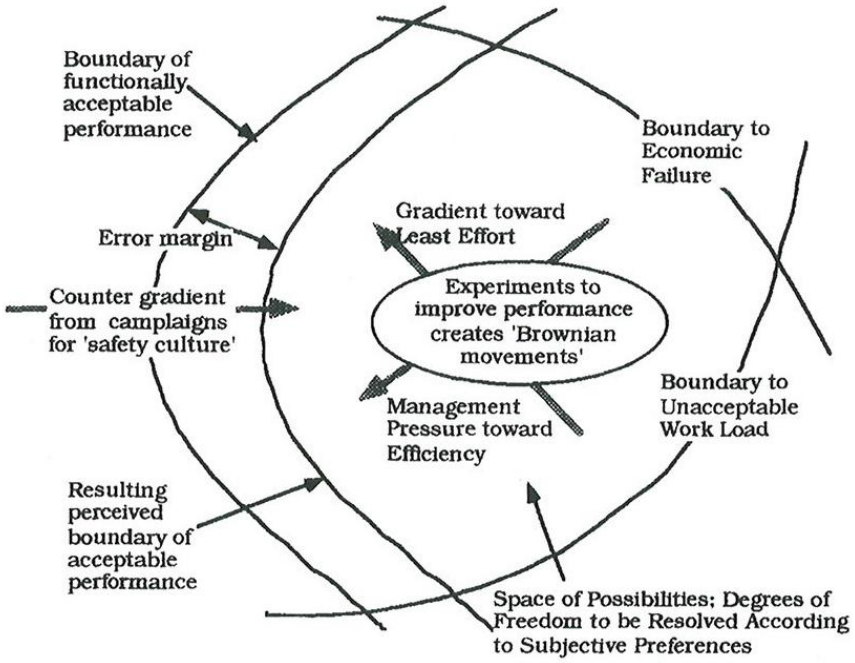

Figure 1

Figure 1 illustrates the approach that is related to the "Gibsonian concepts on invariants and affordances" (Rasmussen 1997, p. 191). Rasmussen (1997) indicates that to analyze human behaviour in context we need a matching high level representation, something more than what task analysis can offer in this highly dynamic environment. What is needed is a process, tool or application which is able to identify the boundaries and the work conditions that exist inside this boundary. There is also a need to recognize which counter-gradients prevent operations from drifting across this space. The challenge is to make performance variability an asset to the system but also "making the boundaries explicit and known and by giving opportunities to develop coping skills at the boundaries" (Rasmussen, 1997, p. 191). This is in contrast to the traditional approach that attempts to control behaviour by fighting deviations from a pre-determined path in order to establish system control. Post incident, there is often a tendency to restrict and reduce the performance variability (discretionary space) back to the rules. However, this limits the very attribute that makes the system manageable and efficient. Hence, enabling and enhancing performance variability while

making the boundaries of safe performance visible, is likely to increase the system's effectiveness because work can be performed up to and close to the edge.

Summary

In the traditional view, it is believed that safety can be achieved (or at least improved) if incidents can be reduced, or more ideally, prevented. By taking an individualistic approach to failures and concentrating on human errors, it is hoped that learning will take place from studying things that have gone wrong. This stands in stark contrast with resilience theories which assert that workers successfully manage complex work using the resources they have available; their knowledge, skill and abilities - all while balancing multiple goals. The resilience perspective recognizes workers are the most valuable contributors to safe systems - anticipating, adapting and responding to changes to execute the appropriate course of action given the set of circumstances or conditions. Fundamental to this perspective; performance is contingent on system influences and workers are inseparable from the features of their work and their entire work system. As well, resilience assumes the same behaviour exists regardless of the outcome. Hence, more effort is directed towards understanding why things go right rather than why they go wrong. And finally, resilience recognizes conditions are almost always underspecified and as such, a certain amount of adjustment is necessary, to fit the circumstances. In this way, safety needs performance variability.

This thesis is organized around four assumptions which have emerged from the previously discussed literature. The next section describes the research approach and method that were used to explore the hypothesis of whether performance variability is necessary or counterproductive to safety. The results and discussion section begin with a summary of the four the assumptions and themes from the empirical evidence. This section continues to

discuss in detail how the empirical data sustains or refutes the four assumptions. Lastly, the conclusions, reflections and limitations of this study are presented.

METHOD

Selecting the Research Approach

This study used a qualitative research approach to facilitate the collection of information to understand and appreciate behaviour in context – in a holistic way. Prior to preparing the data collection and analysis protocols for the research, the specific qualitative approach had to be determined. Based on the expected value and importance of the fallers' and supervisors' dialogue regarding their experiences and skills around manually felling trees, we considered the phenomenological approach[1] well suited for this research. Using this model enabled: (1) Themes and connections with the theoretical work to emerge from the raw empirical data providing the most relevant and clear message. (2) It provided a structure to guide our understanding of their common experiences in the context of this high-risk, dynamic forest setting and (3) it provided a basis to explore the research hypothesis: Is performance variability necessary or counterproductive for safely felling trees in the coastal region of B.C.?

Preparing the Research

Participants

The participants for this research included fallers and faller supervisors, specifically: 2 contract fallers, 4 faller supervisors, 12 company fallers and 4 non-active fallers. Each had a range of experience (15 to 45 years) from a variety of coastal logging operations. To help obtain access to the fallers and supervisors for this research, the BC Forestry Safety Council

[1] Phenomenological research describes the meaning for several individuals of their lived experiences of a concept or a phenomenon (Creswell, 2007).

sent out several e-mails explaining the nature of our research. Fallers and faller supervisors were invited to provide their perspectives regarding safety in their unique, challenging and dynamic profession of manual tree falling. Interested participants responded and were informed that each interview was expected to last approximately two hours and that their participation was completely voluntary. They were also told that we would make accommodations to be available both before and after working hours if required.

Collecting Data

The empirical evidence to answer the thesis question was gathered by conducting face-to-face semi-structured interviews with fallers, and forestry supervisors (bullbuckers). 5 out of 22 interviews were digitally (audio) recorded and accompanied by hand-written notes. The remaining interviews were only manually recorded. Both the voice recordings and the hand-written notes were transcribed for later analysis.

Interviews

Interviews were arranged to accommodate participants' schedules and location. 20 interviews were conducted on Vancouver Island, British Columbia between March 17 - 20th. The majority of interviews were conducted individually, but one interview was conducted with falling partners and two interviews were conducted with a faller and his supervisor. Due to availability and location, two additional interviews took place one week later in Richmond, B.C.

At the outset of each interview, each participant was given a consent form to read and sign (see Appendix3). It outlined the purpose and potential benefits of the study, how the interview will be conducted as well as the intention to digitally record the interview. It was

explained that the research will be for the benefit of the University of Lund and to advance safety in forestry and many other industrial domains.

Confidentiality

It was explained to participants that this study was not a WorkSafeBC initiative and measures would be taken so that the content of the interviews would not be disclosed to WorkSafeBC. Each participant was informed that any information provided during the study would remain confidential and all forms of personal identification would be removed from the research data. Participants were identified with letters 'A' through 'V'.

