



## Relating safety, productivity and company type for motor-manual logging operations in the Italian Alps

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### ABSTRACT

The study compared the performance of four different logging crews with respect to productivity, organization and safety. To this purpose, the authors developed a data collection method capable of providing a quantitative analysis of risk-taking behavior. Four crews were tested under the same working conditions, representative of close-to-nature alpine forestry. Motor-manual working methods were applied, since these methods are still prevalent in the specific study area, despite the growing popularity of mechanical processors. Crews from public companies showed a significantly lower frequency of risk-taking behavior. The best safety performance was offered by the only (public) crew that had been administered formal safety training. The study seems to deny the common prejudice that safety practice is inversely proportional to productivity. Instead, productivity is increased by introducing more efficient working methods and equipment. The quantitative analysis of risk-taking behavior developed in this study can be applied to a number of industrial fields besides forestry. Characterizing risk-taking behavior for a given case may eventually lead to the development of custom-made training programmes, which may address problem areas while avoiding that the message is weakened by the inclusion of redundant information. In the specific case of logging crews in the central Alps, the study suggests that current training courses may be weak on ergonomics, and advocates a staged training programme, focusing first on accident reduction and then expanding to the prevention of chronic illness.

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### 1. Introduction

Italian forestry is characterized by steep terrain, ownership fragmentation and the application of close-to-nature management criteria, such as continuous-cover forestry (Mason et al., 1999). All these factors tend to slow down the inevitable introduction of mechanized harvesting (Spinelli et al., 2009), determining the current prevalence of labour-intensive operations. Motor-manual operations in steep terrain are inherently dangerous (Wang et al., 2003) and cannot benefit from the safety improvements offered by mechanization (Bell, 2002). Realizing that, Italian authorities are making a massive effort to improve safety in forestry, by enforcing the use of personal protective equipment (PPE) and by promoting a number of training campaigns, focusing on safe working tech-

nique, as well as on the correct use of PPE. In several regions, this effort has evolved into an even more ambitious and articulate safety certification and licensing scheme, similar to the many such schemes already deployed in Europe and North America (MackKay et al., 1996). The task at hand is not easy, and for a number of reasons. First of all, many operators perceive safety as conflicting with both comfort and productivity (Cavazza and Serpe, 2009), and often deliberately choose to take risks (Williams and Geller, 2000). The perceived antinomy between work pressure and safe behavior seems to be a universal problem, being already reported by many authors (e.g. Nieuwenhuis and Lyons, 2002; Zohar, 2008), despite any principle statements about the convergence of safety and effectiveness, as resulting from good practice (Jokiluoma and Tapola, 1993). Secondly, the effectiveness of safety training programmes in reducing injury rates is not guaranteed (Bell and Gruschcky, 2006). The limits of safety training were made evident already many years ago by Östberg (1980), who sustained that further safety training cannot substantially reduce the accident rates among already experienced forest workers. More recently, the work by Salminen et al. (1999) seems to have denied any significant relationships between risk-taking and accident frequency among Finnish forest work-

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**Table 1**  
Characteristics of the different crews and of their work organization.

Crew no. and type	Type	Plot	Crew size	Formal training	Logging method	Extraction system
1 Consortium	Public	1	4	No	CTL	Sliding
2 Private	Private	2	3–2 <sup>a</sup>	No	FLS	Sliding/winching
3 Association	Semi-private	3	3	No	CTL	Sliding
4 Regional Agency	Public	4	4	Yes	CTL	Sliding

Notes: CTL: cut-to-length: trees are delimitated and crosscut into commercial-size logs before extraction; FLS: full-length stems: trees are delimitated but not crosscut before extraction.

<sup>a</sup> 3 workers in the first day and 2 workers in the following days.

