

# “Think Twice, Cut Once”: Interview Study Examining Non-Technical Skills in Forestry Operations

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## SUMMARY

Non-technical skills are the cognitive and social skills that enable safe and effective performance in safety-critical environments, yet little is known about how these skills are used within one of UK’s most hazardous industries, forestry. Using semi-structured interviews with UK-based machine operators, this study examined both the use of non-technical skills and the performance-influencing factors that shape them. The findings suggest that operators of forestry machinery (harvester, forwarder, skyline winch) depend upon skills such as situation awareness, decision making, and communication to work safely in this high-risk context.

## KEYWORDS

Non-technical skills, forestry, safety

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## Background

Modern UK forestry operations are increasingly mechanised, relying on complex machinery such as harvesters, forwarders, and skyline winches in challenging dynamic environments. Operators must perform cognitively and physically demanding tasks at pace while managing hazardous conditions and organisational pressures. In this high-risk context, performance and safety depend not only on technical competence but also on non-technical skills (NTS), i.e., the cognitive, social, and personal resource-management skills that underpin work in safety-critical domains (Flin et al., 2008). Despite their recognised importance in other high-risk sectors (e.g., aviation, healthcare), research on NTS, and human factors more broadly, remains limited within forestry. Emerging evidence, however, points to their relevance. In New Zealand, approximately 70% of reported incidents were attributed to human factors, most commonly cognitive failures, with fatigue impacting performance in nearly 80% of cases (Hinze et al., 2021). Findings from the U.S. additionally highlight work pressure as a contributor to error and emphasise the need for building and maintaining accurate situation awareness (Newman et al., 2018). To date, only one study has examined the full range of NTS within forestry, finding them highly relevant but focusing solely on chainsaw operators, supervisors, and managers (Irwin et al., 2023).

Performance influencing factors (PIFs), including for example fatigue, pressure, and environmental conditions, also shape how NTS are used, yet little research has explored how these factors interact with and influence NTS within forestry, or how operators themselves experience and manage them. This study addresses these gaps by examining the use of NTS, alongside PIFs, among forestry machine operators, thus expanding the research to additional machinery beyond chainsaws.

## Method

Semi-structured interviews incorporating the Critical Incident Technique (Flanagan, 1954) were carried out to explore how forestry operators use NTS during routine and high-pressure tasks. Fifteen professional machine operators (harvester, forwarder, skyline winch) were recruited from forestry organisations across the UK, reflecting a range of operational environments.

Interviews were conducted remotely, lasted 35–72 minutes (M=50), and were audio-recorded, transcribed, and analysed in NVivo using directed content analysis (Hsieh & Shannon, 2005) guided by the chainsaw operator NTS framework (Irwin et al., 2023). Coding focused on identifying behaviours associated with established NTS domains (situation awareness, decision making, task management, cognitive readiness, teamwork and communication, and leadership), supplemented with inductive coding to capture forestry-specific elements. Additionally, PIFs were identified and categorised. Coding decisions were reviewed within the research team to ensure consistency.

## Results

Six NTS (situation awareness, task management, decision making, cognitive readiness, teamwork and communication, and leadership) were identified as relevant for forestry machine operators within the present study. Each skill is comprised of individual elements, which are further illustrated by context-specific behavioural examples (see Figure 1).

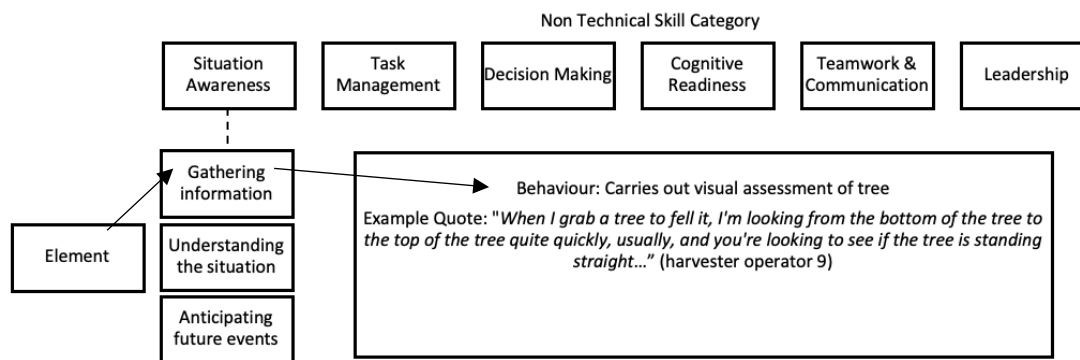


Figure 1: NTS categories, example of skill elements and behaviour with illustrative quote.

**Cognitive skills:** Operators discussed situation awareness, including assessing and continuously monitoring tree stability, terrain and changes in the weather. They emphasised the importance of anticipating how trees could move during felling or extraction. A tree’s behaviour, they acknowledged, could vary greatly depending on, for example, tree type, -physiology, -condition and -size. Task management included detailed planning pre-task commencement (including machine routes and access for the team and subsequent timber hauliers), checking and maintaining equipment, and adapting operations to environmental constraints. Cognitive readiness focused on how operators manage unexpected challenges using problem solving and adaptability. Decision making emphasised selecting and, when appropriate, altering task approach, including making safety critical stop-work decisions triggered by changing conditions or unexpected events.

Table 1: Selected illustrative quotes with codes and proposed Cognitive NTS categories and elements.