Questionnaire

The questionnaire in Appendix 2 was used. The questionnaire consisted of 14 open-ended questions to probe and draw out knowledge, perspectives and experiences. However, the dialogue often diverted to their experiences over the course of their career making it difficult to follow the questionnaire systematically. The questionnaire supplied the framework for the discussions and permitted an easy reference to ensure topics that were central to the interview were covered. This approach was useful for exploring the validity of concepts in context. The first two questions were included to delve into their world and to help us develop an understanding for their day-to-day working context. This set the stage to explore the application and effectiveness of procedures when faced with the challenging situations they had just described. This lead into the remaining questions that focused on how technical skills are applied in context, how the unforeseen is dealt with and what jeopardizes or creates safety.

From Raw Data to Themes and Meaning

The analysis of the collected data formed the framework to discuss resilience practices, safe work procedures and performance variability with the purpose to answer the hypothesis question: Is Performance Variabilty Necessary or Counterproductive for Safely Felling Trees in the Coastal Region of British Columbia?

The analysis of the data followed Creswell's (2007) qualitative procedures for analysis and interpretation. The general protocol of analysis consisted of the following steps:

Step 1: We read through all the transcribed data and began recording preliminary thoughts about the data.

Rationale: To obtain a general sense of the information. By reflecting on its overall meaning and tone, the goal was to gain an impression of the depth and usability of the information and ideas discussed.

Step 2: We constructed four assumptions from two contrasting viewpoints on how safety is created and maintained that were derived from the theoretical literature.

Rationale: Constructing these assumptions nicely framed four angles; resilience may be uncomfortable for traditional safety practitioners, procedures don't fit every situation, alone safe work procedures (SWPs) are insufficient to create safety and hence; performance variability is necessary.

Step 3: We categorized the data informally and began loosely coding the information.

Rationale: To permit themes to emerge from the different perspectives and thus permit inductive reasoning to take place.

Step 4: We combined the interview data according to each assumption that we derived from the literature.

Rationale: This permitted us to really get a sense of the fallers' collective perspectives regarding each assumption and was useful for organizing the data into themes.

Step 5: We refined the empirical data by grouping key statements into recurring themes. This formulated the structure for the discussion of each assumption.

Rationale: This was effective to explore the variety and depth of statements relating to themes that in essence, the fallers created from concepts and ideas that they echoed as important.

Step 6: We matched the empirical data with our assumptions.

Rationale: This matching exercise helped to show where the empirical data was strongly connected and consistent with theories and findings defined in the literature review.

Step 7: We identified key messages in the empirical data and structured the empirical data – highlighting where it reflected current literature - to sustain or refute some of the existing resilience theories and principles.

Rationale: We used ideas, stories, experiences and language from the empirical findings to explore whether performance variability or counterproductive to safety.

RESULTS AND DISCUSSION

This section provides a discussion of the empirical data in relation to the theoretical research. As previously mentioned, four assumptions were derived from the literature. From the interview dialogue, four themes surfaced for each assumption. The themes are collectively displayed in Table 1. This structure was used as a framework for exploring the answer to the research question: Is performance variability necessary or counterproductive for safely felling trees in the coastal region of B.C?

Assumptions (derived from the literature)	Themes (emerged from the empirical interview data)
Resilience may induce discomfort in traditional safety practitioners	• Stump evaluations are a priority • Stumps are used to evaluate performance because they are easily measurable • Performance evaluations are conducted out of context • Fallers believe that good (technical) stumps can't guarantee safety
Safe Work Procedures (SWP's) do not fit every situation	• Conditions are more complex than SWPs can cover • Multiple SWPs can be applied to the same condition • SWPs lag behind practice • Post incident there is a procedure for everything
SWPs alone cannot create safety	• SWPs must be followed to stay safe • SWPs can't be followed (all the time) • SWPs are guidelines • SWPs alone cannot create safety (more is needed)
Performance Variability (PV) is necessary	• Decision making and actions are context dependent • PV manages a high level of contextual variability • Degrees of freedom are necessary • Judgment and discretion are necessary

Table 1: Traditional and Resilience Views and Four Assumptions

Findings for Assumption 1:

Resilient Practices May Induce Discomfort

According to the traditional view of safety, it is believed that safety stems from following and adhering to predetermined rules. This view advocates constraining and reducing performance variability by adding more rules or strictly enforcing existing rules. As one faller explained the traditional approach is presently focused on the regulated accepted practice: "Now they breathe over you, make you nervous and the goal is to meet the standard". This practice of maintaining safety is in contrast to Slovic's (1992) research, as described earlier, which highlights the challenge of measuring safety by an objective means. He continues to discuss that safety is not an entity that is separate from human performance, independent of our minds and culture, ready to be measured.

Rochlin (1999) adds to Slovic's research by saying measurements of error are not difficult to obtain but rather, what is more challenging is identifying and assessing the indicators of the wider social and organizational context of safety. He describes the challenge of the traditional safety perspective by reiterating, "…evaluations of safety are not easily connected to objective measures of real world performance" (p. 1551). Yet, there is often comfort in assessing performance against pre-determined rules because there is a belief that it highlights the absence of safety. However, this strategy does not recognize that rules have "become increasingly restrictive, often reducing the range of permitted actions to far less than those necessary to get the job done under anything but optimal conditions" (Reason et al., 1997, p. 290). The fallers were consistent with Reason's theory in that forestry conditions are rarely optimal or standard. Yet, adaptive performance is sometimes misconstrued as being unsafe when objective measurements are taken but Dien (1998) states, detailed, inflexible rules

overlook "the characteristics – both strengths and weaknesses – of operators" (p. 181). Relying on rules to measure safety does not recognize the fallers' discretion and judgment which may have been necessary, given the context.

One reason why traditional safety practitioners may be uncomfortable with the resilience perspective is that there is presently no way of assessing what level, of performance variation (if any) is necessary, acceptable or safe. While rules are intended to protect, fallers often regard them as restrictive and impractical. Enforcing strict adherence to rules in this environment may actually compromise safety. Dekker (2006) explains, rather than narrowing the gap between procedures and practice, over-specification can widen it as "rules … grow more and more at odds with the context-dependent nature of practice" (p. 8). One faller provided an example of rules conflicting with context by saying that the pressure for technical accuracy actually hinders their ability to keep a peripheral sense of the environment around them – the very thing they explained is critical to staying safe. A faller explained in more detail how this conflict affected their safety:

> "Focusing on stumps too much can jeopardize safety. It's not about having perfect tree stumps - it's there so the tree won't come back on me and to control the tree – not for scoring. [Being] too busy on the stump doesn't allow time looking up – a perfect stump won't guarantee safety".

Many fallers commented on the detriments of focusing too much on the stump because it can 'distract' you from the plan for the day. However, they recognized that the present safety structure values this measurement and the consequences that result when poor stumps are observed: "Too many 'bad' stumps and now your job is in jeopardy". They reported what is needed out there is more emphasis on "working with the fallers rather than the paperwork

that can insult them". Although they believed that technical cuts on stumps can show expertise, this method of evaluating work without context can lead to assumptions. Evaluations that are contextually isolated and independent are consistent with the view that measuring or tabulating performance provides evidence of performance decrements. Yet, many fallers explained that there may well be justification for the way stumps are cut – it's all about context of the entire situation or set of conditions that exist in the forestry surroundings at the time.