ers. Taken together, these works may hint at a basic deficiency of standard training courses, which may prove very effective in increasing the safety of inexperienced workers, and yet unable to teach experienced workers much more than they already know. In a standardized or semi-standardized training course, the crucial new notions get lost in the prevailing background noise of redundant information. To avoid this, one should design dedicated courses targeting specific safety-related behaviors (Komaki et al., 1978), after these have been properly identified (Killimett, 1991). The identification of training priorities may be conducted at a national (Bentley et al., 2002), regional (Myers and Fosbroke, 1994) or state (West et al., 1996) level, but probably the most effective approach is the local, case-by-case study (Bordas et al., 2001). In fact, if one of the main purposes of training must be behavioral change, it is crucial that the course be interesting and convincing enough, since both enforcement and positive reinforcement (Catania, 2000) are very difficult to administer to crews typically working in isolation (Olson and Austin, 2001). Finally, safety-related behavior should be analyzed jointly with the other factors influencing risk and risk-taking, and especially external conditions and operational organization (Wirth and Sigurdsson, 2008). Therefore, the primary goal of this study was to determine the frequency and the type of violations to the prescribed safety rules occurring in a typical sample of Italian logging crews through direct observation. Furthermore, we wanted to determine (a) how company type affects the organization of the crews, their productivity levels and their safety-related behavior and (b) if productivity and safety-related behavior are related, positively or negatively. The ultimate goal is to use this information for designing specific training modules that can target critical areas while omitting redundant information, in the pursuit of maximum efficiency.

## 2. Materials and methods

Four crews were selected to represent the different types of forest companies involved in Italian close-to-nature forestry. In particular, the four crews were considered representative of the central Alps, in Lombardy (northern Italy). The four crews belonged respectively to: (1) a consortium of public owners, mostly municipalities (henceforward named Consortium); (2) a private company (Private); (3) a forest-owners association, partly supported by public subsidies and therefore considered semi-private (Association) and (4) the regional forestry agency (Agency). Of these, only the members of crew no. 4 had received formal training, whereas all the others had been trained on the job. None of the crews had previous recent accidents or fatalities.

A study site was identified in the Azzaredo-Casù municipal forest (Latitude 46°02'38.94"N, Longitude 9°39'32.85"E, Altitude 1395 m above sea level) in the Province of Bergamo—Northern Italy. The stand was an uneven-age mixed conifer forest dominated by Norway spruce (*Picea abies* L. Karst) and Silver fir (*Abies alba* Mill.). For composition and structure, this stand was very near to the natural forest type of the area (Grassi et al., 2003). The silvicultural treatment was a selection cut, removing about 80 m<sup>3</sup>/ha. Four adjacent plots of about 1 ha were selected for the test. All plots

extended for about 100 m uphill from the forest road located at their lower border. Each crew had to carry out the felling, processing and extraction of 60 previously marked trees, within the maximum allotted time of 1 work week. Plots were randomly assigned to the crews.

The comparative aim of the study required the plots to be as similar and homogeneous as possible in terms of terrain and stand characteristics, so that no crews had significant advantage or disadvantage on the others. In order to check the actual similarity of the plots, the following parameters were measured and analyzed: slope gradient at the base of each harvest tree (%), diameter at breast height (DBH, cm) of all harvest trees, space available for the tree fall—the latter express by a code comprised from 1 to 4 in order of ascending difficulty.

To reduce the differences in motivation, all workers in all test crews were paid an hourly wage. This is the standard payment system for the workers employed by public and semi-public agencies, whereas the members of private crews are paid on a lump-sum contract base, which may cause them to speed up their work pace in order to complete the job as soon as possible and become available for another contract.

No specific limits were set concerning the organization of the operation, each crew being free to organize the operation as they felt best. The characteristics of the crews and of the chosen logging systems are described in Table 1.

During harvesting, two researchers followed each crew and recorded time consumption, timber volume output and the eventual violations to the health and safety prescriptions. Work time was split into time elements (Bergstrand, 1991), recorded separately for every worker involved in these tasks. The reference cycle was the individual tree being treated, identified by a numeric code painted on its bark. All time data were recorded with centesimal (1 min = 100 cmin) stopwatches. Delays were recorded separately, and subdivided into the following categories: rest and personal delays, organizational delays, service and repair (Björheden et al., 1995). The wood volume processed during each work cycle was associated to time consumption in order to calculate productivity (Olsen et al., 1998).

Safety performance was quantitatively evaluated by recording all main violations to safe working practice, as described in the mainstream current handbooks (Neri and Piegai, 2005): different codes were developed for main violations (Table 2), and every time a worker committed any such violations the respective codes were associated to the data collection record by the researcher performing the time-study. That way, it was possible to relate the frequency of risk-taking behavior to both time and the number of process actions performed. If several violations were committed by the same worker in the same process action (e.g. felling one tree), then all the corresponding codes were recorded.

The Kruskal–Wallis non-parametric multiple-comparison test was used to check the similarity of the test plots concerning the DBH of harvest trees, the slope gradient at the base of these trees and the space available for the eventual fall (SAS, 1999). Non-parametric statistics were adopted, since the data was not normally distributed.

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