Quote	Behavioural Code	NTS category (element)

<i>'And it depends on what size trees you're felling. If you're felling small trees, it doesn't really come into it. If you're felling really big trees, you really need to be aware of the wind direction'. (P13 – harvester/forwarder)</i>	Recognises need for different felling approach depending on tree size	Situation Awareness (Understanding the Situation)
<i>'you have a lot of timber stacked at roadside, you've got four haulers booked, but they don't turn up. So I mean, there's nowhere to put any more timber. So you've got to ... change the plan during the day.'</i> (P04 – harvester/forwarder)	Alters activities or location in response to changing conditions	Decision Making (Identifying and Selecting Options)
<i>'It was about 80% cut so there was very little to play with. So when you've got a tree in that situation, you put the wedges in to secure it, which also pushed it in a favourable direction for me.'</i> (P10 – harvester/forwarder)	Uses available equipment to address an issue	Cognitive Readiness (Applying Problem Solving)
<i>'And sometimes you might have like a water supply intake that will be in that ravine so you can't contaminate it even at all. So, then you have to try and plan the site so you're not crossing that. '</i> (P01 – Skyline)	Identifies and marks areas of worksite that can/cannot be worked	Task Management (Planning & Preparation)

**Social skills:** Teamwork and communication were viewed as essential for exchanging information, including sharing plans and worker movements. Particularly in a dynamic context such as a forestry felling site, it was believed to be of utmost importance to communicate any emerging hazards or adaptations to operations (location, task approach, order of task execution, etc), to facilitate and maintain shared awareness and understanding of the plan. Leadership behaviours were less common but still evident in coordinating and overseeing tasks, checking colleagues' competence for high-risk activities, and offering guidance when required.

Table 2: Selected illustrative quotes with codes and proposed Social NTS categories and elements.

Quote	Behavioural Code	NTS category (element)
<i>'there is times on site where the forwarder has to pass close to where I'm working as he's leaving site with a load of timber and therefore he can communicate with me: 'I'm going to be entering your risk zone in the next 5 minutes, will you stop and let me by?' ' (P09 – harvester)</i>	Maintains communication during tasks to share task progress or worker movement	Teamwork & Communication (Exchanging Information)
<i>'I assessed him as to whether he'd be suitable or not, decided he would be. I helped him get a provisional licence which would give him six months to learn to drive the machine. And I mentored him and got him his 90 hours minimum time in the seat' (P04 – harvester/forwarder)</i>	Arranges appropriate mentoring experience with a range of workers	Leadership (Providing Guidance and Oversight)

**PIFs:** Operators described a range of PIFs shaping NTS use, including environmental factors (unstable terrain, poor visibility, unpredictable weather), organisational pressures (production targets, limited staffing, maintenance delays), and human elements (fatigue, complacency, stress).

Table 3: Selected illustrative quotes with PIF codes.

Quote	PIF Code
<i>'So, we, [NAME 2] had a problem where we had a near miss because there's a lot of, what we call understory, there's a lot of broadleaf understory in the bit we were working. You couldn't actually see the track in front of him.'</i> (P11 – harvester)	Limited visibility – restricted line of sight
<i>'People get tired and they just think 'oh, I'll just quickly do that'. Well, it never really works. That's when things go wrong. So, fatigue is a, a big influence on good or bad decision making, I would say.'</i> (P03 – harvester/skyline)	Fatigue – cognitive impact

## Discussion

The current study represents one step in a series of research studies aimed at developing a tailored NTS taxonomy for the UK forestry context. Participants' responses support the idea that NTS provide the cognitive and social foundation necessary for technical proficiency. These insights suggest that NTS are perceived by operators as essential for navigating high-risk conditions where technical skill alone may be insufficient to manage emerging hazards.

Findings illustrate how the unique environmental and structural challenges of UK forestry necessitate a highly specialised application of NTS. Participants' responses suggest that, unlike industries that operate in more controlled settings, forestry is defined by variability such as unstable terrain and unpredictable tree physiology. The data suggests that these factors demand a high level of continuous situation awareness and adaptive decision making, highlighting that operators must manage physical risks as they emerge, relying on active judgment to navigate the inherent unpredictability of the site.

Unlike the conventional approach to NTS where frameworks are highly individualised towards one specialised job role (e.g., within healthcare; surgeons (NOTSS, Yule et al., 2008), scrub nurses (SPLINTS, Mitchell et al., 2012), anaesthetists (ANTS, Fletcher et al., 2004), medical students (Medi-StuNTS, Hamilton et al., 2018)), the present research explores the possibility of developing a forestry framework which encompasses multiple job roles / machines by grouping the framework not by a specific job title, but more broadly by the operation of timber felling and extraction. This approach was believed to better reflect the context of forestry as participants explained that they are proficient with a variety of forestry machinery and, particularly for smaller teams, it is not unusual to move between working on different machines throughout the week or even across a shift. Consequently, these individuals identify as 'forestry operators', rather than operators of one machine type and they described using similar behaviours irrespective of equipment use. For instance, communication and coordination goals remain consistent regardless of the machine in use, suggesting that skill use being specific to the operations but not defined or restricted to the machine type. Moreover, cognitive behaviours also transcend specific roles, including for example evaluation of terrain gradient to plan safe pathing, and making decisions on whether to adapt work approach or location depending on weather. While machine-specific behaviours (e.g., organising- and ensuring stable timber stacking for forwarders) will be included in the framework to faithfully capture the context, the framework will prioritise behaviours applicable across the wider operation.

These findings extend our understanding of NTS use within the forestry context, offers new insight into how machine operators use NTS in practice, and provide a foundation for creating a forestry-

specific behavioural framework to inform training and assessment. Beyond practical implications, this work contributes to the human factors field by extending NTS research into mechanised forestry, a thus far underexamined area characterised by complex human-machine interaction and highly dynamic and difficult operational conditions.

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