Fallers expressed that they are concerned that they spend more time worrying about the stump when the hazards are up above in the canopy of the trees. This shows the pressure the fallers feel under the traditional safety approach - the pressure to conform to the rules sometimes to the detriment of their own safety. They communicated that they are trading their own safety for the sake of technical accuracy. One faller described it this way,

> "… Instead of me nowadays analyzing and watching everything around me, spending all that time, I spend less time doing that and more time on that stump trying to get that. And, I know … I know it's not good, but I do it. I do it because I'm going to get somebody in every week looking at my stumps. …I spend less time analyzing everything around me and just analyzing that stump. And that's the problem with investigations … when … there's been a fatality, or someone hurt badly, everyone beelines in on the one stump".

Many talked about the stress of stump evaluations in contrast to the importance of contextual assessments. Although challenging to assess, the fallers advocate practices that are more consistent with Rochlin's 1999 theories: "Look at the whole picture. Sure there are things that aren't perfect, but it's important to evaluate the context". They recommended safety practitioners "Don't focus on the stump – it puts pressure on the guys – rather, assess the

quarter and look at hazards such as snags[2] etc." This dialogue shows the divide in the differing comfort levels; between the fallers, who are inherently variable (flexibly and proactively applying rules), to safely accomplish the work - and those who govern safety.

Although practitioners may find comfort in being able to measure performance against a pre-determined set of rules, resilience perspectives believe that this is not a valid indicator of safe performance. Abandoning this strategy and adopting the new perspective may be uncomfortable to some because the alternative approach sees that procedures are an incomplete and imperfect specification for action. This may leave traditional safety practitioners in a quandary about how to determine what safety looks like and how it's assessed. Overall, the majority of fallers explained that performance in this environment has to be context dependant. They stressed that their strategies and practices are based on the context of their entire surroundings and that they require freedom and autonomy to continually plan their actions according to the environment. This dialogue is consistent with the resilience research which illustrates the importance of context and the value of workers who are able to adapt and respond to changing environments

Findings for Assumption 2:

Safe Work Procedures (SWP's) Don't Fit Every Situation

Safe work procedures are often incomplete and/or imperfect. Due to the complexity in a forest environment, procedures are often unable to cover all the possible situations. The participants described this environment as being fraught with dead, rotten, heavy-leaning and windblown trees that are situated on rock bluffs or in steep terrain[3]. Manually felling trees has only a small percentage of certainty, as to where a tree will fall and what conditions may

[2] 'Sang; is a dead tree - Usually highly unpredictable
[3] Faller dialogue to explain environmental conditions.

arise from that motion. Actions taken in this setting are not always predictable or foreseeable and once taken, often highlight unknown, interrelated and interdependent features of the environment. One faller discussed the application of procedures in practice: "Safe work procedures, they don't fit every situation and, you know, why they don't fit? It … it's basically because situations are more complex than [written procedures]". Because of the complexity, adjustments need to be made to compensate for the underspecified conditions.

A faller provided an example of how applying standardized procedures to certain situations is not always ideal:

> "You're not going to wedge it or jack it along the face. You made a hole for [the tree] to go up … up the hill slightly. I'm not talking straight up the hill, but up at an angle. You're supposed to be on the high side of the tree when you fall a tree. Well, I don't … if you think about it, and you're standing on the high side of the tree, you're below where it wants to fall. I fall it from the bottom side, so I'm not below it where the undercut's going to be. And, it's … it's against the rules, but it's my preference of being able to get out of the way and see where it's going, and when it's going to go. It's easier to watch it".

At best, procedures can only loosely prescribe the actions necessary for the actual situation. For example when felling a limb-tied tree or falling a heavy leaner[4] there are multiple variables to consider - variables that are often outside of or not specified by procedures. Dekker (2003a, p. 234) explains, "Documentation cannot present any close relationship to situated action because of the unlimited uncertainty and ambiguity involved in the activity". While forestry work is anything but predictable, written procedures assume they are, that the

[4]Technical terminology used to describe tree conditions

resources and tools for the job are readily available, conditions are manageable and production can reach targets, while following procedures. But a forestry setting does not always reflect what is expected and hence, controlling it with procedures is largely ineffective. Hollnagel (n.d.) explains that in dynamic and complex situations, rules, regulations and procedures are not always valid and perfect. An experienced faller explained the double bind they face by following the perspective that rules alone will keep you safe. He stated, "Even with doing everything right [following all the rules], you can still get killed". This relates to Dekker's (2003a) perspective: "Pre-specified guidance is often inadequate in the face of novelty and uncertainty" (p. 235). Therefore in order to safely accomplish the work, informal methods of work develop so individuals can adequately cope with local complexities.

The challenge lies in recognizing "certain activities lend themselves to being proceduralized, while others do not" (Dien, 1998, p. 298). In forestry, conditions are non-routine, poorly structured and unpredictable and do not easily lend themselves to proceduralized control. Even for those conditions where procedures are matched and helpful, in the diverse and ever-changing forest setting, multiple options exist when selecting and applying procedures. No one rule applies every time. Depending on the situation, the goal (fell, pivot, de-limb, push, etc.), the ground conditions, the tree, the weather, one's knowledge and comfort level, many different work procedures could apply to get the job done. One faller expressed it this way:

> "You might do something a bit differently – figuring out the best practice for that situation. You look at the situation and judge each [one] differently. You have to use your intuition and individual sense to apply the rules. For example, Dutchmen[5] can

[5] This leading cause of loss of directional control of a tree is created in the undercut when the cuts do not meet to form a proper 'V', i.e., the bottom cut meets the top cut too soon creating a flat spot which can continue across the full diameter of the stump.

be used for directional control. Used in context with rationale, it can be a tool in the belt. Identify [the tree] and mark it for rationale".

In relation to the applicability of procedures to best deal with hazards and safely get trees on the ground, the plethora of unknowns and exceptional circumstances are far greater than what is contained in a set of prescribed rules. As one faller remarked,

> "I still see stuff that I've never seen before - everything's different day-to-day. There's situations out there, like you could go out there now, and I'd probably see something happen I've never seen before. And, it's not in any book. Every tree is different, each area is different, and every quarter is different".

Given the immense variability, there is always a choice to make. Often:

> "More than one work procedure can be applied - you can push [a tree] – the sequence may change or be tweaked to match the conditions – you have to anticipate what may happen and, if you're in doubt, you try to have two, three, four, five different procedures that [will work]. For example, you know, you can get behind a big tree, or … maybe you can … the problem you got, you can hit it with another tree, or there, you know, there's a thousand different little methods of … if you're, you know, trying to make sure that, that you … you don't get surprised".

While all the fallers agreed on the merits of procedures and thought that they were necessary as a foundation for safe practice, their limitations were discussed. Much of their dialogue was consistent with research by Dien (1998), that asserts a procedure which considers only a single route to follow or a limited number of alternatives may not be suitable in this environment.

In this complex and dynamic work environment, there is seldom a good match between procedures and actual conditions. This is because procedures are often developed from recommendations in response to the latest incident. This means that procedures will always lag behind actual practice. While the majority of fallers agreed and explained the value of knowing and applying the fundamentals, they explained that procedures can never fully prescribe what is out there and how best to deal with it. A faller stated, "Safe job procedures I think are very good, they're very encompassing, but, they're a program that's been added to year after year". They collectively agreed that, in order to maintain safety, they have to adapt the rules to match the conditions. Fallers stated, "You can't go by the book on every single procedure; they're always one step behind". Furthermore, "There are exceptions to every rule", "sometimes the high side [of the tree] might not be safe or maybe 10 feet is not safe and maybe 2 feet behind a tree is and at times you go "by trial and error".

In the practice of felling trees, "rules emerge from practice and experience rather than preceding them, procedures in other words, end up following work instead of specifying action beforehand" (Dekker, 2003a, p. 234). Post incident, when it is concluded that fallers didn't follow a particular procedure, their work is often labeled as non-compliant. Yet, every day, fallers respond to unpredictable local conditions, multiple hazards and pressures and by doing so, develop a "license to think" (Reason, et al., 1998, p. 299). This know-how provides the basis for operation and yet, when practices are found which are not in accordance with the rules, they are judged unacceptable. And while from the retrospective outsider, these actions are labeled as violations, from inside the system (from the faller's standpoint), they are considered valuable and useful. They are the traits of an expert; a professional faller who can make intelligent adaptations.

One faller discussed the double bind they face when their work is evaluated according to procedures after an adverse event has occurred:

> "After the fact there is a rule for everything. And, yeah, after the fact, well, maybe we should've done this or put this in the manual. With everything changing out there, with so many variables, you try your best and do what the situation dictates. There are times when he made the decision thinking it's the right thing to do at the time but after the rules are applied in hindsight it appears all wrong. One time we had a log roll up hill, yes! And, we couldn't figure out how it did it. It pivoted somehow; it was the strangest Goddamn circumstance I've ever seen in my life. Like, I said, it was 35 of us up there all scratching our head".

Post incident, traditional safety practice begins to dissect the faller's workmanship and in many cases, performance is labeled as wrong or unsafe. In contrast to this approach, "updated perspectives in safety that see accidents as emergent from everyday interactions that make up normal organizational life, whether successful or not" (Dekker, 2003, p. 216). Most of the time, the skills to compromise, adapt and improvise in the face of multiple challenges on the front line are successful. This happens despite of conflicting goals, limited resources and company pressures but on occasion outcomes are not as expected. Regardless of outcome, the same skills and actions are present and the intention to be safe was there.

Findings for Assumption 3:

Safe Work Procedures (SWPs) Alone Cannot Create Safety

As described earlier, the traditional approach to safety subscribes to the belief that, if procedures are followed, safe outcomes will prevail. Procedures are designed to limit and curtail unsafe behaviour and if adverse outcomes still occur, procedures are changed or more strictly enforced. Confident of their necessity and value, procedures are used as the primary

tool to shape safe practice with manual tree fallers. Procedures are relied upon to ensure that fallers assess their situation and decide on an appropriate course of action. One supervisor explained, "If you do what's in there - do what you've been taught - systematically follow the procedures - you will stay safe" adding, "rules are there for a reason - to keep people safe" and, its "…when people don't follow them, that's when things happen". In agreement with the supervisor's opinion, a faller explained, "Following the rules is a fact of being safe and doing things properly". These perspectives agree with the model of procedures and safety put forth by Lautman and Gallimore (1987). Additionally, authors Furuta, Sasou, Kubota, Ujita, Shuto, and Yagi (2000), state, "Procedures represent the best thought-out, and thus the safest way to carry out a job, procedure-following is mostly simple IF-THEN rule-based mental activity … and safety results from people following procedures" (p. 233). In addition, the fallers' statements fit with the work of Dien (1998) and Hopkins (2005) that claim if the rules are complied with, human errors can be avoided, employee safety can be maintained and risk can be kept within acceptable bounds.

The majority of fallers interviewed described procedures as "resources for action" asserting consistently, "they are useful" and "a very solid resource". This agrees with research conducted by Dien, (1998), suggesting that procedures can help approach a situation and are useful to help bring it under control. Overall, fallers agreed that rules are good. However, the point was also made that, "discretion is based on those rules" saying, "Nothing is concrete" out there. There is a "sliding scale between rules and discretion depending on context". Collectively, there was a consistent message that the basics are essential: "There are rules that get applied in every situation - about a half a dozen…or so" but after that, the knowledge and experience that is gained from being in the forest and listening to stories is of the greatest value.

Despite the uncertain and tremendously dynamic and complex situations fallers regularly face, they stated, “Procedures will take you a long ways”. While rules were generally considered beneficial, in the forest environment where conditions are dynamic, resultant tree interactions are unforeseeable and situations routinely do not meet the specifications as stated in the procedure, following the rules all the time is impossible. Several participants said, “Safe work procedures can’t be followed for every situation and the regulation or rule is actually pushed over reality”. A supervisor explained, “There’s so much that isn’t covered by rules or where “the conditions are outside the rules”. “Not all the rules are always going to fit” and “where safe work procedures don't exactly fit in the condition, you have to improvise”. One faller explained the mismatch between rules and practice:

> “There are times I recall when they were going strictly by the book, and it was … it was ridiculous. And, it … it didn't work. You're supposed to get away 10 feet from the stump; but there are … there are occasions where it's just physically impossible”.

In a forest setting, changes occur continuously. Nothing is static – “this floating nature often causes mismatches between administrative frameworks and the ways in which the system is actually utilized” (Fujita, n.d., p. 19). Realistically, sometimes the rules are in conflict with each other. What may not be obvious is that rule following maybe problematic or even impossible (Reason et al., 1998). Thus, when dealing with situations that are not covered by procedures at all, or are only partially covered by procedures, operators make swift decisions and take immediate action in order to overcome the ambiguity. Fallers explained “sometimes the rules do get bent because that’s the safest way – safe practice is sometimes outside the rules”. But in the end, following an adverse outcome, performance is compared against the written procedures and often judged deficient. Fallers described it this way:

> "Like, you're not intentionally trying to break the rule, but you know if you do it just a little bit differently that it's a safer way of doing it. And, it's something you can't write down in a book that you can keep if the scenario ever happens again".

This dialogue is consistent with the work of (McDonald, 1999, p. 161), agreeing that "along with following procedures, judgment is needed in determining how tasks are done". In support of procedures as a helpful tool, Reason et al. (1998, p. 291) discuss that at some point, "nearly all hazardous operations involve (making) actions that lie outside the prescribed boundaries, yet remain within the limits of what would be judged as acceptable practice within the work group". Given the many different elements in the forest, the vast range of conditions, and complex interconnections that are often difficult to predict, recognize, and/or mange, work is often accomplished using procedures as a guideline. The detriment of "forcing operational people to [rigidly] stick to the rules can lead to ineffective, unproductive or even unsafe local actions" (Dekker, 2005, p. 141). Fallers explained: "You keep the principles in mind" while exercising skill and judgment to successfully manage work in a setting where no two situations are similar.

While most believe procedures are helpful for safety - even if applied flexibly as guidelines - realistically, rules are not always followed. Following adverse or unwanted outcomes this, lack of 'rule-following' is often quickly judged as causal. However, simply stating that a faller failed to follow a work procedure fuels the belief that the solution rests with following the rules. While the belief that getting workers to follow the rules will keep them (and the system) safe is persistent, the notion that procedures alone create safety is inaccurate and incomplete. The truth is that in the forest, fallers regularly have to take independent initiatives, i.e. temporarily diverting from a procedure in order to make up for its oversights;

and compensating for the static aspects of the procedure. As a result, procedures will not ever be enough in themselves, to create and sustain safety. Fallers explained, "There just aren't rules for everything", "there's so many variables" and "there are [many] exceptions". "It's important to look at every scenario with the rules in mind, but it is also important to apply experience in how you'd deal with the situation" stressing that:

> "Falling to the book can be scary -just relying on the rules is insufficient. When somebody made a booklet or something on falling, I mean, there was no way that it could cover everything. I fell for just about 30 years, and there were new things that came up all the time that I'd never seen before".

So while procedures are available, they are not the panacea. In order to deal with the plethora of unknowns in this environment, fallers require options and flexibility. Dien (1998) points outs that, procedures are but one option: individual skills and experience, collective know-how (team coordination, cooperation, and communication), planning, quarter management rules and everyday practices are also very useful. When asked what is needed to create safety, fallers, responded saying, "Creating safety out there really involves so many factors". They provided many examples including providing a forum and means for "open and frank communication" which creates opportunities "for talking about situations without reprisal and sharing stories". As well, an "apprenticeship and mentoring program where the younger guys are taught by the more senior people and, that, that person will visit and give them tips as they go along". But also, many fallers supported "having good trainers and supplying proper training in a gradual progression". In the field you need "work planning, good equipment, inspections and importantly, a buddy system and really looking after each other out there". The fallers communicated, that rather than performance being driven solely by procedures, it

is the camaraderie and the sharing of knowledge which builds expertise, professionalism and enhances safety.

Findings for Assumption 4:

Is Performance Variability Necessary?

The research on individual performance variability presents two contrasting arguments; the first asserts humans are a source of risk. In the second, humans are considered assets in the system. In the first perspective, which aligns with the traditional view of safety, performance should be controlled and constrained to reduce and limit performance variability. By contrast, the second perspective – as upheld by resilience theorists such as Dekker, Woods and Hollnagel - humans are valuable and positive contributors to safety. In this section, multiple opinions are discussed as to whether or not individual performance variability is actually necessary to safely fell trees in the B.C. coastal region or alternatively, whether performance variability could be counterproductive to safety.

From the interview dialogue, the majority of fallers expressed that judgment, discretion, imagination and anticipation were indeed necessary because of the massive variability of conditions that exist in a typical forestry setting. The rules are a foundation and the necessary degrees of freedom are related to complexity and other system level factors. Several mentioned that the skill of manually felling trees requires calculating physics on the fly, knowing the mechanics and how things are going to pivot, shift, interact and move. They need to be able to recognize where hidden tensions may exist and have the skills to understand the 'chain reaction' that can result when a tree, that was once stable, is destabilized. One faller described: [I need to] recognize that it's going to kill me, what's

going to go where, you know your angles and your tension and all that kind of stuff".

Another explained,

> "You have no idea how … how loaded those trees are. Have to know about how things, you know, react under certain forces, and …we kind of got to work on the fly up there".

This dialogue highlights the necessity and value of being able to anticipate the reaction of interactive forces. This skill is a multi-faceted expertise that takes place all while maintaining control in such a complex environment. This repertoire of adaptive and responsive skills that fallers have developed is in-part, created by the constant assessment of their environment and learning from those assessments. Participants explained that personal interpretation and performance variability are necessary to utilize their technical skills in context due to the unpredictable and ever-changing conditions:

> "I'm not sure that a lot of people actually, you know, take that rule on a piece of paper and apply it in the field. One's view of two safety routes away from a tree might not be the same as somebody else's. Well and … it's not that . . . it's not your choice to deliberately do it, it's what the circumstances demand".

These types of adaptive performances could be viewed as amplifying the risk - intentionally swaying the rules but the fallers believe that they build a skill set of adaptive strategies over time from constantly assessing and matching performance to specific environments.

One faller gave an example of situated cognition in these dynamic and complex conditions:

> "Like when you fall a tree, you...believe it or not, there's about… within about five seconds or less, there's fifty things gone through your head. You've already looked, you know that what's out there, you know what's out there on the ground. You've

> already, in the back of your mind, you've done it. But that's what I used to do, I used to say, now I'm going to do this to every tree and its [snap sound] like that. If that goes wrong, what am I going to do here? Where am I going? I know I'm going here but if this doesn't work, you know, this quick, well I'd better have a plan B".

Many of the fallers explained the level of cognitive demand that is necessary is these types of conditions. They stated that they have to make snap decisions. "Have to pick the lean and have to deal with it on the fly - hindsight gives you vision."

Hollnagel (n.d.) explains that this adaptive ability is how performance becomes normalized "not what is prescribed by rules and regulation but rather what takes place as a result of the adjustments required by a partially unpredictable environment" (p.13). Many fallers were consistent with this philosophy and collectively, stated, "In the end, judgment is necessary". "Rules help to see the situation and help someone decide" but "rules are [only] half of it, the other half is all your ability to see [interpret]. . ." And "after you've applied judgment, the [rules] are guidelines that you follow". "The [rules are] there to help you along but the knowledge you gain is more important". The complexity and unpredictability of the environment is why fallers feel that performance variability is necessary and that they have to develop the skills to handle and predict the unforeseen.

"As time goes by, you gain the experience of knowing more or less what's happening around you. And, you always [expect] the unexpected, you work at that not happening". Several fallers spoke of their caution and apprehension towards certain trees in order to reduce the surprise factor. They relied more on their assessment strategies and continued to assess it critically on more than one occasion:

> "You know, but even sometimes there were challenges where I wouldn't touch it for a week. I'd leave it alone and study it, and analyze it, and go over it in my head and how I was going to do it, and then go after it".

This reflection demonstrates that the formation of the setting is sometimes unique and ambiguous so therefore, judgment is necessary to assess. It shows how immersed they are into their work environment and how the context of the environment shapes the decisions and actions of the fallers. It shows that decisions are not in isolation but are naturalistic given the very dynamic and complex situations they face (Rasmussen, 1997). Therefore an approach that examines the whole system is necessary to understand the influence of those factors on the cognition of workers (Orasanu et al., n.d.) is required. Performance has to be re-situated back into the context in which it found itself to truly develop an understanding of why certain actions appeared achievable.

To demonstrate the importance of the resilient attributes, the participants talked about the struggles of new fallers coming into the profession who have not yet developed any performance variability skill; "Well, you have that new guy … especially if he has zero experience … he has to be shown how to apply those rules, and how to do them safely. And he has to be shown a number of different skills in order to get [into the domain where judgment is necessary]". Fallers reported that the ability to anticipate and respond [beyond applying technical skill was challenging for some newcomers. One explained:

> "And, nine times out of ten, they couldn't read the situation. Like, if they put an undercut and a backcut in, they knew that if they put undercut in here, and a backcut here, the tree was supposed to go there, but they didn't realize that there's some extra weight on the top, and it's pulling the tree back, and they don't put a wedge in. So, now they got another problem, you know. They're just … they can't think ahead, or

> they can't plan far enough ahead. So, you just have to say, 'Look, you can't do it'. If you can't multitask, you're not going to survive."

Dekker (2003a) explains that the transition from procedures to highly dynamic contexts can be challenging due to the level of uncertainty and ambiguity in certain activities. As a result, formal, written procedures are not able to capture this relationship effectively and meaningfully.

The fallers were unanimous in their opinion that the interpretation of procedures is a difficulty that newcomers have to overcome to be successful in this profession. The experienced fallers support Dekker's (2003a) perspective that: "Very often working a dynamic environment happens, not in violation of procedures but without procedures all together" (p. 234). Their reflections on the performance of newcomers strengthens their perspective that technical skills will only take you so far and that performance variability is one of the key assets that actually creates and maintains safety. When asked what does it take to apply the technical skills to such a dynamic context, the fallers were consistent in their description that having rules or "know[ing] the rules doesn't mean you know how to apply them" (Dekker, 2006, p. 7). One faller explained, "The basics are like feeder rules. And, then as your experience goes on, you're still working by the rules, but you've seen the situation before, so you're going to handle it a bit differently". It's the experience, knowledge and level of awareness that makes a difference. In context, "you're still using the rules but you've expanded them, or…they've sprouted out a little bit". "You might be tweaking the rule, but you're doing it through your experience – the safest way you think you can do that". Fallers expressed, "Rules do get bent a smidge with experience but they're bent in a way that they're still going to be safe in their interpretation of the rules".

Consistently, fallers claim that safe work procedures provide benefit but ultimately, discretion and judgment is essential.

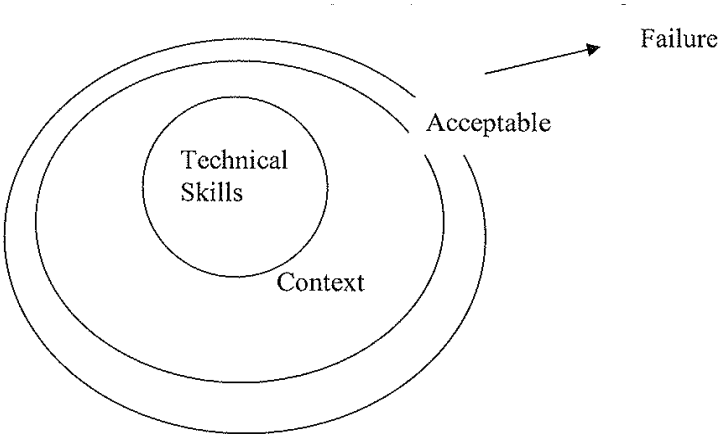

Figure 2

When presented with this illustration (Figure 2) during interviews, fallers articulated what repertoire of skills was necessary to take technical skills and apply them to context. They explained that the possession or formal application of technical skills doesn't mean that you're competent. For example, one faller states, "I have the info-flip (training standard), and I could give it to my 13 year old kid and say 'study this', and he'll pass the test 100 percent. You need a background to apply them in context". With a dynamic setting like the forest, several fallers agreed, "Applying the rule will improve your odds – I will say they do help – but they'll never guarantee". One supervisor stated that you really have to assess where you're working: "Access the face and understand what you're working up against". "Keep the big picture in mind". He stated that judgment is always needed and experience is what fills in the discretionary space between technical skills and acceptable performance. For example:

> "You have to use discretion to fall as you come up the face unless there's a definite hazard. Each situation is different – if there are hazards uphill go on the on low-side.

> Might not be able to fall the face, maybe have to fall in a circle. If there is rationale or justification behind the judgment, then use your own judgment".

This dialogue demonstrates that in actual performance fallers have to adapt strategies to make the operation successful. It shows evidence of contextual or situational variability - such as Hollnagel (2009) explained earlier, when situations are under-specified, performance has to be adjusted in order to achieve the best possible outcome. In part, this is how they are able to cope with applying static procedures to dynamic conditions.

Is Performance Variability Counterproductive to Safety?

While it is true that most of the time workers successfully apply their knowledge, skills and experience to be flexible and safely accomplish the work, it is also true that the same qualities can sometimes account for making the situation vulnerable. If a faller's assessment doesn't match their expectations and an adverse outcome occurs, it could be viewed as a result of erroneous decisions on behalf of the faller. However, when actions produce unexpected outcomes this is more likely due to the variability of context and conditions rather than the failure of human actions or decisions. Hence, whether or not an action is deemed erroneous or not depends on outcome - judged in hindsight. But early researcher Ernst Mach (1905) clarifies that: "knowledge and error flow from the same mental sources, only success can tell one from the other". Erik Hollnagel updated this in 2009 and restated: "performance variability is the reason why things most of the time go right, as well as the reason why things sometimes go wrong" (p. 97). The fallers were consistent with this philosophy and believed the outcome only occasionally differed from their expectations. Fallers explained that they assess cues from features of their environment and calculate the expected interaction of forces in motion. However, due to the sheer complexity and the unforeseen nature of the

environment, conditions are often likely to violate their expectations. If this occurs, consequences are often severe.

Fallers expressed that decision making is complex because of the variability in conditions which cannot be simplified. They believed that judgment and discretion are necessary but at the same time could be counterproductive to safety. Most paticipants absolutely agreed that, decision making was fallible because it was based on how conditions were interpreted and assessed and so, judgment and discretion could be counterproductive. One faller gave an example of his assessment and the consequences:

> "So, I'm thinking, well, do I cut that up first, or do I cut up the snag? Now, if I cut that up, the … the little tree, and it doesn't come … fall away from the snag, well now I got to go down below it. And, I got to cut a tree up above me. So, I thought, well, it was pretty small, so I just undercut it, and if I have to, I can scramble up there and throw a quick backcut in it, and let it all go slowly, like right above this. And, it went 'that' way. I did it my way, which I thought was right, and it was wrong, so … But, you make hundreds of decisions all day long. They're not all right".

Although rare, assessments are occasionally incomplete or incorrect and, therefore can make the system vulnerable to adverse outcomes.

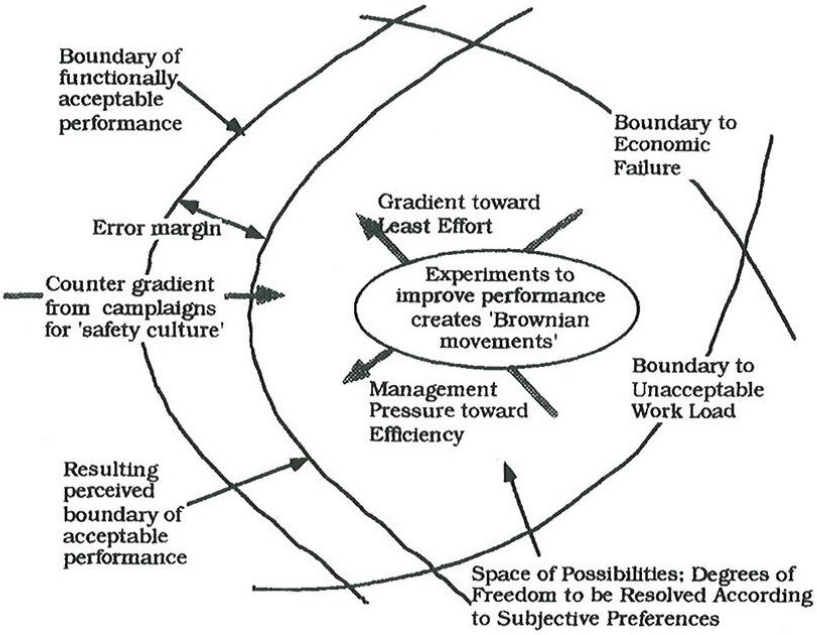

Figure 3

According to the illustration above (Figure 3), there is a space in which performance variability is acceptable and necessary however research has shown that if the boundary is crossed, it is likely that an incident will occur. As discussed earlier, Rasmussen (1997) explains that the discretionary space needs to be there to allow exploration to be guided by process criteria such as workload, and cost effectiveness. The difficultly is, knowing where the boundary of safe performance is and the degrees of freedom that are available before failure occurs. There is also a need to recognize which counter gradients prevent safe performance from drifting across this space. Rasmussen (1997) explains that "normal changes in local work conditions lead to frequent modifications of strategies and activity will show great variability" (p. 189). Therefore, there is also a need to recognize which system level entities act as counter gradients and will ensure that performance does not drift across this space.

Yet crossing the boundaries is never intentional. A faller remarked that, although discretion could be counterproductive there is never intent for adverse outcomes, "Yeah, I mean, if you

know the consequences of what's going to happen, you sure as hell ain't going to do something, I would say. . ." This is an example of the local rationality principle which states that action is only taken when it is believed to be safe (Dekker, 2006). Therefore, if it is believed to be safe, the boundaries of acceptable performance need to be more clearly visible. Rather than attempting to push performance back to pre-determined procedures, the emphasis should be on making performance more compatible with the variations in this environment. This includes providing the faller with more coping skills and resources for particularity challenging situations.

In relation to resources, there was discussion regarding the benefit of rules as a foundation and the requirement to recognize when a 'stop rule' is necessary (when further action would be considered too detrimental to safety). But when asked at the end of the interview what is more beneficial: To invest in programs that focus on reducing /limiting performance variability (adaptability) or enhancing it? The majority of fallers felt the value was in enhancing performance variability. The fallers replied that rules are necessary and required but the ability to vary performance turns the application of falling into an art. It is not a profession that easily lends itself to rigid rule following but once learnt it is seen as a measure of true professionalism to be able to balance the complexity of the environment and the demands of the other work pressures.

CONCLUSIONS

This research paper explored the concepts of resilience engineering against empirical evidence to evaluate whether performance variability is necessary or counterproductive to safely felling trees in the coastal regional of B.C. The empirical evidence provided data about how actual work is practiced and those practices were consistent with theoretical concepts on resilience. The four assumptions derived from the theoretical literature were explored during the empirical data collection: 1. Accepting and adopting resilience strategies are unexplored (and uncomfortable) to many safety practitioners. 2. Safe Work procedures (SWP's) don't fit every situation. 3. SWP's alone cannot crate safety and 4. Performance variability is necessary for creating safety.

The findings from the data showed that the current method of assessing performance is consistent with the traditional safety perspective. There is a focus on quantifying performance through measuring the accuracy of technical skills. Although many may find comfort in objectively measuring performance to ensure safe practices are being followed, the empirical data contrasted this methodology by stating that often, focusing too closely on technical skill in the field actually reduces safety. Concentrating on making perfect cuts limits the faller's opportunity to continually and critically assess the peripheral environment which is so vital to staying safe. The level of performance that is necessary to deliver high levels of technical accuracy limits the variability that is required in such a highly dynamic and complex environment. Given the characteristics of this environment, focusing on quantifying performance by focusing on stumps misses the importance of the contextual features of the surroundings. Fallers remarked that, although an asset, absolute technical accuracy will never guarantee safety in these types of conditions.

The complexity and dynamics of this type of environment were the primary reason why SWP's don't fit every situation and in themselves, cannot create safety. Fallers explained that even after thirty years of falling there are situations that they've never come across before so procedures cannot possibility account for, or be detailed enough to cover every situation. Although traditional safety practice relies heavily on SWP's for controlling performance the fallers stated that how the rules are applied, when they should be applied and whether they should be applied, depends very much on the circumstances at the time. This is why, they explained, performance variability is necessary to maintaining safety. They need the degrees of freedom and latitude to adapt and respond as conditions dictate rather than be restricted to rule following. Fallers explained that due to a multi-variable environment, judgment and discretion are necessary. Technical skills and procedures are the foundation of practice but having the ability to vary performance to match conditions is the key to staying safe.

Examining performance in this environment demonstrates how decision making, action, goals and available resources are intrinsically interwoven with the features of the environment. Decisions stem from the constant assessment of the environment and action is formulated based on the assessment. Although action taken will always make sense at the time, the human limitation of being able to accurately assess and consider all possible dynamics in such levels of complexity, could leave the system open to vulnerability. When a faller's assessment doesn't match the conditions, their expectations are violated when the unexpected happens and this can be seen as counterproductive to safety. Therefore, while it was agreed that performance variability is necessary and is the reason why things go right most of the time, the same variability is the reason why things sometimes go wrong. The fallers

confirmed the theory that the same performance exists behind success or failure and it is only the outcome that determines the difference.

Over all, the empirical evidence supported the resilience philosophy; fallers are adaptable and contribute positively to safe and productive systems. They bring a collection of skills and strengths as well as limitations to manage complex and dynamic work. In the context of competing goals, and economic constraints, fallers constantly manage the system level trade-offs and priorities to keep the system within safe operating boundaries. Organizations who embrace the resilience theories can develop ways to support people's skill at judging when and how to adapt. They can enhance the attributes of performance variability that are so essential in maintaining and managing limits of control and keeping system performance within safe and acceptable limits. Although resilience strategies require constant monitoring of system performance, appreciating and adopting this philosophy offers the potential to enhance the system of work and increase safety, efficiency, productivity and quality.

REFLECTIONS OF THE STUDY

Until now, resilience theories have been unexplored in the forestry industry in BC. However, the rich empirical findings can now offer support and validity to apply these current theories. It also has the opportunity to positively contribute to the repertoire of existing research on resilience that has been conducted in other high risk industries.

Even though the industry has struggled with the injury and fatality rate for decades, the resilience perspective may still not be the 'silver bullet' to prevent all adverse outcomes. However, it goes a lot further and contributes a lot more because it has the ability to understand how work is actually performed and how safety is created. Not by being limited

to understanding why things can sometimes go wrong but more importantly, why they usually go right. Focusing on failure misses the value of how people are usually creating safety. If the rate of 'failure' is rare, how are people successful for the majority of time? Based on the exposure to the risk in the fallers' occupation, it is a fine line between what constitutes success and what constitutes failure. In such complex and under-specified conditions, it is necessary to know why things can go wrong but also why they go right so those actions can be replicated. Although traditional safety has value, the qualities and characteristics of the resilience perspective are far more suited for work in forestry settings. In such dynamic circumstances, individuals and organizations have to be flexible, adaptable and able to respond to variable conditions. The industry or the profession of the faller is by no means a controlled and predictable environment and so therefore, new interventions that manage and adjust as the system faces new forms of variations and challenges are essential.

LIMITATIONS OF THIS WORK

While this research can certainly add to the growing field of resilience perspectives, there were several limitations to the study. Assumptions were made that the forestry industry practices the traditional approach to safety beyond the regulatory requirement. This practice certainly exists because of the legal obligations for Occupational Health and Safety. Particular components are required so organizations can show that they are ensuring safety for their workers. And although there is evidence of this formal documentation and practice occurring in the forestry industry, this research did not enquire as to what measure these practices were considered valuable to the industry. Therefore, we cannot be fully assured to what degree the industry subscribes to the traditional perspective. The industry produces evidence of following the regulatory requirements but to what extent it is practiced and valued remains unknown.

Also, this research did not delve into whether the industry or organizations were already practicing resilient strategies. If they are, they would be able to support the individual resilience strategies that the fallers are practicing but if they're not, there will be a divide. Without fully knowing what perspective that the industry is subscribing to, it is difficult to draw conclusions as to the compatibility or incompatibility between the two approaches. Further research would be required to explore if organizational resilience is being practiced and to what level. Establishing this would then open research to look at whether a gap exists and whether that gap could be detrimental to safety.

On a micro level, several limitations were also identified in the research design. To begin, participants were solicited to participate in interviews. With a keen interest to infuse a fresh perspective to advance safety in this industry they willingly volunteered. Since we did not select the participants, this was not a randomized sample and may have biased the empirical data.

One of the distinguishing features of a qualitative study is to collect data in the field where participants work and encounter their day-to-day challenges. However, for this qualitative study, observations were not made within their workplace context - the forest. Without the face-to-face interaction with fallers at their worksites, the first-hand experience with the participants was missed. As a result, we were unable to record real-time information and this afforded less opportunity to see and explore aspects of the fallers' work, working environment, etc. that may have been difficult for participants to articulate.

Finally, this study only relied on a single source of data – interviews. Not employing other forms data collection such as making observations and reviewing documents may have limited the complete and wide-ranging contextual meaning that otherwise may have been available through other data sources. As well, participants were informed that the research was for the benefit of the University of Lund, and for the purpose of advancing safety in forestry and many other industrial domains. They were also informed it was not an initiative of the employer for which the researchers work (WorkSafeBC). Even though the interviews will not be disclosed to WorkSafeBC, our presence as employees may have biased some responses.

ACKNOWLEDGEMENTS

We would like to thank everyone who helped us in making this thesis possible by either directly or indirectly contributing to its creation. From providing support on many levels - both personally and professionally - to locating fallers, arranging meetings and facilitating the data collection in order to access this fascinating world of manual tree falling. It is only with all of this support and cooperation from WorkSafeBC, our corporate librarians, the BC Forest Safety Council, the United Steel Workers Union, fallers, supervisors, colleagues, family and friends that this work was made possible. To all who so graciously contributed so much along this journey – we thank you.

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APPENDIX 1 – CALL FOR PARTICIPANTS

Good morning,

The BC Forest Safety Council is helping to promote research on Human Factors and falling.

Jenny Colman and Heather Kahle are human factor specialists at WorkSafeBC and are in their final stages of completing their master's degree in Human Factors and System Safety from the University of Lund, Sweden. To complete this program they would like to talk to approximately 20 fallers and 20 falling supervisors about their experiences with safety in this unique forestry environment. Ideally they are looking for a cross section of workers – new, experienced, old, young, etc.

For logistical purposes, they are hoping to get some clusters of fallers assembled to interview individually in continuous blocks of time over a period of 3 days. They would like to hold these interviews between March 17-20th at the location and time of your choice on Vancouver Island. The Council has a meeting room in Nanaimo that can be used if requested. The researchers will work around your schedule and are available before and after working hours if required. The interviews are each expected to last 1.5 - 2 hours (7-10 questions) and the information provided will remain confidential and all forms of personal identification will be removed from the research data. The research will be for the benefit of the University of Lund and to advance safety in forestry and many other industrial domains. It is not a WorkSafeBC initiative and interviews will not be disclosed to the Board.

We hope that you will be able to assist Jenny and Heather in this opportunity to voice your experience and opinions on safety within this industry. For inquiries and to confirm interview times, please respond directly to jenny.colman@worksafebc.com or to heather.kahle@worksafebc.com. Jenny and Heather can also be reached by phone at 604-233-4053 or 604-233-5343.

Regards,

APPENDIX 2 – INTERVIEW QUESTIONS

1. What are some of the conditions you deal with? Example: The worst? The best?

2. Describe a memorable situation.

3. Is this a situation where more than one work procedure may have been able to be applied?

4. How much leeway/freedom do you have in applying the SWP's?

Freedom ——————————————————— No Freedom

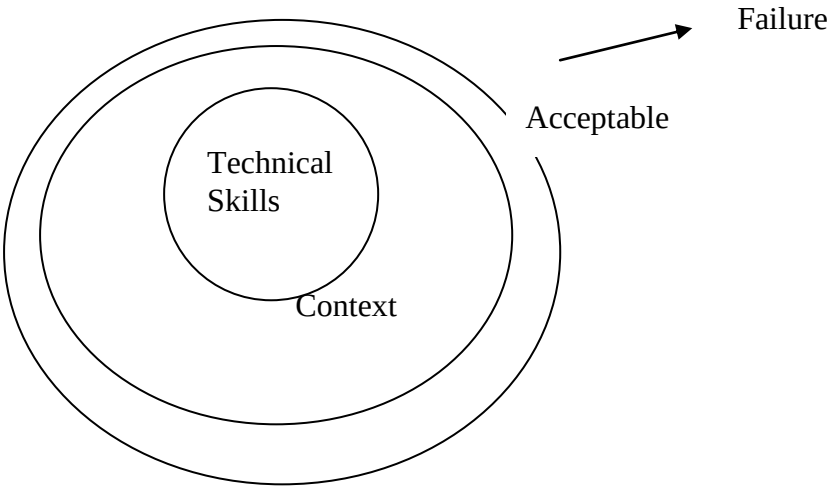
△

5. What influences your decision/judgment?

6. Do SWP's fit every situation?

7. What/why/when don't they fit?

8. Circle chart – what takes it to context? Technical to context – acceptable performance to boundaries of safety.



9. How do you deal with the unforeseen?

10. A. Is judgment/discretion necessary to safely perform work?

10.B. Do you think that using discretion is counterproductive to safety?

11. To what extent do you think written (paper) rules keep you safe vs. your personal contributions (discretion, judgement, knowledge, skill, etc?)

12. Creates or jeopardizes safety?

13. If you had x dollars where would you invest it?

14. Is it more beneficial to invest in programs that focus on reducing /limiting performance variability (adaptability) or enhancing it.

APPENDIX 3

INFORMED CONSENT FORM

Study name: Resilience theories in forestry

Date: March 16-20/2010

Researchers: Jennifer Colman and Heather Kahle. (M.Sc. students of Human Factors and System Safety)

Sponsors: Lund University, Sweden

Purpose of research:
The purpose of this research is to apply up-to-date theories on safety and compare against present working practices.

What you will be asked to do in the research:
You will be asked to answer up to fifteen questions regarding your experience of how work is accomplished and how safety is created and maintained.

Risks and discomforts:
We do not foresee any risks or discomfort to you from your participation in this study.

Benefits of the research and the benefits to you:
The benefit of this research is that it will show empirically how work is performed in reference to the up-to-date theories of safety. This will advance safety for the forestry industry.

Voluntary participation and Withdrawal from the study:
Your participation is completely voluntary and you may choose to stop participating at any time.

Confidentiality:
All information that you give during the course of the interview is confidential. Your name or identity will not appear on any publications. Information from this interview will only be reviewed by the researchers and advisors from Lund University.

Questions about the research:
Please contact either Jenny Colman at 604 233 4053 / jenny.colman@worksafebc.com or Heather Kahle at 604 233 5343 / heather.kahle@worksafebc.com

I_____ consent to participate in the Human Factors and System Safety research study conducted by Jennifer Colman and Heather Kahle. I have understood the nature of this project and wish to participate. My signature below indicates my consent

Signature_____
Date_____

Participant
Signature_____/
Date_____

Principal Investigator/s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